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OTTAWA, 23rd May, 1918.

The Right Hon. Sir GEORGE E. FOSTER, P.C., G.C.M.G.,
Chairman of the Sub-Committee of the Privy Council for
Scientific and Industrial Research, Ottawa.

SIR,—I have the honour of presenting to you my report on the work of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1918, as required by the terms of the Act (7-8 George V, Chap. 20) constituting the Council.

I have the honour to be,

Your obedient servant,

A. B. MACALLUM,
Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research.

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REPORT

OF THE

ADMINISTRATIVE CHAIRMAN

OF THE

Honorary Advisory Council for Scientific and Industrial Research.

I. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL.

On June 1, 1916, there was constituted by Order in Council a Sub-Committee of the Privy Council, consisting of the Right Honourable Sir George E. Foster, K.C.M.G., Minister of Trade and Commerce (Chairman), the Honourable the Ministers of the Interior, Agriculture, Mines, Inland Revenue, and Labour, with the object of having charge of all measures to foster the scientific development of the industries of Canada, in order that during and after the present war these may be in a position to supply all Canadian needs and extend Canadian trade abroad.

Under this Sub-Committee of the Privy Council, and by its direction, an Honorary Advisory Council for Scientific and Industrial Research was constituted on the 29th of November of the same year, composed of eleven representatives of the scientific, technical, and industrial interests of Canada.

This Research Council, by the direction of the Chairman of the Sub-Committee of the Privy Council, was charged with the following duties:—

(*a*) To ascertain and tabulate the various agencies in Canada, which are now carrying on scientific and industrial research in the universities and colleges, in the various laboratories of the Government, in business organizations and industries, in scientific associations, or by private or associated investigators.

(*b*) To note and schedule the lines of research or investigation that are being pursued by each such agency, their facilities and equipment therefor, the possibilities of extension, and, particularly, to ascertain the scientific man-power available for research and the necessity of adding thereto.

(*c*) To co-ordinate these agencies so as to prevent overlapping of effort, to induce co-operation and team work, and to bring up a community of interest, knowledge, and mutual helpfulness between each other.

(*d*) To make themselves acquainted with the problems of a technical and scientific nature that are met with by our productive and industrial interests, and to bring them into contact with the proper research agencies for solving these problems, and thus link up the resources of science with the labour and capital employed in production so as to bring about the best possible economic results.

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(*e*) To make a scientific study of our common unused resources, the waste and by-products of our farms, forests, fisheries and industries, with a view to their utilization in new or subsidiary processes of manufacture and thus contributing to the wealth and employment of our people.

(*f*) To study the ways and means by which the present small number of competent and trained research men can be added to from the students and graduates of science in our universities and colleges, and to bring about in the common interest a more complete co-operation between the industrial and productive interests of the country and the teaching centres and forces of science and research.

(*g*) To inform and stimulate the public mind in regard to the importance and utility of applying the results of scientific and industrial research to the process of production by means of addresses to business and industrial bodies, by the publication of bulletins and monographs, and such other methods as may seem advisable.

The Meetings of the Council.—The first meeting of this Research Council was held in Ottawa on December 4-6, 1916, the sessions of which were chiefly devoted to organization and the formulation of the lines of action along which the Council should proceed to carry on its functions. At this meeting it was decided to recommend to the Sub-Committee of the Privy Council the appointment of an Administrative Chairman who should give his time wholly to the duties of the position. This recommendation was, before the end of the meeting, given effect by Order in Council, by the appointment of the present Chairman.

Since the inception of the Council, twelve meetings in all have been held, and monthly, with the exception of July and August, during which the Administrative Chairman and three members were absent on a visit to the western provinces for the purpose of consulting various Boards of Trade and Technical Organizations on the subject of the development of the industries of Western Canada. The great majority of these meetings covered three days of continued sessions, but the work done by the members was not confined to the occasions of the meetings, for all were more or less engaged, in some cases continuously, in the intervals, on the questions brought forward at the meetings, and some of the members, acting as chairmen of committees of the Council, have attended assiduously to the duties which their position involved.

Research Council Act.—The interest which the members of the Council have manifested in the service they are enthusiastically rendering has been given an enduring character through the establishment of the Council as a permanent organization by the Act which received vice-regal assent on August 29, 1917, and which gives to the Council, under the supervision of the Sub-Committee of the Privy Council powers and responsibilities, the wise exercise of which must greatly enhance its usefulness.

Expenditures of Council.—The expenditure of the Council during the first four months, ending March 31, 1917, of its existence was met out of the vote to the Department of Trade and Commerce for the development of Canadian trade.. For the last year the expenditures have been met out of the parliamentary grant of $91,600 to the Council, but only $50,374.65 was disbursed, since, as the grant was given in the Supplementary Estimates, it was available only during the last six months of the year and, in consequence, only a half of what was in the programme for the year could be appropriated and expended for definite projects within the financial year.

Assisted Researches.—There were many applications for assistance for special researches in the industrial as well as in the scientific field, which could not be granted, primarily because the total of the amounts asked for exceeded by three times the amount the Council had at its disposal for this purpose. Further, the task of sifting out those which appeared to be deserving of assistance was not, in every case, an easy

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one. Care was exercised that the projected research for which a grant should be made should be capable of being brought to a successful conclusion. This made it necessary to examine and carefully consider each case, and, accordingly, a number of them have been approved and granted the assistance applied for. Several of these, however, have not been undertaken because of the difficulty involved in finding the investigators required for carrying them out, while two others could not be followed up owing to the impossibility of obtaining the apparatus or the mechanical outfits required for undertaking them. This is what may be expected. Problems cannot be solved in time limits. A grant to aid in research, therefore, should not involve a time penalty, and, hence, researches begun in one year may extend beyond the year in which the grants given to assist them are made.

A list of the grants which have so far been made, with an account of the nature of the researches involved and the progress achieved in each problem, is given in Section V.

All the problems are of industrial interest and some of them are of very special importance. Several of these may be singled out for mention here. The results of the research on tar fog can be, and doubtless will be, applied to plants in Canada engaged in the destructive distillation of coal, wood, the liquid products resulting from the manufacture of producer gas, etc., as the cost of installation of the necessary outfit and of power is low and the action is effective. The straw gas research involves the practical utilization for heat and light on the farms of the Prairie Provinces of the enormous quantities of straw, estimated at 20,000,000 tons, now burnt to dispose of it. The results of fog signalling experiments forecast a new type of sirens for use in the River St. Lawrence and in the Gulf, and accordingly contributing to the safety of navigation therein. The studies on the composition of sulphite liquor waste of our Canadian pulp mills, enormous in quantity and poured into streams and rivers, poisoning all fish life therein, gave results which seem to point the way to the commercial utilization of at least the sugars they contain, to furnish alcohol for industrial purposes. The necessity for investigations on the production of a rust-resisting wheat is found in the fact that in one year as much as $19,000,000 were lost through the occurrence of the rust disease in Manitoba, Saskatchewan, and Alberta.

Studentships and Fellowships.—To increase the number of investigators in science who may be induced to follow a career as such in connection with the Canadian industries, the Council established twenty-five studentships and fellowships to be awarded to young graduates of our Universities and Technical Colleges, who have given evidence of the possession of the special knowledge and capacity required for the conduct on their part of independent research in some department of Science, which bears on industrial processes. Owing to the depletion of the student ranks in our Universities, which has been going on for the last three years, the number of such graduates has been very small, and, in consequence, only seven were found qualified for appointment, three to fellowships and four to studentships, all of whom are now engaged in research, each on a different problem, under the supervision of the professor or director of a laboratory in one of four different Universities. (Appendix B.) The Council hopes to increase the number of appointees for the year now commencing.

The institution of these studentships and fellowships, it may be pointed out, is in accord with one of the recommendations of the report of a British Committee, of which Sir J. J. Thomson was chairman, appointed by the Prime Minister in August, 1916, which urges that "concerted efforts should be made by employers, local education authorities, and the State, to increase the flow of capable students to the Universities and higher Technical Institutions, with a view to securing the larger supply of trained scientific workers required for industrial and other purposes."

Associate Committees.—In order that the Council may have the assistance of the best expert advice along a number of technical lines, it appointed several committees, composed of a number of leading specialists, to whom may be referred, as the occa-

sion may require, questions and problems in the solution of which the wide experience and technical knowledge of each such committee may be of very great service. Three of these are permanent organizations: the Associate Chemical Committee, the Associate Committee on Mining and Metallurgy, and the Associate Committee on Forestry. It has been arranged that the chairman of each shall be a member of the Council, in order that its work will be in intimate relation to that of the latter. It is contemplated that other such committees will be appointed as the need for them develops.

Associate Committee on Chemistry.—The report of the Associate Committee on Chemistry (Appendix A) gives a summary account of its activities during the first seven months of its existence and indicates the character of the questions which were referred to it. A number of these were advanced in the answers given in questionnaire No. 3 issued to the industries (*vide* Section III) for the purpose of ascertaining the extent of their equipment for industrial research and their problems involving scientific and technical processes of importance to their development. Each problem was carefully considered and a report thereon, embodying the best expert information on the subject, was furnished to the Firm or Company which advanced the problem.

Associate Committee on Mining and Metallurgy.—The Committee on Mining and Metallurgy had a smaller number of problems, chiefly from the answers to questionnaire No. 3, to consider and report on, and they were dealt with in the same way. The committee, under the call of the chairman, Dr. F. D. Adams, held a meeting in Montreal on March 5 and 6, at which there was an attendance of seventeen members, and during its sessions the whole subject of Mining and Metallurgy in Canada was passed under review. Several proposals were advanced concerning the utilization of ore and fuel deposits in various parts of the Dominion, which were referred to appropriate special committees to be reported on to the Research Council. It is proposed to hold meetings of this committee at regular intervals in order to concentrate attention upon the development of our mineral resources.

Temporary Committees.—Temporary committees, composed chiefly of members not otherwise associated with the Council, have been appointed to deal with the following subjects:—

Flax Cultivation in Canada. (Prof. Ruttan, Chairman).

Cold Storage Research. (Prof. E. E. Prince, Chairman).

The Fraser River Salmon Question (in conjunction with the Biological Board of Canada).

Plant and Animal Diseases.

Underground Waters for the Western Plains.

Flax Cultivation.—The Committee on Flax Cultivation in Canada, consisting of Professor Ruttan, Mr. J. H. Grisdale, Director of the Central Experimental Farm, Mr. Ferd. Van Bruyssel, and the Administrative Chairman, appointed in view of the decrease in flax cultivation in Russia, Holland, and Belgian because of war conditions, and the consequent deficiency in the supply of linen and twine, had the assistance of Mr. Stewart Cox, representatives of the Fibre Corporation, of London, sent to Canada to report on the possibilities of increased cultivation of flax for the manufacture of linen required for the construction of aeroplanes. It recommended that every effort be made to increase the acreage for 1918 of the flax grown in Eastern Canada. Mr. Grisdale was asked to represent the urgency of this step to the Flax Growers' Association, a meeting of which took place in March. Mr. Grisdale reports that the acreage sown in 1918 may be 14,000, as compared with 8,000 sown last year, but this depends on the availability of the seed and the labour required. The crop of 1917 has not all been worked up

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owing to scarcity of the labour skilled in scutching. The flax of Saskatchewan and Alberta, from about 800,000 acres, has been produced for seed only, and cut instead of pulled, the straw of which was disposed of by burning it, as, owing to the character of the stalks and to climatic conditions, which make "retting" on the Western Plains practically impossible, it could hitherto not be economically utilized. Efforts are, however, now being made to use this straw for making fibre for cordage and twine, efforts which are deserving of attention in view of the scarcity of linen fibre now in such demand everywhere.

Cold Storage Research.—The Cold Storage Research Committee, composed of Prof. E. E. Prince; Mr. J. A. Ruddick, dairy and cold storage commissioner; and Dr. F. T. Shutt, associated with the British Cold Storage Board, is engaged in gathering all the information bearing on the use of methods of refrigeration in connection with the storage and transportation of fish, meat, fruit, etc. Two bulletins, to be published shortly—one on the proper utilization by consumers of cold storage products; the other on the right application of refrigeration for the preservation of fish—are the first products of its activities.

The Fraser River Salmon Question.—The committee on the Fraser River Salmon Question was appointed to consider the measures to be taken to preserve the supply of sockeye salmon, the first amongst the more important fishes of British Columbia waters. Urgent representations were made to the Research Council by the British Columbia Canners' Association and other organizations in that Province concerned in the fish industry, to the effect that, owing to reckless and even criminal overfishing of it in its course in international waters in the strait of Juan de Fuca and to the mouth of the Fraser river, to ascend to its spawning beds in the upper reaches of that river, it was in danger of extinction and that immediate action would be necessary to prevent this. From fifteen to ten years ago efforts were made to bring about an agreement between the authorities of the State of Washington and the Canadian Government to limit the number and use of seines, nets, traps, and other contrivances employed to catch the sockeye in its course to the spawning grounds, but influences, under the guise of State rights, made these efforts ineffective. The question became an acute one last year, owing to the failure in the run of the sockeye, and, in consequence, all parties on the north and the south of the boundary line in that locality were ready for arranging an agreement as to the measures to be taken to ward off the threatened danger.

The committee, consisting of Professors F. D. Adams, A. P. Knight, J. Playfair McMurrich, and R. F. Ruttan, and the Administrative Chairman, gave careful attention to the question, and it was found, as results of its inquiry:—

1. That the sockeye salmon, unless appropriate measures are taken to prevent it, is in danger of extinction as a food fish in the waters of southern British Columbia.

2. That this danger is due chiefly to overfishing with traps, seines, and nets so numerous that only a very small proportion of the fish reach the mouth of the Fraser River to spawn in its waters.

3. That an agreement to limit this fishing would have to be in the form of a treaty between the United States and Canada, in order that the forces and influences may be set aside, which might imperil continuity of operation of the proper measures to be taken to obviate the danger, a continuity that is absolutely necessary if the end sought is to be attained.

The committee reported that such an international agreement should be sought, the main provision in which would be an International Commission empowered to exercise untrammelled jurisdiction regarding the fishing, not only in the international waters in which the overfishing occurs, but also in the Fraser River, to the upper reaches of the same.

The Council, after full consideration of this report, recommended that negotiations for such an international agreement be undertaken at the earliest possible date.

The council has provided for the publication of the report of the committee, as one of the series of reports which are being issued for general distribution.

Plant and Animal Diseases.—The Committee on Plant and Animal Diseases, of which Dr. W. C. Murray, President of the University of Saskatchewan, is chairman, has concerned itself with investigations on swamp fever of horses in the Prairie Provinces, and on wheat rust which has caused enormous financial losses in the West.

In close co-operation with Dr. Torrance, Veterinary Director General of the Department of Agriculture, the work on swamp fever was carried out by Dr. S. Hadwen, biologist, and Dr. Cameron, entomologist, of that department, at the University at Saskatoon during the season of 1917, and they found that the disease is much more prevalent in Saskatchewan than they had previously supposed it to be, and that the losses which the farmers experienced because of it constituted it a serious problem to them. It is proposed to continue this investigation during the coming summer with the hope of reaching results which will enable the agricultural authorities in the West to combat this evil.

Wheat rust was the subject of a conference, held August 16 to 18, 1917, between representatives of the Dominion Department of Agriculture and the Universities and Agricultural Colleges of Manitoba, Saskatchewan, and Alberta. This conference recommended that, under the leadership and responsibility of the Dominion Department of Agriculture, investigations in plant pathology, more particularly on wheat rust, be instituted and carried on in the Agricultural Colleges of the Prairie Provinces. These should each provide a greenhouse, laboratory, and office accommodation, with free light, heat, and water, and a plot of land for experimental purposes, all to be under the direction of a plant pathologist, whose salary and the expenses of his laboratory assistance and equipment should be met by the Dominion. The plant pathologist, it was also recommended should be permitted by the Dominion Department of Agriculture, to give lectures, not exceeding two a week, with necessary laboratory work, on such terms as may be agreed upon by the Colleges and appointee.

The conference gave attention to the question of the part played by the common barberry (*Berberis vulgaris*) as a host in the propogation of wheat rust, and it resolved to recommend to the Ministers of Agriculture of the provinces of Saskatchewan and Alberta, that steps should be taken to eradicate this shrub and its varieties, as has been done by the Province of Manitoba and the States of Minnesota and North Dakota.

This conference recommended also that investigational work for the determining of methods of crop and soil management best suited to lessen the damage from rust be instituted by the Dominion Department of Agriculture on each of its branch Farms and Stations in the Prairie Provinces, and by the Universities, Agricultural Colleges, and Schools in the same.

Council Committees.—In order to economize the time of the Council as a whole, and to obtain expert reports on industrial questions for its action, it has appointed from its membership a large number of committees to deal with individual industrial problems, such as:—

Hydro-power Development.
Potash and Phosphates.
Nitrogen Fixation.
After-the-war use of Munition Plants.
The Utilization of the Lignites of the Western Plains.
Industrial Power.
Co-ordination of the Technical Societies of Canada.
Land Classification and Soil Survey.

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The British Columbia Advisory Committee.—Though the Council was not constituted with the view of representing territorially the different parts of the Dominion, its membership includes residents of all parts of Canada except the extreme west. The difficulties that distance imposes determined this exception. A member resident in British Columbia, who could not attend at least the majority of the meetings of the Council, would not be in a position to give much assistance to the Council in its efforts to promote the interests of that province on its technical and industrial side. Were he to attend ten meetings, each of which would involve twelve or thirteen days' absence from home, he would spend thereby in each year over four months, five-sixths of which time would be given to the railway travelling, a sacrifice he should not be expected to make. It was inevitable, therefore, for at least the present and the immediate future, that British Columbia should be unrepresented on its technical and industrial side in the Council. Its interests in mining and metallurgy, forestry, fisheries, and agriculture are, however, of such national importance that sustained attention to their development is a duty of the first order, and, accordingly, the Council gave early consideration to the subject.

The wishes of those concerned in the leading industries of British Columbia had first to be considered. To ascertain them a deputation of the Council, consisting of the Chairman, Professors Adams and Ruttan, and President Murray, appointed to visit the Western Provinces with the object of investigating and reporting on their needs in relation to the functions of the Council, interviewed various Boards of Trade and representatives of the more important industries of British Columbia. The deputation, on its return in September, reported to the Council the opinion, practically unanimous in that province, that a local representative committee should be created with the function of considering all matters affecting the scientific development of the industries of British Columbia and reporting recommendations for action thereon to the Council. This committee, it was suggested by the Boards of Trade, should be nominated by the Council after a survey of all the interests which could be promoted by such a committee, and the number of members and the regulations governing its activities were to be determined by the Council.

The Council, after a careful consideration of this report, decided that such an advisory committee be created and that the membership should be fifteen, of whom five should be directly appointed by the Council after the remaining ten had been nominated, five each by the Board of Governors of the University of British Columbia and the Council of the Joint Technical Organizations of the Province. These have made their nominations, the Council has made its five appointments, and, in consequence, the advisory committee as now constituted will shortly organize for the performance of its functions. It will constantly keep under survey the industries of the Province and report its recommendations, as they are agreed upon, to the Council for action thereon. The Council believes that this advisory committee will be of great service in assisting it to give appropriate attention to the needs of British Columbia as regards industrial development.

The advisability of constituting advisory committees for certain other portions of the Dominion has been under consideration, but, as the need for such is not so pressing as in the case of British Columbia, no action has been taken, but, should urgency develop in connection with any of these, a decision thereon will not be delayed.

Promotion of Research in Canada.—The Council has had under consideration for the last nine months the question of the organizations which should be created and the methods to be adopted, by the aid of which Canadian industries may be assisted to develop by the application to them of the most advanced scientific processes, and thereby enabled not only to meet the needs of the home markets but also to compete with their rivals abroad. This question is one of paramount importance to Canada, in view of the intensified application of science to industry, which elsewhere will be fostered after the war by the State and also through private enterprise. Through the answers given in questionnaire No. 3, addressed to the industries, it has been ascer-

tained that not 2 per cent of the Firms have research laboratories and only about 10 per cent have routine laboratories, chiefly for the elementary testing of materials.

The situation indicated and the problems involved are discussed in detail in Section IV. *To meet the one and solve the other the establishment, at Ottawa or some other centre, of a research institute having the functions of the Bureau of Standards at Washington or of the National Physical Laboratory of Great Britain, is advocated. Attached to the Institute, it is suggested, should be laboratories that may be at the disposal of Guilds or Associations for Research which may be founded by the various Canadian industries, each in its own line, the Firms or Companies of which are unable individually to undertake experimental investigations with the object of improving their manufacturing processes.*

Special Problems, Lignites and Forestry Studies.—Amongst the special problems which early engaged the attention of the Council were the briquetting of lignites to form domestic fuel and the measures to be taken to preserve our forest wealth. The action taken towards a solution of both is indicated in Section II (*a*) and (*b*).

The importance of the lignite question may be indicated in a few sentences. The Provinces of Manitoba and Saskatchewan import annually from Pennsylvania about half a million tons of anthracite for domestic fuel, and send out of the country therefor more than $4,000,000. There are in these provinces, it is estimated, about 57 billions of tons of lignites, of a poor grade, largely disqualified from serving as domestic fuel. It has been shown on a super-laboratory scale, however, that they can be carbonized and briquetted and that the briquetted product is an equivalent of anthracite. There remained only the demonstration on a commercial scale of this carbonizing-briquetting process, to prove that a substitute for anthracite could be so produced, which would be cheaper in that market than anthracite, and the Council proposed that the Government should undertake to erect (and operate) at some point in southern Saskatchewan a plant to turn out 30,000 tons of this fuel yearly, the cost of which, it is estimated, would not probably exceed $7 per ton. The success of this demonstration would be far-reaching in its effect on the fuel situation in the West.

Research Inventory.—In compliance with one of the duties required of the Council, by the Order in Council establishing it, it endeavoured to make a survey of the present situation as regards research, and the equipment and man-power for the same, in Canada. Questionaires were addressed to all the Universities, Technical Institutions and Societies, Government Departments, and to several thousand industrial firms and organizations, with a view to eliciting the information required. The return of them is not yet quite complete, and, therefore, a final summary of the data required is not at present possible, but enough has been gathered from those received to furnish an indication of the present status of scientific research in Canada (*vide* Section III).

Affiliation with British Advisory Council.—The Research Council has been kept in touch with the work done during the last ten months by the British Research Council, through the attendance at the meetings of the latter of Prof. J. C. McLennan, F.R.S., as assessor and representative of the Canadian Research Council.

Professor McLennan has been assiduous in performing the duties this position calls for and also in attending meetings of the various committees at which industrial problems of interest to Canada were discussed, and, in consequence, the Research Council has the benefit of the views of our British Scientific and Technical confrères on these matters.

II. SPECIAL PROBLEMS.

(*a*) *The Briquetting of Lignites.*

At the first meeting of the Council, a committee consisting of Mr. R. A. Ross (chairman), and Drs. Adams, Mackenzie, and Murray, was appointed to review and report on the question of the utilization of the lignites of Western Canada for domestic fuel. The urgency of the fuel situation at the time prompted this, which urgency has since been accentuated.

What the urgency was and is now, is so well recognized that it does not require to be explained here. What contributed, and will contribute, to the urgency, and what measures other than temporary which may be taken to meet it, are less generally recognized, and they may, accordingly, be referred to, somewhat briefly.

The output for 1916 of the coal mines of the United States was approximately 550 millions of tons. The demand for coal in 1917 was in excess of the output for 1916 by 100 millions of tons, a demand which could not be met, although it was hoped to increase that output by 50 millions of tons. There was, therefore, a shortage of supply, of which Canada, as part of the market for American coal, experienced the effects.

The coal imported into Canada is distributed in the provinces of Quebec, Ontario, Manitoba, and Saskatchewan. The amount involved in 1916 was 17,551,116, of which 4,570,284 were of anthracite. Ontario and Quebec were supplied from this source practically alone, they taking in that year 14,671,239 tons, of which 4,037,284 were of anthracite. The prospective coal famine of 1917 in Canada chiefly affected these Provinces, and they could not look to Canadian sources of coal, for the output of the Nova Scotia mines was not, and could not be materially increased, and that of the Western Provinces was practically excluded from Central Canada because of the long haulage and the lack of transportation facilities. This makes, and will make, as far as one can forecast, for many years ahead, the two Central Provinces dependent on the United States for the coal they need and, consequently, any decrease in the supply from that source will be a matter of grave concern to Canada.

A part of the imported supply also goes to Manitoba and Saskatchewan, the former Province receiving in 1916, 1,952,998 tons, of which 325,000 were anthracite, and the latter 926,879, of which 208,000 were anthracite. Of western coal, almost wholly lignites and bituminous in character, Manitoba used in that year only 98,629 tons, and Saskatchewan 1,302,926. *The two Provinces, therefore, consumed 533,000 tons of anthracite imported from Pennsylvania,* nearly one-eighth of the total quantity of anthracite imported into Canada in that year.

If the coal output of the mines of the Eastern United States should be reduced, or if it should remain stationary, the needs of the home market would be paramount, and there would be a diminished supply for Ontario and Quebec, which require annually about 4,000,000 tons of anthracite, used chiefly for domestic fuel. The diminution in the supply of this in 1917 was due, in part, to war conditions, but it is doubtful if the annual output of the anthracite mines of the United States can go on increasing as it has been during the last fifty years, without reaching very shortly a figure which would predicate their exhaustion in less than a century, a possibility which has already been discussed by American authorities[1] on this subject, and it has been urged by several of them that an embargo should be placed on the exportation of anthracite, which, they hold, should be reserved for the American people alone. It is, indeed, not at all improbable that a limitation on export of anthracite may be determined upon at any time in the next few years, a decision which would seriously affect the fuel

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[1] Eliot Jones: "The Anthracite Coal Combination in the United States." The Harvard University Press, 1914. The data on which the calculation is made as to how long the anthracite supply will last is given on pp. 110-113. The answer is 115 years.

situation in Central Canada which, for reasons already referred to, must depend on the United States for its coal supply. The risk of a shortage to Ontario and Quebec would be more or less remote if all the anthracite exported to Canada were limited in its distribution to those provinces. In that case the half of a million tons annually required for supplying Manitoba and Saskatchewan, if replaced by a satisfactory substitute to be provided for those provinces, would equate the possible shortage of anthracite supply and permit Ontario and Quebec to receive the quantity of hard coal they require from the amount available from Pennsylvania.

The source of this substitute would be in the West itself. There is a very limited supply of anthracite at Bankhead, near Banff, Alberta, which is in a more or less comminuted condition when mined, and a considerable portion to be used as a domestic fuel, has to be briquetted[1]. Of this, only about 142,985 tons were marketed in 1916, almost wholly in Alberta and Saskatchewan. Coal of this class occurs in large quantities in the Brazeau District south of Jasper Park. Extensive deposits of anthracite obtain north of Hazelton in northern British Columbia, but certain difficulties in working them, and the very long haulage, with consequently high transportation charges, will practically exclude the mined product from districts east of Alberta. There are extensive deposits of very good bituminous coal in the Crow's Nest district, but it has not found favour in Saskatchewan and Manitoba as a domestic fuel as compared with imported anthracite, as witness the half millions tons of the latter supplied to these two Provinces at a price per ton at least 30 per cent greater than that charged in the same area for Crow's Nest coal.

The substitute, therefore, is not economically available from nature's original product in the West. It may, however, be manufactured artificially and from lignites so abundant in the West and constituting at least 70 per cent of Canada's fuel resources—that is, 12 per cent of the world's supply of fuel[2].

The utilization of these lignites, because of their vast extent and availability, as a source of power and heat for domestic use, is for the present a question of prime importance for Western Canada, and, ultimately, it may be for the whole of Canada. The better grades of them can be used for the production of power, and even the poorer varieties have been, and are being, used for this purpose.

For heating, however, they, and especially the poorer varieties of them, are largely disqualified, for the following reasons:—

1. They contain an amount of water ranging in the various grades from 20 to 40 per cent, and its evaporation on combustion in the fire-box entails the dissipation and loss of a large quantity of the heat produced.

2. They, after being mined and exposed to the air for some weeks, lose this water by evaporation, and, in consequence, they are "slacked"—that is, reduced to a powdery form—which makes their use, in domestic furnaces of the common type, difficult and disagreeable.

3. They do not, in the unslacked form, "stand up" in the fire, and are quickly consumed, this character necessitating frequent stoking. They cannot, also, in consequence, be converted into coke.

4. On combustion in the domestic furnace the heavy condensation products of the smoke, abundant in quantity, obstruct the flues and cover the hot water or steam pipes; this making necessary very frequent and tedious cleaning operations.

5. In transportation in the recently mined form the charge for what corresponds to the water content influences considerably their market price.

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[1] All the so-called anthracite of Western Canada belongs to the "semi-anthracite" class.

[2] The magnitude of this supply may be gathered from the fact that the coal supply of the Maritime Provinces is only 2 per cent of the total of Canada's coal. The lignites of Western Canada are, therefore, at least 35 times the quantity of the eastern coal deposits. The proportions of the coal supply of the world, by countries, are, in percentages, as follows: United States 51, Canada 17, China 12, Great Britain 2·4, Australia 2·2, and Germany 5·4.

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6. The heat value is low, as a pound of lignites of the different grades gives in British thermal units a range of 6,500 to 8,500, whereas the B.T.U.'s of anthracite are 11,500 to 13,200, and for bituminous coals from various sources, 9,000 to 14,800.

The question of briquetting these lignites has often been advanced, and various proposals have been made with that object in view. The briquetting processes are not readily directly applicable to them, and, especially, to the poorer grades such as obtain in Saskatchewan. Their bituminous content is low—on the average not more than 1 per cent.—and, unlike the German and Austrian lignites, which are rich in tarry matters, they require for briquetting an addition of pitch which will make the content of the latter at least 6 per cent. It is, indeed, possible to briquette them without the addition of any binder, but the briquettes so made do not resist disintegration under ordinary weather conditions.

Briquettes made from lignites, with the addition of a binder, are not a substitute for anthracite, and could only, at best, serve as a semi-bituminous coal with a B.T.U. value of 8,000 to 10,000. The product would have nearly all the disqualifications of the raw lignites. An equivalent for anthracite cannot be made from them simply by briquetting them.

The way of producing such an equivalent from them was indicated in part by the experiments of S. M. Darling, carried out at Estevan in 1913-14 in an investigation conducted by him for the Government of Saskatchewan, and in part by those of Prof. E. J. Babcock, Dean of the School of Mines for North Dakota, conducted at Hebron, N.D., for the State Government. These experiments were made on a semi-commercial scale, and the results were of such a character as to attract attention.

The committee of the Council, in view of the importance of the subject, as indicated in the foregoing pages, applied itself to a very thorough study of all aspects of the problem, reviewing for this purpose all the literature bearing on it, published by, or in the possession of, the various departments of the Dominion Government, and also that published by the National Government of the United States as well as by various State Governments. It also availed itself, through the good offices of the Department of Mines and of the Conservation Commission, of the services of Mr. B. F. Haanel and Mr. W. J. Dick, respectively, who assisted the committee in gathering the information necessary, and to whom the Council now extends its cordial thanks for the service they thus rendered.

The results of the investigations made by the committee were formulated in a report presented to the Council at its meeting on June 8-9, 1917, which report was, after full consideration of it, adopted by the Council and recommended for action thereon, to the Sub-Committee of the Privy Council for Scientific and Industrial Research.

The findings and conclusions of this report[1] may be summarized, as follows:—

1. The lignites, even the poorest, of the Western Plains, can be carbonized at a low temperature and give a fixed carbon residue of between 40 and 50 per cent. This residue can be briquetted, using for this purpose a binder of tar, or of sulphite pitch.

2. The processes involved have already been carried out on a super-laboratory scale, and their feasibility on an industrial scale remains only to be demonstrated.

3. From every two tons of poor lignites thus carbonized enough fixed carbon may be obtained, which with a binder can be briquetted to furnish, approximately, one ton of fuel practically equivalent to anthracite in its heat value.

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[1] This report is now being published for general distribution as the first of a series which the Research Council will issue.

4. The cost per ton of the briquettes so made would not exceed $7, with a plant equipped for turning out 30,000 tons a year, allowing for war-standard prices in the material used in its construction, in its equipment and operation, allowing also for its amortization, for interest on its cost and for a fair price for the raw lignites.

5. In estimating this cost, the value of the by-products, such as gas (10,000 cubic feet per ton of lignites), ammoniacal liquor (from which ammonium sulphate, a fertilizer, can be made), and tar, was completely disregarded.

6. With this cost per ton at the plant, assuming the latter situated at or near a central railway point in Southern Saskatchewan, for example, Estevan, and with a transportation charge of $1.50 per ton to Moosejaw, and the dealers' profit and delivery cost of $1.50 more, the retail price in that city should not exceed $10 per ton, accordingly less at Regina, and at Winnipeg $11 per ton, prices that would compare extremely favourably with the prices that have prevailed and do prevail for anthracite at these points.

7. The estimated cost of the plant and of its operation for one year, including charges for amortization, interest on the expenditure of construction for one year, repairs, etc., would approximate $400,000, a sum that would be beyond the enterprise of private capital for what should initially be undertaken by the Government as a public utility.

8. The demonstration of the commercial feasibility of this carbonizing briquetting process should be made on poor lignites, such as those of Southern Saskatchewan, in order that when this is shown to be successful these processes could, without further experimentation, be applied to the better lignites of Alberta.

The Council recommended that the Government should provide the sum required to undertake this demonstration, which should be conducted by a Board of Management constituted of business and technical men entrusted with the construction and operation of the plant required for this project, which would look after the details of the marketing, under the best business conditions, of the output of the plant.

Action was not immediately taken on this recommendation, and in July and August last the Administrative Chairman, with the approval of Sir George E. Foster, Chairman of the Sub-committee of the Privy Council for Scientific and Industrial Research, entered into negotiations with the Governments of Manitoba and Saskatchewan, with the object of inducing them to provide a portion of the total amount required. The reception accorded this proposal was a favourable one and on this basis an arrangement is now being negotiated whereby the three Governments will undertake jointly to provide the sum necessary for the project, and whereby the latter may be carried out under the best business and expert conditions.

The success of this project is to be fraught with results which are to be of more importance than the immediate object of it. It will induce private capital to go into this enterprise, and eventually several plants may be erected which will supply the half a million tons that will be required to replace the anthracite hitherto imported into Manitoba and Saskatchewan from Pennsylvania, thus retaining in the country about five millions of dollars, now annually spent abroad for the supply of this fuel. It will blaze the path for the utilization not only of the *57 billions of tons of lignites of Saskatchewan,* but also of the vastly greater quantity of the better grade of this fuel in Alberta. It will inevitably lead, eventually, to a process of utilization of the vast quantities of the by-products which result, by-products which now are not highly

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[1] Anthracte gives, on the average, 12,000 B.T.U.'s and the briquetted product would have, it is estimated 11,700 units. The latter would be more efficient since all its energy would, through complete combustion, be obtained as heat, whereas with anthracite a portion of the fixed carbon always escapes in the cinders.

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valued but in the years to come will be the raw materials of great and flourishing industries. Finally, it will constitute the first step in the systematic, scientific utilization of the vast stores of energy locked up in the lignites of the two provinces, which are, unlike the other Provinces of the Dominion, scantily supplied with water-power.

(b) Forestry Studies.

In a memorandum of January 13, 1917, prepared for Mr. R. H. Campbell, Director of the Forestry Branch of the Department of the Interior, by the Advisory Board of the Branch, it was urged that the forestry situation in Canada, especially in the East, was such that the exhaustion in the near future of our resources in that line could not be regarded as a negligible prospect and that the measures necessary to meet this danger ought to be taken at the earliest possible date.

It was pointed out that these measures must be founded on definite information, which has not yet been ascertained, regarding the rate of reproduction and growth of Canadian forest trees, especially those of the commercial species, and also regarding the available supply of sawlog and pulpwood material. It was this lack of information that has led Governments and private concerns to treat their forest areas and limits as if they were mines instead of crops, in place of managing them for a constantly sustained yield. With this attitude was associated a disregard of waste in milling and logging, which, it was conjectured, amounts in the average to 65 per cent of the tree as it stands in the forest.

The ascertainment at an early date of all this information, the memorandum further pointed out, is imperatively necessary, for the exhaustion of the virgin supplies is drawing near and at the present moment Canada's timber wealth could not supply the present sawmill capacity of the United States for more than twenty years.

The extent of the forest supplies of the Dominion is now engaging the attention of the Conservation Commission and data on this subject, regarding British Columbia and Nova Scotia, have already been obtained. In respect to the rate of reproduction and growth of our forest trees, and particularly those of commercial value, no investigation has been inaugurated, although the question is of fundamental importance in the formulation of any measures taken to prevent depletion. Systematic and careful studies in silviculture have been carried on in Europe, and the results obtained can be applied, with reservations, to the varieties and allies of the European species of trees that occur in Canada. For the species that are common to the United States and Canada the results of the investigations of American Forestry Departments are available. The climatic and soil conditions in Canada, however, are factors which render all the information derived from investigations carried on abroad more or less uncertain when applied to our forest trees, to promote their reproduction and growth under home conditions. There has not been, as yet, undertaken any systematic study of the biology of any of the Canadian species, a knowledge that is absolutely necessary to its successful cultivation. As regards rate of growth, we have no growth or yield tables, nor have we any volume tables which can be used in timber estimating. The only datum regarding reproduction, which seems to be unquestioned, is that the replacement of our cut timber requires more years than is generally believed. So far as forest culture in Canada is concerned, therefore, investigation of the rate of reproduction and growth is of the first order of importance.

In view of all these facts and considerations, the Advisory Committee of the Forestry Branch made the following recommendations:—

1. That the stock-taking of the timber standing in Eastern Canada should be completed, with particular attention to pulpwood supplies.

2. That a rapid reconnaissance, partly in connection with the stock-taking, should be made of the condition of cut-over lands as regards timber repreduction.

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3. That a study of the possiblities and successful methods of securing reproduction of our more important timber trees, notably the white pine and spruce, should be initiated.

4. That the necessary measurements be undertaken to determine rates of growth in volume of our most important timber trees, individually and in forest stands, to permit calculations of possible quantity of reproduction. As a preliminary to this work, the construction of volume tables will be necessary.

In consequence of the representations and advice given in this memorandum from the Advisory Board, Mr. Campbell, the Director of the Forestry Branch of the Department of the Interior, approached the Research Council with the request that it should give assistance in the achievement of the objects of the last two of the above cited recommendations. It was premised that these objects would require a number of years, perhaps ten at least, and a considerable annual outlay for their attainment, but, because of war-time conditions and the depletion of the staff in the Forestry Branch, the investigations required might be launched and couducted for several years in a modest way and at a moderate expense.

It was proposed that these investigations should be carried out on the Petawawa Military Reserve, a part of which, 25 square miles in extent, only is used for military purposes, the remaining 80 square miles being, therefore, available for this purpose. This is part of an old cut-over lumber district on which a second forest has begun to develop and the timber on it is, therefore, at a stage of growth which makes it very suitable as material for the investigations. The work, it was proposed also, should be carried on during the Summer season in each year, beginning with 1917.

The Research Council gave careful consideration to this request, and, recognizing the importance of the information which it was proposed thus to obtain, recommended to the Sub-Committee of the Privy Council for Scientific and Industrial Research that a grant of $6,000 be placed in the Supplementary Estimates for 1917 for the carrying out of this investigation.

Owing to the fact that these estimates were accepted only in July, the staff appointed to carry on this investigation did not begin work till August, and, accordingly, a preliminary survey, lasting two months only, was possible, but it was sufficient to furnish information whereby more carefully detailed plans were made for the work of the season of 1918, for which preparations of the Forestry Branch are already completed for a programme which will begin in May.

The expenditure for the season of 1917 was $2,490.32. The amount which the Research Council recommends to be allowed for the work of 1918 is $6,000.

The Research Council is of opinion that this investigation of the growth and reproduction of our forest trees, thus inaugurated and continued, will in a few years enable the Forestry Departments of the Dominion and Provincial Governments to inaugurate, on a scientific and practical basis, a scheme of reforestation, which will parallel the best results obtained in the past in Europe, and, in consequence, preserve for Canada one of her greatest and most enviable resources now in danger of exhaustion because of reckless waste and of the almost entire disregard of any system required for its preservation.

III. THE DETERMINATION OF THE EQUIPMENT AND MAN-POWER FOR RESEARCH IN CANADA.

Amongst the duties with which the Research Council is charged by the Sub-Committee of the Privy Council are:—

(1) The tabulation of all the agencies in Canada now engaged in scientific and industrial research;

(2) The scheduling of the various researches that are now being conducted by them; and

(3) The ascertainment of the man-power for research in the Dominion.

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The performance of these duties was necessary in order that all the data thus ascertained may be available for the development of all the scientific forces of the nation, to the end that its present industries may be advanced to the utmost and that new industries involving the utilization of the raw materials of our untouched natural resources may be established and their success assured. There were no data of this character previously compiled although information of an indefinite kind was current in certain quarters, but this could not be of much service in determining the exact situation as regards research in Canada.

It was therefore absolutely necessary that a systematic campaign should be made in order to secure all this information in a form that would enable the Research Council to know how most effectively to attack the problem referred to. After full consideration of the subject it was decided to issue a series of questionnaires, four in number, to each of:—

1. The Universities, Colleges and Technical Institutions;
2. Government departments, Dominion and Provincial.
3. Managers and directors of Canadian Industries.
4. Members of Scientific, Professional and Technical Societies.

The main objects of each of the first, second and fourth of these were to ascertain among other facts, the man-power for research in Canada, the researches that are being pursued either in pure or applied science, in the various laboratories and under private auspices, the researches that had to be abandoned or suspended and for what reason, the amounts that are spent annually to assist research, and the equipment and accommodation for carrying on research that each institution, or department of the same, possesses.

In questionnaire No. 3, addressed to the managers and directors of the industries, the data required were: whether they regularly employed researchers (chemists, physicists, engineers, or other experts, and whom), the research problems they attacked, the equipment and accommodation available for research, the amount of money spent in each industry for this purpose, the problems which require to be investigated in order to promote the further development of the industry, the raw materials used in the industry, the by-products resulting from the processes of manufacture, and so on.

The distribution of these questionnaires and their return properly filled out, especially that of No. 3 addressed to the industries, constituted a task of more than ordinary difficulty. In the number of industries listed in the census, amounting to more than ten thousand, are a very many which, although worthy in themselves, such as blacksmith shops, brickyards, lumber-mills, garment factories, cheese factories and Chinese laundries, do not in the present stage of the inquiry merit attention, but the character of these was not indicated, and, consequently, their sifting out would have had to be undertaken at the expense of time and great labour, had not the Canadian Manufacturers' Association, the Canadian Mining Institute, the Society of Chemical Industry, the Canadian Society of Civil Engineers, the Joint Technical Committee of Toronto and other technical organizations, each in its own sphere of activity, come to the assistance of the Research Council. These organizations were of additional material assistance. The return of these questionnaires, properly filled out, from each important industry, if not prompted by adventitious influences, would have largely been conditioned by such factors as apathy, indifference, temperament and a lack of knowledge of what was involved in this quest for information, and, consequently, the result would have been far short of what was aimed at. The organizations referred to volunteered to aid in this matter, and, accordingly, their members in various centres in the Dominion personally interviewed all the managers and directors of the important industries with the object of promoting the return of the questionnaires adequately filled out. As a result, after eight months of such volunteer assistance, about two thousand five hundred of these questionnaires, dealing with as many of the

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leading industries, are in the possession of the Council, and the information they give is now being extracted from them and put in a form which will serve for a thorough study of the present status of science in relation to the Canadian industries.

The Research Council takes this opportunity of warmly thanking the technical organizations and societies, and their members, for their help in achieving these results. It also desires to thank the managers and directors of the industries who have responded to the call for these returns.

Some of the conclusions drawn from the information which has been, and is being, gleaned from the returned questionnaires will be discussed in Section IV. It may, however, be said now that the situation is far from being satisfactory and that urgent measures are required to effect a reform which is of vital importance to the industries.

IV. THE STATUS OF RESEARCH IN CANADA—HOW RESEARCH MAY BE STIMULATED.

A discussion of the position that research occupies in Canada, to do justice to it, would require a much more lengthy presentment than may be given in a chapter or section of a parliamentary report, and, in now reviewing the subject here in its proper place, one must content oneself with a representation of the salient features of it.

As already indicated, the information regarding the status of scientific research in Canada, so far gathered from the questionnaires addressed to the industries, the Universities, the Technical Institutes and Technical Societies, reveals a situation which must cause concern in the minds of all who give thought to the grave problems that will confront us at the close of the war. The gravity of the situation is not wholly due to results of war conditions. Research in our Universities, Technical Colleges, and Government Laboratories is greatly handicapped, and in some institutions is not carried on at all, owing to depletion of the staffs caused by enlistment for military service, and this is true also for the scientific staffs of the laboratories of the industries throughout the Dominion. This is revealed in the questionnaires, and it has been taken into account in summarizing the situation. After making this allowance, however, there remains enough to show that the provision for research, either in pure science or in science applied to industry, has been and is utterly inadequate to our needs, and, consequently, unless vigorous action be taken, and soon, to reorganize our industries on scientific lines wherever possible, Canada will face a very serious industrial crisis in the years following the war.

To realize, however, how critical the situation will be, it is not necessary to go to the information derived from the questionnaires, as the financial prospects reveal it all too clearly. If the war continues for another year there will be a national debt of nearly one and a half billions of dollars, an annual budget of three hundred and fifty millions or more, and a consequently heavy taxation, of necessity, of all kinds.

With the exception of the United States and small neutral countries, other nations will be equally, if not more, burdened, and the burden will only be made tolerable by an increase in international trade, in which, however, the competition will be the keenest and most pitiless that the world has ever experienced. Each nation will organize itself for this struggle and neglect nothing that will in all likelihood promote success. Each will, accordingly, employ all the resources of the most advanced scientific knowledge in the conduct and management of its industries. The nation that fails to do so will be hopelessly handicapped in this struggle, however otherwise it may strive to avert the inevitable result. The new era, therefore, which is about to begin for Canada is one whose industrial problems are to be of such magnitude as to compel a radical recasting of all our industrial methods, and, above all, of the attitude of the Governments, Dominion and Provincial, on the one hand, and of those in control of the industries, on the other, regarding the claims of scientific research as an all-important factor in the promotion of industrial development.

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The state of unpreparedness in Canada for the eventualities of the coming trade struggle cannot be regarded as unique. It was characteristic of Great Britain, Australia, New Zealand, and South Africa. The Imperial Government had till three years ago neglected to make any provision for scientific research[1], except small annual grants to the Royal Society and to the National Physical Laboratory. Research was, however, carried on by private workers and by the teachers in science in the various university laboratories working under discouragements that would have daunted all but the most enthusiastic and courageous in the cause of science. Their contributions to pure science during the last thirty years constitute a just claim to international recognition as a noble achievement in idealism. But they were a class apart, and the Government and the Nation ignored what they represented and paid scant attention to the warning they gave, that the control of the basic national industries was passing into German hands. In consequence, the war found the nation unprepared and lacking in very many of the materials vitally necessary, not only for carrying it on, but also for the continuation of some of the more important industries. The shock of the revelation of the situation swept away, it is hoped, forever the traditions which made the nation, as a whole, indifferent to research as a factor in national progress and development. At once an Honorary Advisory Council for Scientific and Industrial Research was brought into being, which has for the last three years been endeavouring to foster, by every means at its command, research in pure and applied science. As a result of its efforts, a Government Department of Scientific and Industrial Research has been created which has received a parliamentary vote of £1,000,000 to be spent in aiding research in relation to the industries during the five years beginning April, 1917.[2] It would seem that the impression made on the national mind is of too deep a character to wear out, and one gets corroborative evidence of this in the latest manifesto of the Labour Party of Great Britain.[3] Some of its sentences are significant:—

> . . . . "Especially in all the complexities of politics, in the still undeveloped Science of Society the Labour Party stands for increased study, for the scientific investigation of each succeeding problem, for the deliberate organization of research and for a much more rapid dissemination among the whole people of all the science that exists. . . . An autocratic Sultan may govern without science if his whim is law. A Plutocratic Party may choose to ignore science if it is heedless whether its pretended solutions of social problems, that may win political triumphs, succeed or fail. But no Labour Party can hope to maintain its position unless its proposals are, in fact, the outcome of the best political science of its time; or to fulfil its purpose unless that science is continually wresting new fields from human ignorance. . . If law is the mother of freedom, science to the Labour Party must be the parent of law."

All classes are behind the new movement and it is evident that a new era has dawned in Great Britain, an era in which scientific research will be promoted with all the ardor and energy the nation can put into a continued effort to repair the effects of the gigantic mistake of neglecting science during the last forty years. The lesson taught has been also heeded by Australia and South Africa, and their Governments have early followed the example of the Imperial Government by instituting Research Councils. That of the Commonwealth has proposed the establishment of an Institute of Science and Industry in which will centre all the directive forces of the new movement for science. In New Zealand efforts are being made to bring about the establishment

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1 For a critical representation of the attitude of the nation and the Government towards science, see "Neglect of Science," giving the proceedings of a conference of the leading scientific men of Great Britain, held on May 3, 1916. Published by Harrison & Sons, St. Martin's Lane, London.

2 The Department receives also an annual vote from Parliament which for 1918-9 exceeds £200,000.

3 "Labour and New Social Order. A Draft Report on Reconstruction." The Labour Party, 1 Victoria street, London, S.W. (Published January 1, 1918.)

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of an organization which will function more or less like a Research Council. Everywhere throughout the Empire there has occurred, in regard to the attitude of the State towards scientific research, a complete break with the past.

The neglect of science in Great Britain was due to a monopoly exercised by the old learning in all the educational and political circles, supported by individualism and the cult of the laissez-faire principle, the result of the traditions of five hundred years of history. The monopoly had its effect on the industrial classes and resulted there in a contempt for what was known as scientific as contrasted with what was called practical. In Canada, as in the other British Dominions, this attitude towards science had its origin, in large part, in the same traditions. Our educational system is still almost wholly literary, and, in consequence, the directive force of public opinion is very largely influenced by the traditions that hampered progress in science in Great Britain.

It was perhaps natural that it should be so. In the earlier days of our history, from fifty to one hundred years ago, modern science was as yet undeveloped or in its evolutionary stage, and the Universities and higher educational institutions of to-day which were then founded were devoted almost wholly to literary learning, from the dominant influence of which they are by no means as yet free. Science in Canada has, therefore, not come into all her own in the academic world. The work of the eighteen Universities is still in the main along lines outside science. Their Departments of Science, pure or applied, are of comparatively recent origin and the majority of them, it must be said, are very inadequately maintained. Not one of the four or five Faculties of Applied Science is older than forty years, and though several of these have done excellent service so far as their staffs and equipment go, they have been unable to compete in achievement with institutions like the Massachusetts Institute of Technology and other equally equipped Technical Institutions, whose services to industrial science in the United States have been of enormous value. They do not get the financial support that is extended to any of the six or seven best American technical schools. The annual budget of the Massachusetts Institute of Technology exceeds the total of the annual expenditures of all the Faculties of Applied Science in Canada.

The apathy regarding the claims for greater assistance for Applied Science Faculties is due to the fact that public opinion in Canada has not been educated to the point of conceding the principle that science, pure and applied, is quite as vital a concern of the State as is national safety. In consequence, the support of science has hitherto depended in great part on private generosity, which is now heavily taxed for other objects. A continuation of this laissez-faire policy is impossible, for to-day Canada faces an immediate future in which efficiency in science and scientific research must be attained or its industries will be enormously handicapped in the competition with their rivals abroad, who are even now relying for success in this contest on the resources that the most advanced expert knowledge and research are placing, and will place, at their disposal. The State can no longer disregard the claims of science nor can its industries be indifferent thereto.

There are industries in Canada on which the blight of apathy or indifference has not yet fallen. The managements and the directorates of such are conscious of the urgency of the measures that must be taken to meet the issue pending. The capital involved in each is, however, small, and, as research is expensive, they are not, individually, in a position to undertake it, or if they do so, it cannot be on such a scale that will guarantee successful results. For these the outlook is not encouraging unless they combine their resources for a common effort to meet the expenditures required. These industries could enroll themselves in American Associations formed for the purpose of solving their problems by research. Some have indeed already done so. The American Canners' Association, which supports a research laboratory with an annual budget of about $35,000, lists in its members a number of Canadian Canning Companies.

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Such a co-operation may be unobjectionable, and, indeed, is in some cases desirable. There are no international boundaries in Science, and the research problems which must be solved in the development of the industries ignore geographical limitations. But there are reasons why this co-operation cannot be erected into a general system. Some of these concern a cast of psychology inscrutable in the ultimate, if you will, but, nevertheless, potent in directing a policy on this question. Our people could not ultimately be brought to approve of any proposal, however luring it might appear to them, if also its acceptance involved an effacement of the pride and independence that nationality essentially predicates.

The Canadian industries must, therefore, constitute organizations of their own if they are to contribute to the solution of their own industrial research problems. This may be done by following the plan formulated by the British Advisory Council and adopted by the Department of Scientific and Industrial Research. By this the Firms in a particular line of industry are encouraged to form trade associations for research, which will periodically survey the conditions in their respective industries, determine what problems require investigation and initiate researches thereon. The funds for this purpose will be derived by a levy on, or subscription from, the Firms, and, if these are not sufficient, assistance may be given for a period of years by the Department, derived from the grant of £1,000,000 made by Parliament for a five-year budget for the purpose. By this method the systematic development of research and the co-operation of science with industry will be carried out under the direct control of the industries themselves. Researches may thus be undertaken which could not have been dealt with by the individual firms.

The great majority of the Canadian industries, it may be repeated, are relatively small, and, consequently, have individually not the resources required to undertake research. They are then of the status of the British industries for which trade Associations for Research are now being promoted by the Department of Science and Industry. Such Canadian industries could combine, in their respective lines, as Guilds for Research, the funds for which could be derived from assessments of the individual Firms constituting each Guild, the funds to be supplemented, when not sufficient for their objects, by grants from a special parliamentary vote for this purpose. The fund for each Guild could be expended by a committee or board appointed by the Council of the Guild, and the results of the researches obtained would be available for the benefit of each firm in its membership. The members of such guilds could be accorded other advantages as their arrangements might provide.

Such advantages as these may be suggested:—

1. The right to recommend specific problems for research, which must be passed on by the board or committee, and, if approved, carried out without cost to the Firm recommending that the research be undertaken.

2. The right to a periodical service of information for the purpose of keeping it in touch with all the technical developments in this industry, even to the extent of receiving copies of articles, translated if originally in a foreign language, bearing on any subject concerned in the industry. This would cover also answers to technical questions which a Firm may propose.

3. The right to the use of all patented or secret processes which may result from the researches undertaken by, or at the expense of, the Guild.

Other rights or privileges may be guaranteed by stipulation in order to suit the circumstances or situation in any particular industry. Firms in an industry, not members of its Guild, would be excluded from all these privileges, and, especially from the use of all Patents granted to the Guild on any process resulting from a research conducted at the expense of the general fund of the Guild. Information as to secret processes would also be denied to them.

There are a number of trade associations in Canada, which may be constituted into Guilds for Research such as the Tanners' Association, the Textile Association, the

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Pulp and Paper Association, the Clay Products Association, etc. Whether they can be induced to do so must depend on their capacity to meet the new conditions and on the recognition of the value of science and research in helping them to a sure foothold in home and foreign markets.

How far aid should be extended to such Guilds must be determined by the conditions attendant upon each line of industry. Ordinarily, when given it should not, except under special circumstances, be in a direct form but in such a way as to stimulate to the utmost private effort and enterprise in industrial research. If a Guild were provided with ample resources of its own for this purpose, it would be in a position to provide its own laboratories and maintain them and a staff for research to the extent required. For Guilds less well circumstanced such establishments are impossible, for the erection and equipment of small independent laboratories will be beyond their means. To reduce the burden to such and to enable them to concentrate their resources on their necessary researches, it would be advisable for the State to provide them room accommodation in a large laboratory with free light, heat, and, where necessary, motive power, and in which they could place research staffs maintained by them. Relieved thus of the initial cost of laboratory construction and of the expense of the maintenance of the laboratory rooms, each Guild could devote all its funds for research to the solution of its immediate and urgent industrial problems.

Such a system of Guilds directing their energies to research for the purpose of improving their manufacturing processes and thereby increasing Canadian trade would justify the State taking the initial expenditure and meeting the slight annual charges for maintenance. A dozen or more such Guilds would, thus recognized and assisted, transform in the end the spirit of enterprise of Canadian industry. It would lead all lines of industry to follow the example thus set and at least enable them to hold their own in the time of stress that is approaching.

A laboratory establishment of this kind has its existing exemplification in the Mellon Institute at Pittsburgh, founded and endowed by the Mellon Brothers in 1911, and placed under the management of a staff of directors. This Institute has already shown that it is of great service to individual industries which have availed themselves of the privileges it offers. Several of them have enormously benefited thereby, one, the American Bread Company, as a result of a research so instituted and supported, having already reduced the cost of one of its departments by a sum more than equivalent to the cost and equipment of the Institute. It is, indeed, not at all improbable that other establishments like the Mellon Institute may be established at different points in the United States in the near future.

Such a laboratory establishment, founded for the use of Guilds by the Government, could be most economically administered in connection with a Central Institute for Research. The staff of such an Institute, in addition to the duties it would have of directing and carrying on research in its own proper sphere, would serve in an advisory capacity to the investigating staffs appointed by the Guilds to investigate their own problems. Further, with common heating and lighting equipments, the overhead expenses for such a united Research Institute and Guilds Laboratories would be reduced to the minimum possible.

The question of the establishment in Canada of a Central Research Institute has been discussed by the Research Council at great length at its meetings for the last nine months and all aspects of it have been passed under review. The facts and considerations which tell for, as well as those which tell against, the proposal to establish such an Institute have been carefully considered and the Council has taken pains to get the views of those whose experience under other conditions makes their opinions of value, whether it be in favour of, or against, the proposal. The Chairman on several occasions in 1917 consulted, collectively and individually, the heads of the various Technical Bureaus in Washington on the subject and a majority of the members of the Council visited that city in February for the express purpose of discussing with these officials and others all the facts and views bearing on the question. On this occasion two

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séances of three hours each were held at which every phase of the subject, regarded in the light of official experience, was gone into. There is no systematized organization of these National Technical Bureaus, each of them having been instituted as the need arose, without provision having been made for its co-ordination and co-operation with those earlier established, and, in consequence, the situation cannot be described as ideal, either from the point of view of economy or as regards efficiency, although the various Bureaus have done, and are doing, signal service. It was this lack of system that was admitted, almost generally, as the cardinal defect of the Bureaus, a defect that cannot now be readily remedied and it should be provided against in Canada, according to the advice of the officials consulted.

In Washington there is a Bureau, the Bureau of Standards, of recent foundation, the function of which is to deal with standards of all kinds, of length, weight, time, mass, quality and performance, specifications of material and determination of physical contents. The departments with which it concerns itself are heat, electricity, optics, chemistry, metallurgy, ceramics, and structural engineering. The equipment is a very extensive one. The Bureau carries out tests of materials, contractors' supplies, etc., required for the various Government Departments. Very cordial co-operation exists between it and the industries which it endeavours to serve along the line of its functions. It has undertaken researches in conjunction with some of the leading Manufacturers' Associations. When an investigation undertaken for a private Firm or a Company is not likely to give results of common application to a considerable section of the public, the Firm or Company is charged with the expense incurred, but, if it may possibly lead to general public benefit, the research is carried out at public expense. The Bureau has already completed in the seventeen years of its existence a large number of researchs in pure science, the results of which have been published in Bulletins, thirteen volumes of which have already appeared. For the erection of the laboratories already completed about one million dollars have been spent and the Congressional appropriations for salaries of a staff of 700 and maintenance for the year ending June 30, 1918, total $1,073,000.

There are elsewhere organizations whose functions parallel those of the Bureau of Standards. The National Physical Laboratory at Teddington, near London, founded in 1900, and carried on in a modest way till 1914, has a staff of 500 and expends annually nearly £150,000. Besides concerning itself with standards, physical, mechanical and metallurgical of all kinds, that is, as a national testing house, it functions as a laboratory for industrial research, and in this latter role it will come into close relation with the Trade Associations for Research. In Charlottenburg, a suburb of Berlin, is situated the Physikalisch-Technische Reichs-Anstalt, which is the Bureau of Standards for Germany. Before 1912 it practically served as the testing house for all the world.

The establishment of such Bureaus is projected elsewhere. The French Government has already provided for one and the Japanese Government has undertaken the establishment of an organization which will have all the functions of an Industrial Research Institute and a Laboratory for Standards. Under the Institute for Science and Industry, as proposed by the Australian Advisory Council of Science and Industry, there will be provided National Laboratories "for special purposes of research and experimental inquiry, including a physical laboratory for testing and standardizing purposes," with which the present Government Laboratories may be co-ordinated.

There is no institution in Canada corresponding to the Bureau of Standards, nor are its functions performed by any of the laboratories of the Government Departments, although in the Mines Branch of the Department of Mines problems in metallurgy, ceramics and fuel-testing are very efficiently dealt with and in the Forest Products Laboratory connected with the Forestry Branch of the Department of the Interior special researches have been, and are being conducted on problems connected with the pulp and paper industry, from which valuable results have been obtained.

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In consideration of these facts, which are advanced to show the general agreement as to the urgency for each State to provide for organized research by the establishment of Institutes or Bureaus for Research to assist the development of the industries of each, and also because of the special need in Canada of one such, the Research Council has approved of the proposal that a Central Research Institute be established at the earliest possible date, whose function will be that of carrying on research, not only in pure science in relation to standards of measurement, quality, and composition of material, but also in science applied to the industries of Canada.

In the building which should house the Institute there should be a considerable number of laboratory units, or series of rooms, provided with free light, heat, and, where necessary, motive power, to be available for use by the various Guilds for Research formed by the Firms in the various industries to enable them at their own expense to carry on investigations with a view to improving the technical processes of such industries.

The establishment of such a Central Research Institute should be initiated on a modest scale, but on a plan which would readily admit of additions or growth without disturbance of symmetry or alteration of the basis of its constitution, or of its management.

Whether local branches of this Institute should be formed is a question which the Research Council, though it has considered the subject, is not prepared to offer a recommendation. The question also of the relation of the University laboratories to this Institute has likewise been considered, but the solution of it is not vital to the realizattion of the main proposal, and can be determined at a later stage. The need of a Central Research Institute is a pressing one, and that must come first in the order of the programme.

The work of the proposed Institute would powerfully aid the development of scientific research in Canada by stimulating the Canadian Universities to increase their resources and facilities for research, and thereby to direct into the ranks of science the ablest of their young graduates desirous of qualifying for a career whether in pure science or in science applied to Canadian industry. It would place at the service of Canadian industry a factor which would ensure its success in the strenuous international trade competition which is near at hand. It would, above all, enable the nation to direct its energies towards the economic and right utilization of its untouched stores of national wealth, in order that it may bear, with some degree of ease, in this and the next generation the almost Atlantean financial burden it is assuming as a result of its playing its part in the present world struggle.

V. ASSISTED RESEARCHES.

The Council, during the last year, received applications for grants for assistance to researches which totalled more than $80,000.

The Committee on Assisted Researches carefully considered these applications, and finally reported a number which, in its opinion, were of immediate practical importance, and which, also, were capable of being conducted to a successful issue within a reasonable period of time.

The Council adopted this report and made the grants called for. These grants are as follows:

1. The investigation of tar fog, carried out by the Council employing Dr. J. G. Davidson, Professor of Physics in the University of British Columbia—$5,000.

2. The utilization of the waste straw for the production of gas for heating and lighting farm houses, by Professor R. D. MacLaurin of the University of Saskatchewan, and Mr. Harrison of Moosejaw—$1,500.

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3. An investigation regarding the transmission of sound with a view to improving methods of fog signalling, by Professor L. V. King, Physics Department, of McGill University—$600.

4. A study of Canadian waste tobacco with a view of preparing nicotine sulphate, under Dr. R. F. Ruttan, carried out by Mr. A. D. Hone—$500.

5. The determination of vapours in gases under Professor Parker of Manitoba University, carried out by Dr. H. S. Davis with assistance—$1,000.

6. Possible uses of the tar sands of Alberta, under President Tory of the University of Alberta, with the assistance of the members of his staff and associated engineers—Amount of grant undetermined.

7. Experiments on the application of the principle of flotation to new economic ores, in charge of Prof. J. B. Porter—$700.

8. The amount and character of the sugar in sulphite liquor waste, carried out by Dr. V. J. Krieble, under Dr. R. F. Ruttan—$200.

9. The genetics of wheat, carried out by Professor W. P. Thompson of the University of Saswatchewan—$2,000.

10. The reduction of low grade ores by means of gas at a comparatively low temperature, under Dr. A. Stansfield, Professor of Metallurgy, McGill University—$2,500.

Detailed Specifications of the Assisted Researches.

1. *Tar Fog Recovery.*—The Council, recognizing the national importance of conserving economically the products of destructive distillation of wood, coal, and the liquid products produced during the manufacture of producer gas, etc., engaged Dr. J. G. Davidson, of the University of British Columbia, to make investigations on a commercial scale.

The principle was the application of the Cottrell precipitation process to the recovery of the heavy liquid and solid matter passing over in the hot gases resulting from distillation. Preliminary experiments had shown Dr. Davidson that a very effective separation of the heavy materials from water and gas could be effected by the electrical discharge in the Cottrell system. A plant on a commercial scale was established at Sault Ste. Marie, in connection with the coke works in that centre. Numerous difficulties developed in the course of the experiments owing to the clogging of the pipes by tar, and the short circuiting of the system brought about by carbon particles. Great delay also occurred owing to the difficulty of obtaining machinery and equipment. Dr. Davidson was required to pick up one by one and assemble the portions of several of the units required.

The plant was assembled at the beginning of December, 1917, and in April, 1918, the major difficulties of working on a large scale had been overcome, and the process demonstrated that a great saving could be effected in recovering the products of the destructive distillation of wood and tar, as these can be separated from steam and gas at a high temperature so that subsequent evaporation and treatment of the water mixture were avoided.

This process will probably be utilized by several of the distillation plants in Canada in the near future. Dr. Davidson intends to make his interest in this process in some way a public asset when it is developed. The installation and power costs of this process are low and the action has been shown to be very effective.

2. *Straw Gas.*—Some plan for the utilization of the thousands of tons of straw which are annually burned in the Prairie Provinces appealed to the Council as being one of national importance.

Prof. R. D. MacLaurin, of the University of Saskatchewan, and Mr. Harrison, of Moosejaw, have carried out some experiments which resulted in the development of a

form of retort which enabled them to distil the compressed straw and obtain from it a large yield of gas of high heating powers and a residue of carbon which could be used as fuel and for other purposes. With a view of developing this process on a commercial scale and demonstrating to the farmers of the Western Plains a method of utilizing their waste straw, a grant was made to these gentlemen to continue their research on a larger scale. This grant was given to enable them to obtain material and construct two or three retorts, one of which was to be erected at or near the University of Saskatchewan, where very accurate records of the conditions of combustion of the straw could be made, and one or two installed in farm houses, with full equipment necessary for heating and lighting them. This investigation and demonstration is now under way, but has been seriously delayed owing to the great difficulty in obtaining the materials and castings required for the retorts. It is expected by this to demonstrate that retorts and distilling apparatus of very simple design and automatic in operation can be supplied to the farmers at a cost of about $500.

3. *Fog Signals.*—A grant was made to Prof. L. V. King of McGill University, to enable him to employ and obtain apparatus to develop the efficiency of fog signalling apparatus. The work was conducted in co-operation with the Department of Naval Service and with the assistance of some experts from American Universities and from Washington, chiefly at Father Point, Quebec.

The objects of the experiments were to investigate the construction and testing of an apparatus from the direct measurement of the intensity of sound waves generated by powerful sirens, to determine the nature of the large energy loss in the development of sound, and thus to compare the efficiency of the various types of fog horns and sirens used for signalling purposes in the St. Lawrence River and the Gulf.

To sum up the results achieved by the tests referred to above, it may be stated that methods of measuring sound quantitatively and qualitatively have been developed and tested in practice. The acoustic characteristics of a siren may now be determined with fair accuracy in absolute measure, whereas, previous to these experiments, an almost complete ignorance existed on these points. Measurements of the intensity of the master tone may now be carried out at distances of several miles and the influence of meteorological conditions on the propogation of sound may be studied in the light of accurate data. These achievements conclude an important chapter in practical acoustic engineering.

(A synopsis of the work accomplished will appear in the form of a Bulletin in the month of April.)

4. *Nicotine from Waste Tobacco.*—Dr. Hewitt, Dominion Entomologist, called the attention of the Research Council to the very high cost of the most valuable insecticide for certain shrubs and fruit trees, namely, nicotine sulphate. This could only be obtained from Kentucky, and cost the Canadian fruit growers $1.25 per pound. He asked whether it would be possible to obtain a sufficient supply from the waste tobacco of Canada. In 1916, over 2,000,000 pounds of tobacco waste of various kinds were produced in Canada, this waste tobacco then selling at ¾ cent to 1¼ cents per pound.

The Council asked Dr. Ruttan to obtain some one to ascertain whether the waste stems and leaves of the various tobacco factories in Canada could be utilized for the production of this valuable alkaloid. This investigation was carried on by Mr. Arthur D. Hone in the laboratories of the University of Toronto. A determination was made of the nicotine from the soaking of the leaves in the factory, and also of the various wastes in the form of stems, dust, etc. It was found that the stems of Canadian tobacco gave about 2·4 per cent of the alkaloid, and a good yield was also obtained from the dust and scraps. It was demonstrated that, at the current price, nicotine sulphate could be economically manufactured from Canadian refuse. The research

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was carried further with a view of determining the most economical method of extraction. These waste materials were found to contain, in addition, a very high percentage of potash; quite sufficient of this valuable chemical to justify its extraction, approximately 7 per cent was found in the leaves and stems. The research was begun in the summer of 1917, and practically completed in March, 1918. The full report is now in process of preparation by Mr. Hone and Dr. Ruttan. Owing to the enormously enhanced value of tobacco waste, since the research was undertaken, it is questionable whether the utilization of the important results of this investigation can be undertaken until after the war.

5. *Determination of Vapours in Gases.*—A research was undertaken by Dr. Harold S. Davis, assisted by Mary D. Davis and Donald C. McGregor, under the supervision of Prof. M. Parker of Manitoba University, on the detection and estimation of vapours in gases.

This research was directed towards devising a method for determining the amount of benzene and toluene vapours found in gases such as coal gas, products of distillation of wood, etc. A form of apparatus has been devised which enables a chemist to determine accurately the amount of these vapours in coal gas. The apparatus has been reproduced and has been sent to England to be used in the recovery works in the various gas plants under the Imperial Munitions Board.

Three papers have been published on the extension of this work: (1) "A new method of the quantitative estimation of vapours in gases." (2) "The estimation of benzine and total light oil content of gases." (3) "The study of the absorption of light oils from gases."

The last paper is of great value in determining the conditions necessary to obtain a maximum amount of these valuable light oils during the carbonization of coal.

The work on this research is nearly completed, but still further study is being made to determine the best possible conditions for the recovery of toluene from gases during distillation.

6. *The Tar Sands of Alberta.*—A research has been planned on the chemical and physical properties of the very large deposits of tar sands found in northern Alberta. Some preliminary work had been done in connection with these sands by Mr. S. C. Ells and some experiments were tried in Edmonton to demonstrate their value in the construction of pavement, similar to asphalt. The latter went to show that the material required very little mixing with other substances to produce a paving as durable as the best asphalt. It was deemed advisable to make more thorough study of the chemical composition of the tar itself as well as to investigate the best methods of extracting the tar commercially and the preparation of road materials and other commercial products from the tar of the raw material.

President Tory has undertaken the organization of a number of members of the staff of the University of Alberta with other engineers and chemists to make a thorough technical investigation of the value of these tar sands. Owing to President Tory being called to Europe, little progress has so far been made in this organization, but, under Professor A. F. L. Lehmann and Mr. W. F. Seyer, considerable advance has been made in ascertaining the chemical composition and products resulting from the distillation of these tars. Certain pieces of apparatus and machinery have been gathered this winter for a thorough study of this problem, and arrangements have been made for the delivery of a large quantity of the tar sand in Edmonton during the coming summer.

7. *Application of Flotation to New Ores.*—Under the supervision of Dr. Porter and Dr. Bell, of McGill University, a study is being made of the relative value of Canadian oils and imported oils for the flotation of ores and also of the application of the flotation process to Canadian ores not being at present satisfactorily treated by this process

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The grant was made to enable Professors Porter and Bell to obtain the materials required and the services of Mr. J. M. Scott to make the control analysis.

The experiments carried on so far have been with a view of comparing the value of certain waste oils obtained during the distillation of Canadian woods with those now imported into the country. The flotation process, using Canadian oils, has been applied to copper ores from the Bruce Mines, zinc ores from Notre Dame des Anges, and to several ores from British Columbia which have not hitherto been treated by the flotation process. The complete results have not as yet been reported.

8. *The Sugars in Canadian Waste Sulphite Liquors.*—A research on the composition of sulphite liquor waste with a view of obtaining from it ethyl alcohol and other commercial products was undertaken, under the direction of Dr. R. F. Ruttan, by Dr. V. J. Krieble.

Several of the sulphite pulp mills, on the suggestion of the Associate Chemistry Committee of the Council, contemplated the production of ethyl alcohol from sulphite liquor waste by fermenting the fermentable sugars which are found in this waste liquor. This process has been carried on commercially in Sweden for a number of years, and has recently been undertaken in Mechanicsville, N.Y.

It was necessary, as a fundamental study, to determine whether the sulphite liquor waste, produced from Canadian woods by the processes employed in our pulp mills, would yield the required amount of fermentable sugar, and, secondly, whether the process in these mills could be so modified as to increase the amount of fermentable sugars, if alcohol plants were established.

Dr. Krieble is also studying the variety of yeast which will yield the largest amount of alcohol from our Canadian waste liquors, the various forms of sugar which are found in these wastes and the percentage available for conversion into alcohol. The research is nearly completed, and it has been found that the sulphite liquors from three of the five mills studied gave a better yield of fermentable sugar than is obtained at the Mechanicsville plant.

It is thus established that the waste liquors of our sulphite mills can be economically used for the manufacture of alcohol, and two of the largest Firms concerned are now negotiating with the Imperial Munitions Board and with the holders of the patents with a view of establishing an alcohol plant in the immediate future.

9. *The Genetics of Wheat.*—A grant has recently been voted to Prof. W. P. Thompson, of Saskatoon, to enable him to obtain the assistance necessary to develop a variety of wheat which will mature at an early period in the season, and which will be rust-resisting. In the opinion of experts, the method proposed by Mr. Thompson is very likely to yield results of great value to wheat growers of the Northwest.

The research is now in progress.

10. *Reduction of Low Grade Iron Ores.*—Another research has been recently undertaken by Prof. A. Stansfield, professor of metallurgy at McGill University, to carry out, on a semi-commercial scale, experiments on the reduction of low grade iron ores, which abound in Canada, by means of reducing gases at a comparatively low temperature, with the idea that the final fusion and reduction can be carried out in small electrical smelters at a number of localities in the country.

This research has not yet begun, but will be taken up during the coming summer.

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APPENDIX A.

SUMMARY OF THE ACTIVITIES OF THE ASSOCIATE COMMITTEE ON CHEMISTRY FOR THE YEAR ENDING MAY 1, 1918.

REPORT OF PROF. R. F. RUTTAN, CHAIRMAN.

The Committee was organized by the Council at the August meeting, 1917. Two reports of progress have been transmitted to the members of the Committee by the Chairman. In these reports were outlined the main chemical problems which had been brought to the notice of the Council, either by special letter or arising out of the questionnaire which had been distributed during the summer. The members were informed regarding studentships and fellowships, assisted researches, and the enactments of the Department of Militia and Defence regarding the exemption of technologists. Among the more important questions studied by the committee were:

1. *The Production of Potassium Salts in Canada, and the Possibility of Increasing the Output.*—Enquiries were sent to the various members of the committee and a very complete synopsis of the literature of the subject was obtained. It was found that Mr. B. C. Emslie of the Division of Chemistry, Department of Agriculture, had studied the production of potash fertilizer from the kelp and rockwood at Clark Harbour, and obtained very encouraging results.

The report of Mr. A. T. Cameron on the commercial value of the kelp beds of the Pacific Coast estimated that these beds could supply alone more potash than is used at the present time in Canada, and recommended the establishment of a plant. The committee was unable to find that any of the processes for obtaining potash from potash feldspar was being carried on in a large commercial scale, but that several preliminary investigations were under way in Ontario and elsewhere to find a commercial process.

A commercial process for obtaining potash from feldspar and from the glauconite of the green sands of New Jersey has been established, but the by-product, which is a brick of very great value, is more important than the potash, so the process employed is used for the production of high grade brick with 4 per cent. to 6 per cent. of potash as a by-product.

It was found that the ash from the soft woods of British Columbia and from straw did not yield potash in commercial quantities. The condensation of the vapours and dust from cement works has been a profitable source of potash in the United States. One of the larger cement works in Canada is now introducing the Cottrell process for the recovery of this by-product in cement making. There is little doubt but the dust from other cement plants might be economically recovered. This waste dust should be analyzed in all cement plants.

It was found that a considerable amount of potash is being made in Canada from hardwood ashes, a revival of the old industry, and in the larger cities these hardwood ashes are being collected and leached.

A certain amount is also produced, as for instance in New Toronto, from garbage, and also from the waste liquor from sugar works, e.g., the Dominion Sugar Company in Chatham.

The Geological Survey report that as yet they have not been able to find any salt lakes or other deposits of potash salts sufficiently rich to justify their use as a source of this chemical.

The deposits of alunite in Canada are so limited that they have not been seriously considered, although this mineral is worked in the United States.

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The rock known as nephelin syenite, found in the vicinity of Bancroft, Ont., which carries 4 per cent. to 5½ per cent. of potash, is being investigated with a view of obtaining a potash fertilizer, which will relieve the present shortage in the market.

Every encouragement has been offered to those who are investigating methods for obtaining potash salts from feldspar. Some seven or eight processes have been suggested, which, though feasible on a laboratory scale, were found not to be commercially profitable methods. The solution of this problem, so important in Canada, will be accomplished when a simple method of decomposing the mineral is found which gives, besides the potash, a valuable by-product of wide utility.

2. *Fish Waste.*—The Committee recognizing the great demand and necessity for an increased supply of fertilizers has been making a study of the availability of the fish waste on the Atlantic and Pacific Coasts as a source of nitrogenous and phosphate fertilizer, and also of protein food for cattle, hogs, and poultry.

The fish waste in Canada amounts to over 300,000 tons per annum, but probably not more than half of this would be available for conversion.

The data collected by Dr. McIntosh on the Pacific Coast, Mr. Mackie in Cape Breton, and more especially the valuable information obtained from Mr. J. B. Feilding, led the committee to recommend to the Council that a port survey should be made of the two coasts to ascertain the total quantiy of waste available, the amount that could be economically collected at each point, the fluctuations in the catch throughout the year, and the availability of fish of no present marketable value, such as dog fish. Fish waste is now manufactured into food stuff and fertilizer in California and Washington, very profitably. It has been shown in Sweden and in Germany that a valuable concentrated protein food for cattle can be procured from this waste, and the possibilities of preparing such in Canada are being investigated. With the present prices of protein at $2 per unit, and ammonia at $6.40, the undertaking should be a very profitable one.

The oil, even in a crude form, which can be obtained from this waste, is also a valuable asset to the industry.

The Committee has obtained plans and prices of several forms of apparatus now employed for the purpose of converting this waste into a marketable product and Mr. Feilding is making a preliminary port survey of the Maritime Provinces on behalf of the Council.

3. *Industrial Alcohol from Wood Waste.*—The Imperial Munitions Board in November last called the attention of the Research Council to the desirability of stimulating the production of ethyl alcohol from other sources than grain.

There are three recognized sources of ethyl alcohol from materials which are not foods, two of which might be profitably worked in Canada, namely, the utilization of wood waste and the fermentation of the sugar found in the sulphite liquor waste. The third and most profitable source of industrial alcohol, namely, the waste molasses from crude sugar, is not available in Canada.

Your Committee has been in consultation with Mr. George H. Tomlinson, who is a pioneer in the hydrolysis of sawdust and other wood waste and their conversion into ethyl alcohol.

A company was formed with a view of establishing a plant in Ottawa to manufacture alcohol from waste sawdust. This project is now being seriously considered by several of the large mill owners in the Ottawa district. It is necessary to obtain about 300 to 500 tons of wet sawdust per day in one locality to make the process commercial, and this should be delivered at a cost of a little more than 50 cents to 75 cents per ton to the converters; 300 tons of moist sawdust will yield about 60,000 pounds of glucose, or about 30,000 pounds of alcohol per day. This alcohol is now produced in the United States at cost of about 30 cents to 40 cents per gallon of 95 per cent strength. The objection urged against the establishment of a plant of this sort in Eastern Canada is the shortness of the season and the cost of the raw material. This objection does not hold true for British Columbia, where enquiry

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has shown that from 300 to 400 tons of sawdust per day can be secured at or near New Westminster for twelve months in the year.

There seems every prospect of the establishment in the immediate future of an alcohol industry from waste wood in British Columbia.

4. *Industrial Alcohol from Sulphite Liquor Waste.*—Very considerable progress has been made towards establishing industries in Canada for the utilization of the fermentable sugars in sulphite liquor waste for the manufacture of ethyl alcohol.

Dr. J. S. Bates prepared a memorandum from the literature of the character of the process and the methods employed in Sweden and in Mechanicsville, New York, for the preparation of ethyl alcohol from the sulphite liquor waste.

With the co-operation of the managers of the Laurentide Company and the Belgo-Canadian Pulp and Paper Company, Limited, careful estimates were prepared as to the cost of production of the alcohol in Canada. This report was transmitted to a number of paper mills, and at a meeting held in January last it was decided to take steps to determine definitely the cost of the works, the amount of alcohol which could be obtained, the arrangements by which the patents controlling this process could be used, and the methods now employed in the United States. A careful investigation was made of the mechanical and engineering side of the problem by the Laurentide Paper and Pulp Company, and a careful analysis of eleven samples of Canadian waste liquor was made in the laboratories of McGill University, where a study of the conditions of fermentation was also undertaken. The waste liquor of the Canadian mills gives a higher content of fermentable sugar than that found in the liquor employed in Mechanicsville.

It has been estimated that 2,000,000 pounds of alcohol can be produced at a net cost of less than 40 cents per imperial gallon of 95 per cent. alcohol from the waste liquor of two of the pulp mills of the St. Maurice valley.

A number of meetings have been held between the members of the Chemistry Committee and the managers of the pulp mills, and it seems very likely that at least two works will be established for the utilization of this noxious waste.

In addition to the manufacture of alcohol from wood waste and from sulphite liquor waste, the Committee has been asked to consider several other methods of obtaining alcohol, but none of these gave promise of being economically feasible.

5. *The Industrial Alcohol Problems.*—That ethyl alcohol can be made from wood waste and sulphite liquor economically in Canada may be considered as established.

Manufacturers are hesitating about putting capital into these developments owing to the uncertainty of the market for alcohol after the war.

The normal consumption of industrial alcohol would be more than satisfied by the production from two large pulp mills.

It is to be hoped that industries will develop to utilize industrial alcohol and that the Government will encourage them by supplying ethyl alcohol "duty free," but under control, to the larger chemical manufacturers.

At a meeting of the Chemistry Committee and representatives of the chemical industries in Canada to be held in May this problem of the utilization of industrial ethyl alcohol will be considered and recommendations thereon made to the Government.

6. *The Utilization of Scrap Leather.*—Owing to the dislocation of trade, resulting from the war, the market for leather waste of various kinds was seriously disturbed, and the Chemistry Committee made a careful investigation of the possible market for this material.

It was found that there were upwards of 2,000 tons a year of waste leather, for which there was a comparatively small market, but since the beginning of the investigation there have been works established in Canada for utilizing the more valuable varieties of waste leather, and as soon as the available raw material reaches a quantity of 5 tons daily, the Committee has been assured that a chemical plant will be established for digesting this leather and converting it into a valuable fertilizer. The

industry is now organizing with a view of securing enough raw material to justify the further development of their plan. They are at present able to take care of all scrap leather which can be pulped and made into leather board.

7. *Toluene from Sulphite Liquor.*—Dr. Bates and Mr. Keay have investigated the possibility of the manufacture of toluene from sulphite turpentine in Canada.

Crude turpentine contains about 90 per cent. cymene; one gallon of the latter yields 0·45 gallon of toluene. Removing the turpentine increases the value of the pulp.

The cymene from half the pulp produced in Canada would give 101,250 gallons of toluene, which would yield 1,470,000 pounds of tri-nitro-toluene.

It has been suggested that the conversion of cymene to toluene be carried out by the Imperial Munitions Board at Trenton. The cost of conversion is small, and it is estimated that the Imperial Munitions Board would save over $50,000 on the 100,000 gallons of toluene produced.

SPECIAL ENQUIRIES.

The Chemistry Committee, through its Chairman, has received a large number of enquiries regarding chemical matters, and others have been referred to it from the various departments of the Government. Many of these required a special search into chemical literature and several involved extensive correspondence, but upwards of one hundred inquiries have received replies. Below is a list of most of the questions submitted during the past year. This will give an idea of the diversity of subjects enquired about:—

Uses for infusorial earth,
Alcohol from wood waste,
Radioactivity of waters of British Columbia,
Synthesis of ethyl alcohol by electric discharge.
Dehydration of fruits and vegetables,
Manufacture of potash from kelp,
Inquiries from British Columbia,
Designing a lime kiln for wood fuel,
Nitrocellulose from pulp,
Cyanide in Canada,
Hydrogenation of fish oils,
Fluorspar in phosphate slag,
Gasolene from natural gas,
Disposal of garbage,
Cottrell process for potash recovery,
Value of eelgrass as fertilizer,
Manufacture of adhesives from sulphite liquor,
Vanadium from titaniferous iron ore,
Calcium chloride in Canada,
Chemical standards for steel,
Manufacture of potato starch,
Methyl chloride from natural gas,
Composition of humus.
Manufacture of potato flour,
Utilization of malt,
Ethyl alcohol from waste materials,
Propylene gas from cracked oils,
Alcohol from potatoes,
Most efficient sewage filter,
Utilization of corn broom waste,
Manufacture of acetone,
Sewall gas generator,
Tannin in pulp-wood bark,
A glue that will withstand alcohol,
Ammonia in peat,
Briquettes from straw,
Lampblack from natural gas,
Value of methyl-ethyl-ketone,
Effect of retting flax on the water of streams,
Manufacture of rare chemicals,
Manufacture of toluene from benzene,
Value of slag as fertilizer,
Manufacture of dimethyl aniline and diphenylamine,
Manufacture of sodium bichromate,
Glue for book binding,
Value of potato dextrin,
Possible chemicals from wood waste,
Use of waste materials in canning apples,
Yeast food for human consumption,
Manufacture of gypsum products,
Uses for magnesium lime,
Value of chemicals in leather tanning,
Relative digestibility of whole wheat and white bread.
Cost of coke ovens,
Manufacture of tin oxide,
Value of nitre cake and uses,
Grauel's process for potash from feldspar,
Aluminium from clay,
Alcohol from wood waste,
Ammonium salts in Canada,
Manufacture of paraldehyde,
Carbon tetrachloride as fire extinguisher,
Ferrosilicon from white quartzite,
Value of Western natural gas for gasolene,
Alcohol from sulphite liquor,
Recovery of tin from tin plate,
Utilization of waste lumber,
Electrical distillation of wood,
Distillation of sawdust before burning,
Enamelling of cement,
Value of "Oakoal" as fuel,
Manufacture of sulphuric acid,
Using iron as a catalyst,
Manufacture of and value of wheat starch,
Potash from feldspar using hydrofluoric acid,
Potash from molasses waste,
Dextrin for bound papers,
Manufacture of rice starch,
Value of small units for wood distillation,
Process patents in Canada,
Acid-resisting varnishes,
Drying potatoes,
Platinum in Canada.

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APPENDIX B.

LIST OF STUDENTS AND FELLOWS.

FELLOWSHIPS.

Name.	Where Held.	Subject of Research.
O. J. Walker.....	Chemical Laboratory, University of Saskatchewan.	Products of destructive distillation of straw and their properties. Value and use of the carbon residue as fertilizer and as fuel.
Geo. H. Henderson.....	Physics Department, McGill University.	Thermal conductivity of gases at different temperatures.
W. F. Seyer.....	Chemical Laboratory, Uuiversity of Alberta.	Constituents of the bitumen of the tar sands of Northern Alberta.

STUDENTSHIPS.

Name.	Where Held.	Subject of Research.
W. H. Hatcher.....	Chemical Laboratory, McGill University.	Study of the halogen and hydroxy derivatives of acetylene.
R. J. Clark.....	Physics Department, McGill University.	Investigation of the coefficient of viscosity of different gases at various temperatures.
O. J. Bridgeman.....	Chemical Laboratory, University of Saskatchewan.	The thermosynthesis of higher hydrocarbons from natural gas.
Richard Hamer..... ...	Physics Department, University of Toronto.	Research on rubber colloids.
H. J. C. Ireton..... ...	Physics Department, University of Toronto	*Short wave length radiation and its relation to atomic structure.
J. F. T. Young.....	Physics Department, University of Toronto.	*Short wave length phenomena and their relation to atomic structure.

* Work was not commenced, as both of these students enlisted in the Canadian Naval Service immediately after Studentships were awarded.

APPENDIX C.

GENERAL REGULATIONS COVERING THE AWARD FOR 1918 OF THE STUDENTSHIPS AND FELLOWSHIPS.

A.—Regulations Governing Studentships.

1. These studentships are intended, not to facilitate attendance on ordinary collegiate studies, but to enable students, who have passed through a college curriculum and have given distinct evidence of capacity for original research, to continue the prosecution of science with the view to aiding its advance or its application to the industries of the country. These studentships are open to men and women.

2. The studentships are each of the value of $750 for each year of tenure. The continuation of the studentship for a second year is dependent on the work done in the first year being satisfactory to the Advisory Council.

3. Application for a studentship must be made by the candidate to the Advisory Council. He shall, with his application, submit a complete record of his academic career and recommendations from the President of his University or Institution, the Head of the department with which he was connected, and the Professor or Instructor under whom he worked. He shall state the institution at which he prefers to study, and the general line of work to be followed. The application will be considered and decided upon by the Advisory Council or by a special committee appointed by the same.

4. The candidates must be British subjects, resident in Canada or graduates of Canadian Universities, and must be between the ages of twenty and thirty-two years.

5. A candidate must (1) be a bona fide graduate of a University or College in which special attention is given to scientific study, or (2) have received an equivalent training in an institution possessing adequate facilities of a scientific character for providing such training.

6. The departments of science in which capacity for research will be accepted as qualifying for a studentship are: biology (economic), chemistry, engineering, geology, metallurgy, mineralogy, and physics.

7. The candidate must indicate high promise of capacity for advancing science or its application by original research. Evidence of this capacity is strictly required, this being the main qualification for a studentship. The most suitable evidence is a satisfactory account of a research already performed.

8. Studentships may be held at any Canadian University or Institution approved by the Advisory Council during the first year, but the research may, during the second year, be carried on in some scientific laboratory or works.

9. The principal work of the holder of a studentship must be a research in some branch of science, the extension of which is important to the national industries.

10. Students are required to devote themselves for a period of at least nine months of each year wholly to the objects of the studentships, and are forbidden to hold any position of emolument or to engage in teaching.

11. Students are required to furnish reports of their work at the end of each half year of the tenure of their studentships. At the expiration of each year of studentship the reports of the student are referred to an authority on the subject treated, who furnishes an opinion thereon to the Advisory Council.

12. The studentship stipend is payable in two equal instalments, on September 15 and February 1.

B.—Regulation Regarding Research Fellowships.

1. The research fellowships are of the value of $1,000 for the first year, and of $1,200 for the second year if the Advisory Council should decide to extend the fellowship over two years.

2. Fellowships are only awarded to those who, either through previous tenure of a studentship, or otherwise, have shown a high capacity for research on some problem the extension of which is of importance to the national industries of Canada.

3. Applications for fellowships should be made in a manner similar to those for studentships.

APPENDIX D.

REGULATIONS GOVERNING THE AWARD OF GRANTS FOR RESEARCH.

1. The recommending of the giving or refusing of grants by the Advisory Council shall be in the hands of a Committee of three members of the Council to be known as the Committee on Assisted Researches. This Committee may utilize the advice and assistance of any persons inside or outside the Council who, in their judgment, may be of value in any application under consideration.

2. The applicant must give a brief statement of the proposed investigation, its scope. time required, results hoped for, total cost, grant asked, specific purpose to which grant applied for is to be put, evidence of ability to carry on the investigation, concise statement of adequacy of general equipment of laboratory where investigation is to be carried on. If the applicant has asked for or is receiving a grant from any other body, he must state this fact in his application.

3. Grants will, as a general rule, only be made to persons who are conducting investigations in established laboratories which possess the fundamental apparatus and facilities necessary for research of the nature proposed, and where the ordinary overhead charges are already provided for, and will not be made for the purchase of standard apparatus which a well-equipped laboratory should possess.

4. Grants made are to be for requirements for one year only, but further grants may be made annually.

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5. Grants will be made only to persons who can show capacity for independent research, and who have a reputation for trustworthiness and responsibility.

6. Grants are to be made only for the actual expenses of investigation, but may be used in whole or in part for the payment of assistants, and are not intended to support the grantee while carrying out the investigation.

7. When a grant has been made for a specific purpose, it must be used for that purpose only. If the grantee desires to change in any manner the subject of his investigation he must make application to have the grant made available for the altered investigation.

8. All apparatus and materials purchased with grants are to be regarded as the property of the Advisory Council, and when the investigation is concluded are to be subject to the disposition of the Council.

9. A report of progress is to be made annually by the grantee, or whenever called for, and, in every case, on the completion or conclusion of the investigation.

10. The grantee shall render annually, or whenever called upon, an itemized account of his expenditure, with vouchers. Such account shall also be made on the completion or conclusion of the investigation, and the balance of the grant required shall be paid over to the Advisory Council.

11. The grantee shall present a complete copy of the results of his investigation. before its publication, to the Advisory Council, who shall have the right of publishing it under their own auspices. When the grantee publishes his research, he shall make due acknowledgment of the assistance received from the Council.

12. The Council will give careful consideration to every application, but will not assign reasons for refusing to make grants applied for.

APPENDIX E.

REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL, APPROVED BY HIS ROYAL HIGHNESS THE GOVERNOR GENERAL ON THE 6TH JUNE, 1916.

The Committee of the Privy Council have before them a report, dated 23rd May, 1916, from the Minister of Trade and Commerce, to whom was referred a despatch from the Right Hon. A. Bonar Law, Secretary of State for the Colonies, calling attention to a scheme of scientific and industrial research for the United Kingdom, as embodied in Parliamentary Paper Cd. 8005, attached hereto, and a copy of the Order in Council approving the same.

The Minister observes that this scheme, proposed by Mr. Arthur Henderson, contemplated the appointment of a Committee of the Privy Council which should be responsible for the carrying out of the same, and a small Advisory Council resonsible to the Committee to be composed mainly of scientific men and men actually engaged in industries dependent upon scientific research. By Order in Council, 28th July, 1915, effect was given this scheme, and the Committee and Council proposed therein were appointed and their respective duties set out. The scheme was to be applied to the United Kingdom as a whole and was not intended in any way to interfere with the arrangements already made by the War Office and the Admiralty in respect to obtaining scientific assistance for the improvement of munitions of war, but was designed to establish a permanent organization for the promotion of scientific and industrial research.

The Minister observes that after this scheme had gone into operation, suggestions were made from various sources that it should be extended and made applicable to the Overseas Dominions or even to the Empire as a whole. These suggestions were approved in principle by the Committee of Council, and a memorandum was prepared intimating certain preliminary steps that might be taken to bring about gradually co-operation of effort and co-ordination of research throughout the Empire.

On the 20th January, 1916, the Minister of Munitions caused to be distributed to educational institutions in the United Kingdom a circular letter inviting co-opera-

tion in the improvement and invention of appliances for the prosecution of warfare, and copies of the same were sent to certain universities in Canada. As a result these universities have given full information on the facilities they possess for carrying on research work in respect to the specific purpose of the Minister of Munitions. They express willingness also to co-operate and assist in the work of industrial research, and are of the opinion that some department of the Government of Canada should undertake to co-ordinate and supervise this work and act as a medium of communication.

The Minister desires to point out the urgent necessity of organizing, mobilizing and encouraging the existing resources of industrial and scientific research in Canada with the purpose of utilizing waste products, discovering new processes—mechanical, chemical and metallurgical—and developing into useful adjuncts to industry and commerce the unused natural resources of Canada. At no period has the importance of such united and thorough action been so evident as since the conditions brought about by the war, when the scarcity of certain compounds and processes has caused confusion and paralysis in industries and greatly added to costs of living. Canada has educational and scientific institutions more or less well equipped for conducting this research, which have already done much along their several lines and are willing and anxious to equip themselves for doing more. There are also private, corporate and Government laboratories, more or less engaged in research work. The manufacturers are alive to the importance and absolute necessity of such work in relation to the industries of the country and are anxious to co-operate in and support it.

What seems to be immediately urgent is to have some method of co-ordination and direction which shall combine the efforts of all, along the lines for which each is best adapted and which would tend to avoid duplication and promote efficiency of action. To this end the Minister has been more or less in continuous communication and conference with representatives of the Universities, the Canadian Manufacturers' Association and the scientific institutions. The consideration thus given has resulted in a practically unanimous agreement both as to the necessity of immediate action and as to the lines along which it should be taken.

The Minister, therefore, recommends the appointment of a Committee of Council to consist of the Minister of Trade and Commerce, the Minister of the Interior, the Minister of Mines, the Minister of Inland Revenue, the Minister of Labour, and the Minister of Agriculture, which shall be charged with, and responsible for, the expenditure of any moneys provided by Parliament for scientific and industrial research, and also an Honorary Advisory Committee, responsible to the Committee of Council, to be composed of nine members, representative of the scientific and industrial interests of Canada, who shall be charged with the following duties:—

(*a*) To consult with all responsible bodies and persons carrying on scientific and industrial research work in Canada with a view to bringing about united effort and mutual co-operation in solving the various problems and industrial research which from time to time present themselves;

(*b*) To co-ordinate as far as possible the work so carried on so as to avoid overlapping of effort, and to direct the various problems requiring solution into the hands of those whose equipment and ability are best adapted thereto;

(*c*) To select the most practical and pressing problems indicated by industrial necessities and present them when approved by the Committee to the research bodies for earliest possible solution;

(*d*) To report from time to time the progress and results of their work to the Minister of Trade and Commerce as Chairman of the Committee of Council.

That a competent Secretary be appointed on the nomination of the Committee and paid by the Department of Trade and Commerce.

That the travelling expenses of the Committee shall be paid by the Department of Trade and Commerce.

The Committee concur in the foregoing and submit the same for approval.

RODOLPHE BOUDREAU,
Clerk of the Privy Council.

OTTAWA, June 28, 1919.

The Right Hon. Sir GEORGE E. FOSTER, P.C., G.C.M.G.,
Chairman of the Sub-Committee of the Privy Council for
Scientific and Industrial Research, Ottawa.

SIR,—I have the honour of presenting to you my report on the work of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1919, as required by the terms of the Act (7-8 George V, Chap. 20) constituting the Council.

I have the honour to be,

Your obedient servant,

A. B. MACALLUM,

Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research.

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THE SUB-COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

The Right Honourable Sir GEORGE E. FOSTER, P.C., G.C.M.G., *Minister of Trade and Commerce, Chairman.*

The Honourable ARTHUR MEIGHEN, K.C., *Minister of the Interior.*

The Honourable T. A. CRERAR, *Minister of Agriculture.*

The Honourable MARTIN BURRELL, *Secretary of State and Minister of Mines.*

The Honourable G. D. ROBERTSON, *Minister of Labour.*

The Honourable L. A. SIFTON, *Minister of Customs and Inland Revenue.*

THE HONORARY ADVISORY COUNCIL.

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Honorary Recording Secretary: J. B. CHALLIES, C.E. (Tor.), M.E.I.C., Superintendent, Dominion Water Power Branch, Ottawa.

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MEMBERS OF THE ASSOCIATE COMMITTEE OF CHEMISTS FOR THE YEAR 1918-19.

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THE BRITISH COLUMBIA HONORARY ADVISORY COMMITTEE.

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E. A. BOTT, M.A., Ph.D., Lecturer in Psychology in the University of Toronto, Instructor in the Military School of Orthopædic Surgery and Physiotherapy, Toronto.

Prof. D. FRASER HARRIS, Sc.D., M.D., Department of Physiology, Dalhousie University, Halifax, N.S.

Prof. A. P. KNIGHT, M.A., M.D., Department of Physiology, Queen's University, Kingston, Ont.

JOHN LOWE, Jr., Representative of Canadian Manufacturers' Association, Montreal Cottons, Limited, Valleyfield, P.Q.

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Prof. SWALE VINCENT, Sc.D., M.D., Department of Physiology, University of Manitoba, Winnipeg, Man.

Mrs. GEORGE HAMBLETON, M.A., 347 Gladstone Avenue, Ottawa, Ont.

REPORT

OF THE

ADMINISTRATIVE CHAIRMAN

OF THE

Honorary Advisory Council for Scientific and Industrial Research.

I. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL.

The work of the Council during the year has been greatly affected by the conditions under which it had to be carried on. The absence overseas of two of the members, Drs. Adams and McLennan, and the resignation of Professor Kirkpatrick and Mr. Bienvenu, imposed on the other members increased duties and responsibility, calling for more sacrifice of their time and energy. The operations of the Military Service Act greatly limited the supply of researchers, as many of these became engaged in military work either in Canada or overseas. In consequence a number of special researches which were projected were not undertaken owing to the impossibility of obtaining the services of researchers specially qualified for attacking such problems. In other cases it was impossible to get the material necessary for the conduct of the investigations involved. As a result of all these handicaps, the programme of special researches to which grants of money were proposed or considered had to be curtailed.

Even the supply of students for the Studentships and Fellowships instituted by the Research Council was less than in the previous year. Of the twenty-five of such Studentships and Fellowships only four were awarded before October first, the beginning of the Academic Year, and when the Armistice was signed three more were awarded to students who, serving in the military forces in Canada, were released and accordingly began the term of their Studentship after January 1.

Even in the case of investigations for which the Council gave grants of money to assist in the carrying on of these there was a difficulty in getting the necessary scientifically qualified technical assistants.

Though greatly handicapped because of the scarcity of scientific researchers, the absence of two members and the resignation of two others, the Council has made progress along a number of lines of activity, as will be presently shown.

1. *The meetings of the Council and of its Committees.*—During the year ten meetings of the Council were held and monthly, with the exception of August and September, which the Administrative Chairman spent in visiting centres in the Maritime Provinces for the purpose of getting into touch with conditions there. Eight of these meetings were of two days' sessions, and with one exception were held in Ottawa. One of the ten meetings covered four days, during which sessions were held, not only in Ottawa, but also in Montreal and Toronto for the purpose of discussing with the authorities of McGill University and the University of Toronto the measures which should be taken to increase the facilities to be offered to those holding the Studentships and Fellowships of the Council who desire to pursue their courses of graduate study and research at these universities. This was in accordance with the

programme of the Council, which entails also visits to the other Canadian universities to urge them to provide, if possible, similar facilities for such students.

A considerable part of the work of the Council was done by committees, and a large number of meetings of these were held during the year. The work of the majority of these was of special industrial interest, covering such questions, among a large number, as the utilization of fish waste, of the sugar of the sulphite liquor of our pulp mills, industrial alcohol, patents, the establishment of a Central Information Bureau for the natural resources of Canada and the preparation of a compact and succinct handbook of the chemical industries of the Dominion.

A meeting of the Associate Committee on Chemistry was held in Ottawa on May 20 and 21, and was attended by fourteen of the seventeen members of the Committee. A large number of subjects of interest to the chemical industries of Canada were discussed, among which were:—

1. The utilization of waste liquors of pulp mills.
2. Industrial alcohol.
3. The tar sands of Alberta.
4. The utilization of titaniferous iron ores.
5. The utilization of waste straw for gas production.
6. Co-ordination of the scientific work of the departments of the Government.
7. The granting of patents to Government employees.
8. The need of a central bureau for research.
9. A census of the chemical industries of Canada.

A meeting of the Associate Committee on Mining and Metallurgy was held in Montreal on March 4 and 5, with an attendance of thirteen members, several of whom came from the extreme east and extreme west of Canada. An abstract of the proceedings of this meeting is given in Appendix "B."

The British Columbia Advisory Committee, to which, in response to recommendations of the Associate Committee on Mining and Metallurgy passed at its meeting in March, 1918, the Administrative Chairman proposed for inquiry a number of subjects concerning the mineral resources and industries of British Columbia, more especially the economical possibilities of producing iron and steel in that province, presented a report, dated November 28, which is given in Appendix "C." This report is of special interest as affecting the question of the capacity of that province to produce iron and steel, not only for use in British Columbia, but also for export.

2. *Expenditures of the Council.*—The parliamentary vote for the year was $120,000. Of this only the sum of $61,151.62 was expended. The programme of the Council, as already explained, was curtailed by the scarcity of trained researchers required for investigations for which grants to meet the expenses to be incurred were contemplated. The estimated expenditure under this head was $60,000. As a large number of these were accordingly not undertaken, only a small part of this was expended. Another factor in limiting the expenditure was the small number of Studentships and Fellowships awarded. The amount actually spent for this purpose was only $7,150, whereas the estimated expenditure was $17,000. The total amount spent for salaries of the staff and the outlay for office work amounted to $22,520.88.

3. *Assisted Researches.*—The applications for grants in aid of special researches were, for reasons indicated, few as compared with those of the previous year. The staffs of the scientific departments of the universities were depleted by the engagement of a large number of their members in war work in Canada, or engaged in military services overseas, and there were available practically no scientific researchers outside the universities and higher technical institutions. This imposed a policy of carrying on as the situation determined, and only those researches were assisted for which the necessary researchers could be found. Some of these were such as had been assisted in the previous year, others, that, for instance, on the tar sands of Alberta for which a grant was provided, lapsed as they did in the previous year for want of investigators to carry them on.

In spite of the handicap experienced in the lack of researchers some effective work was done. The investigation of the reduction of iron ores by gases, under the supervision of Professor Stansfield, of McGill University, has advanced to a stage which promises important results bearing on the utilization of ores of low grades so abundant in Canada. There is but a small supply of high grade iron ore in the Dominion, which is emphasized by the fact that 96 per cent of all the iron ore smelted in Canada is imported, this importation including, of course, that obtained from Belle Isle, Newfoundland.* The total quantity of high grade iron ore on the Globe available is, through its use for producing iron and steel, diminishing at a rate which makes its exhaustion a not far distant event, and in consequence it will eventually be necessary to turn to those of lower grades for the supply of ore for the industry. If the smelting could be effected on an industrial scale at a reduction in the cost which would offset the disadvantages at present attendant on the utilization of these lower grade ores it would make available, immediately or in the very near future, the immense quantities of such ores in Canada. The Research Council regards the solution of this problem as of very great importance to Canadian industry and as justifying a protracted experimental investigation carried on on a large scale.

The investigation on Wheat Genetics carried on for the past two years, and for which the Research Council made last year a substantial grant, has already given very interesting results. It may be explained that amongst the risks to which wheat growing in the three western provinces is exposed are early frost and the rust fungus. The Marquis Wheat, the origin of which is a very noteworthy achievement resulting from the experiments in wheat breeding on the part of Dr. Charles E. Saunders, of the Experimental Farm, Ottawa, is the staple wheat of the West, and is rapidly becoming the staple wheat of the Northwestern States. It gives a large yield, it has good milling and baking qualities, which are exceedingly valuable factors in making it acceptable as a wheat suitable for cultivation in the West. It ripens earlier than the other varieties, which it has almost wholly displaced, but not so early as to escape the incidence of an early frost. Further, it has a comparatively low power of resistance to rust, which, in some districts, takes a heavy toll on the crop. Professor Thompson, in his investigations, is attempting to breed a variety of wheat which will ripen early, be wholly rust-resistant and have good milling and baking qualities. He has succeeded in producing a variety which ripens nearly two weeks earlier than the Marquis, and also varieties some of which are wholly rust-resistant, others less so. He is now endeavouring to produce a hybrid of these which will ripen early, be completely rust-resistant, give a good yield per acre and have the right milling and baking qualities. The achievement of this object is fraught with consequences of vast importance to agriculture in Western Canada, as it will eliminate all the ordinary risks, except one, namely, deficiency of rainfall, to which wheat growing there is subject, and the Research Council, recognizing what is involved and the agricultural interest concerned, is prepared to support financially this investigation till the object of it is attained, even if it takes a number of years to achieve it. It has already made a very substantial grant to continue the work during the season of 1919.

A grant of $2,000 was made to provide for an investigation on the causation of the discoloration of canned lobster. Of the annual output of the lobster canneries of the Maritime Provinces a large number of the cans are found immediately or ultimately with the contents darkened or blackened and the inner surface of the tin in such cans is covered wholly or in part with a rustlike deposit. This results in an annual loss to the industry of many thousands of dollars. To what this discoloration is due has been variously explained but almost wholly as of purely chemical origin, yet the explanations advanced have not in the slightest degree assisted in suggesting measures

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* The quantity of high grade iron ores in Canada is limited and a large part of it is in British Columbia. The amount in sight there is placed at 14,000,000 tons and there may be in addition, approximately, twice that or about 40,000,000 tons in all. (*Vide* Bulletin No. 2, University of Washington Bureau of Industrial Research: "An Investigation of the Iron Ore Resources of the Northwest." By W. H. Whittier, Seattle, published by the University, 1917).

to prevent the discoloration. Recently it has been found by Miss J. MacFarlane, M.A., who, under the auspices of the Biological Board, worked in the summer of 1918 at the Biological Station at St. Andrews, N.B., and during the last winter in the botanical department of the University of Toronto, that the affected cans examined by her had in every instance a bacterial flora which the unaffected cans did not have. Whether a generalization as to the causation of the discoloration may be drawn from these results must be determined only after further extended investigation. If the causation should definitely prove to be bacterial in character the measures to be taken to counteract it would be comparatively simple and would involve only thorough sterilization of the cans after they are hermetically sealed.

That there are other factors involved is not yet wholly excluded. The discoloration of the contents of the cans is accompanied, though not always, by a discoloration or rustlike incrustation of the internal surface of the cans. As this discoloration of the tin, so far as present observations go, never appears without a discoloration of the contents, it would appear as if it were due to the effect on the tin of products of the action of bacteria on the contents, but the fact that in some of the spoiled tins there is no incrustation indicates either that the bacteria concerned are not all of the same species, or that the surface of the tin plate used in making the cans varies greatly in its capacity to resist chemical action. That there is a variety in this respect in the tin plate used seems to be indicated by the results of investigations carried on by the staff of the Research Laboratory of the American Canners' Association, but whether this generalization can be applied to the tin plate used in the canning of lobsters can only be determined by special investigation.

As the lobster canning industry is one of considerable importance to Canada, and as its success depends on a high grade of product, a thorough and prolonged research on the problems affecting the industry should be systematically planned and carried out. The grant made for this investigation is for preliminary investigations. It is expected that when the Fish Canners' Guild for Research is fully organized it will undertake to continue and support this investigation. The guild, the formation of which was agreed upon at a meeting, held in Amherst in December, of a large number of those engaged in the industry, will include not only such, but also a number of those who are concerned in the fish industry.

A grant of $7,000 was made to the Biological Board of Canada to provide for researches on the chemistry and bacteriology of fish curing and its products. The value of these products in Canada is about six millions of dollars and accordingly but a fraction of the total annual yield of the fisheries. It would be much greater were it of a character which would encourage the consumption of the product. A portion of it is excellent in quality, but the remainder of it is by no means up to the standard of the British, Norwegian, Danish, or Dutch products. This is due to the use of methods which have had a vogue in the trade for a century and therefore of a purely empirical character, but carried out with a lack of care as to essentials that makes the product an inferior or less desirable one. Some of the methods also are quite repulsive in character, although the product may pass muster as to appearance and, in some cases perhaps, as to taste.

It is urgent that all these methods should be either wholly discarded and replaced by others, or greatly improved, in order that the production and consumption of cured fish should be increased beyond that which obtains to-day in Canada. To replace some of the methods or improve others it is necessary to know more about the chemistry and bacteriology of the cured product than is known now. Little work has been done in a systematic way in research in this line. A careful study of the bacterial flora of fish and cured fish has yet to be made and the effects of the various agents, creosote and other compounds in smoke and the salt, used in pickling for example, on fish muscle are only imperfectly understood. The bactericidal action of creosote on fish muscle and its capacity to penetrate in order to exert this action adequately are as little known. Further, the possibility of substitute methods and of other agents which may be more effectively used should be investigated. These are amongst the problems

which must be solved before the industry can be placed on basis which will promote a greater development of it in Canada. The Biological Board will, it is understood, arrange for two series of investigations, one along chemical, the other along bacteriological lines, each to be placed in charge of investigators specially qualified for this work.

4. *The Utilization of the Low Grade Lignites of Western Canada as domestic fuel.*—In the Report of the Administrative Chairman for 1917-18 a full account was given of the question of utilizing the low grade lignites of Saskatchewan to provide a domestic fuel to replace the anthracite which was in previous years imported into Western Canada from Pennsylvania to the extent of over half a million tons annually. The Research Council recommended that the Government of the Dominion make an appropriation of $400,000 to erect a carbonizing-briquetting plant capable of turning out 30,000 tons of briquettes practically equivalent in thermal value, pound for pound, to anthracite, the sum asked for to provide also for the operation of the plant for a year. After an extended consideration of the proposal, the Government, in co-operation with the Governments of the provinces of Manitoba and Saskatchewan, agreed to make the appropriation required, and decided to put the conduct and control of the experiment in charge of a board, which was appointed on the 22nd of August, 1918. This board, known as "The Lignite Utilization Board," is composed of three members, who give their services without remuneration, and who are Mr. R. A. Ross, of Montreal, as Chairman; Mr. J. M. Leamy, of Winnipeg, and Mr. J. A. Sheppard, of Moosejaw. This board met in Montreal on September 16, 1918, and organized to undertake a thorough and comprehensive attack of the problem of utilizing these lignites. It is expected that the preliminary tests will be completed in October or November of 1919, and if the results prove satisfactory the erection of a commercial plant to carbonize and briquette the lignites will be undertaken before the spring of 1920.

An interesting account of the work done by the Lignite Utilization Board up to the end of March, 1919, is to be found in Appendix "E," the author of which is Mr. Lesslie R. Thomson, the Secretary of the Board.

5. *Industrial Alcohol.*—A number of modern lines of industries are dependent on a cheap form of alcohol known as industrial alcohol. Industrial alcohol is very largely ethyl or "grain" alcohol, mixed with some substance which will render it unpotable, but not unfit for the use to which it may be put industrially. The substances the addition of which renders ethyl alcohol unpotable and which are, therefore, called "denaturants," are very numerous, but the uses to which "denatured" alcohol may be put limit the number to a few, such as wood alcohol (methyl alcohol), benzol, pyridine bases, bone oil, etc., and of these wood alcohol is the most common denaturant, giving with ethyl alcohol a mixture known as "methylated spirits," consisting approximately of 10 parts of ethyl alcohol of 95 per cent strength to every one part of methyl alcohol.

Denatured alcohol is very extensively used abroad as a chemical agent, a precipitant, a solvent, a cleaner, in many industrial processes, especially in the chemical industries, and it is also used as a motor fuel to replace gasoline and for illumination purposes. The importance of it in these lines is seen in the fact that the quantity of industrial alcohol used in Germany is very great, amounting in the year ending August 31, 1904, to 101,823,470 gallons, while the consumption of denatured alcohol in the United States for 1913 was 16,953,353 proof gallons, and for 1918 90,644,722 proof gallons. This latter limit was reached by greatly increasing annual consumption since the first of January, 1907, when the manufacture and sale in the United States of denatured alcohol was freed from the restrictions which up to that date had been imposed on it. The consumption before 1907 had been about 1,500,000 gallons annually.

Cheap alcohol is a necessity for a large number of lines of industry and the extent of the consumption of it in a country is an index of the development of its industries, especially the chemical. The large amounts annually used in Germany and the United States are, therefore, significant of the value of cheap alcohol.

In Canada the consumption is a meagre one. It was only 252,000 proof gallons in 1917. If it had been in proportion to the population as compared with the United States the amount would have been in the neighbourhood of 5,000,000 proof gallons, or about twenty times as much as it was.

One of the reasons for this very limited consumption is the cost, a very important contributory factor to which is the conditions under which the denaturation is carried out by the Department of Inland Revenue. All the alcohol so used has to be shipped to Ottawa from the distillery where it is produced and after it is denatured it is shipped to customers. The charges for transportation to and from Ottawa do not matter greatly if the distances involved are small, but when these reach 500 miles and may in some cases exceed 2,000, the charges are a serious tax and tend to discourage the use in industry of denatured alcohol.

Another factor is the present high price of alcohol, due to the bonding system, which requires that alcohol shall be kept in bonded warehouses for two years before being sold to the trade. Much of the present supply in Canada has been in bond for considerably more than two years. This involves interest on the buildings and plants used for this purpose and for that time on the original cost of the alcohol so stored. This can to a certain extent be justified for alcohol that is to be used to produce beverages therefrom, for during this storage there is a gradual alteration, or disappearance, of certain of the accompanying compounds which are more toxic and harmful than pure alcohol is. For industrial purposes, however, freshly distilled alcohol is as effective and serviceable as alcohol which has been allowed to age and consequently it would be considerably cheaper than the latter.

The current price of matured ethyl alcohol in Canada is due to the restrictions referred to, to the high cost during the last three years of corn and other raw material used to produce it. The wholesale price of alcohol of 95 per cent strength at the time of this writing is $7.43 per gallon, which includes the excise duty of $3.96. The distiller then receives about $3.47 per gallon, while the wholesale price of ethyl alcohol of 95 per cent strength in the United States is from 50 to 55 cents per wine gallon.

The alcohol used to make denatured alcohol and the ethyl alcohol used for industrial purposes must, therefore, be, and is, at present supplied from recently distilled spirits which are manufactured to-day in Canada by only two firms whose maximum capacity for production is annually about 8,000,000 proof gallons, but whose output at present is not more than a third of that. The limited supply is due to the limited market in Canada and this is due, again, to the conditions imposed on the production and use of denatured spirits. In consequence, denatured alcohol costs 95 cents a gallon in Canada as against 60-62 cents per gallon (imperial measure) in the United States.

Even the wholesale price of American alcohol is higher than it was in 1914 because of the higher price of corn from which it is made, and so long as the supply of food for the world is scarce, or not abundant, as is the case to-day, the price of alcohol will remain approximately as at present. If, however, other raw materials not foodstuffs, and not used for any object, could be employed in the production of alcohol, the price might eventually be considerably reduced. The waste molasses of the sugar refineries was and is employed for this purpose, but the amount available in Canada is not very large. There is one waste material which in Canada and the United States has not been so used, namely, the sulphite liquor of our numerous pulp mills. Enormous quantities of this are produced annually in Canada, and it is being and has been disposed of by pouring it into the streams and rivers, poisoning all fish and other life therein. It contains ½ per cent of fermentable sugar, from which in the liquor of the pulp mills in Norway and Sweden more than 1,000,000 gallons of ethyl alcohol are produced annually. It has been estimated by Professor R. F. Ruttan, who has given much attention to this subject, that the sulphite liquor of the three pulp mills on the St. Maurice River would, if utilized for this purpose, produce annually about 640,000 gallons of alcohol of 95 per cent strength and at a cost of under 35 cents a gallon. It has also been estimated that the sulphite liquor of all the pulp mills in Canada is sufficient to produce at least 5,000,000 gallons annually, that is, enough to supply the

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needs of Canada for the next twenty years. Perhaps the cost per gallon may be reduced when the resinous and other non-sugar constituents of these liquors, amounting to about 8 per cent of the same, are put to some practical use, not thrown away as now. They are to a certain extent already utilized in tanning and the resinous material, "sulphite pitch", has been suggested as a binder in briquetting slacked coal, and, indeed, it has been used to a small extent for that purpose.

Another kind of raw material for the production of alcohol is wood waste in all its forms, including slabs, strips and sawdust, from saw-mills. The quantity of this annually destroyed, or allowed to decay, is enormous, especially in British Columbia, where it is estimated between five thousand and fifteen thousand tons of wood are burnt daily to get rid of it. As the saw-mills of Eastern Canada operate only about five months in the year, and, further, the collection of their waste is difficult, the utilization of it for making alcohol is not regarded as economically feasible as yet, but in British Columbia the only possible difficulty is the extent of the market for alcohol. The conversion of wood waste into alcohol is carried on elsewhere. At Georgetown, S.C., and at Fullerton, La., are plants in which the Tomlinson process for the conversion of wood waste into alcohol is employed. A description of this process is given by Mr. G. H. Tomlinson, which appears as Bulletin No. 7*. It is possible that this process might be employed in the Pacific coast province, especially if a portion of the waste is used to make glucose, which can be mixed with hay and other fodder to make special cattle foods.

The use of denatured alcohol as motor fuel to replace gasoline is not a remote possibility. The annual consumption of gasoline is increasing and the price per gallon of it is mounting, as new sources of supply do not meet the increasing demand for it. It is, indeed, claimed that the world's supply of gasoline will be exhausted within thirty years. Whether this is so or not, it is clear that the price is going to increase, and this will necessitate the resort to other liquid fuels as serviceable, or nearly so, and amongst these is denatured alcohol. The only handicap to its use is the price. If industrial alcohol could be produced cheaply it would quickly replace gasoline, for it could, with slight changes in the motor engine, be as effectively used. A pound of gasoline will give on combustion about 18,960 B.T.U's, while a pound of alcohol of 95 per cent strength gives 10,355 B.T.U's, and accordingly one gallon of gasoline should as a source of power go as far as 1.54 gallon of alcohol, but the actually efficiency of gasoline is less than this, and therefore industrial alcohol at 30-35 cents a gallon, a not impossible price in the near future, should successfully compete with gasoline at 50-55 cents per gallon, a price that will be reached and exceeded in a few years. Alcohol was produced in Germany before 1914 at a cost of 20-24 cents a gallon, which could not compete with gasoline at 30 cents.

A survey of all the facts concerning gasoline and alcohol as motor fuels makes it almost an absolute certainty that alcohol, denatured for the purpose, will be the motor fuel of the near future. It can be made from materials now considered waste and yet inexhaustible, while the supply of gasoline, unless made synthetically, will become exhausted. As the supply approaches exhaustion the price will rise and alcohol will then, if cheap, take its place as fuel.

Cheap alcohol should be provided not only for its service as motor fuel, but also for the development of Canadian industry. With methylated spirits to-day at 60 cents per gallon in the United States and at $0.95 in Canada, the handicap on Canadian industry is apparent. The necessity of cheap alcohol has been emphasized by the various bodies interested in Canadian chemical industries and especially by the Canadian Branch of the Society of Chemical Industry and by the Associate Chemical Committee of the Council. As a result of the representations of these and other bodies on the question of industrial alcohol, the Research Council gave prolonged and careful consideration to it and formulated recommendations to the Sub-Committee of the Privy Council, which are summarized as follows:—

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* "The manufacture of Ethyl Alcohol from Wood Waste." By G. H. Tomlinson. Bulletin No. 7 of the Honorary Advisory Council for Scientific and Industrial Research.

1. That the production of denatured ordinary alcohol, such as methylated spirits, be carried out at any distillery licensed to that end and under such regulations as the Minister of Customs and Inland Revenue may prescribe and that the denatured alcohol so manufactured be sold, duty-free, delivered and transported without any restriction to dealers, manufacturers, and other persons.

2. That the manufacture of specially denatured alcohol, that is, alcohol which is to be used for the production of some chemicals, ether, chloroform, etc., and for which a special denaturant is required, be permitted under regulations prescribed by the Minister of Customs and Inland Revenue in distilleries licensed thereto and sold duty-free to the manufacturers of such chemical preparation.

3. That pure ethyl alcohol without admixture with any denaturant shall be sold duty-free for use in the manufacture of such products as require the use of such alcohol as a solvent, precipitant or agent, under regulations to be prescribed by the Minister of Customs and Inland Revenue.

4. That pure ethyl alcohol be sold duty-free, under such regulations as the Minister of Customs and Inland Revenue may prescribe, to incorporated hospitals, to universities, and to scientific and research laboratories.

5. That the recovery of alcohol by distillation after its used be allowed in the plant in which it was used, under such regulations as may be prescribed by the Minister.

A bill embodying these recommendations was prepared under the supervision of F. H. Gisborne, K.C., accepted by the Acting Chairman of the Sub-Committee and adopted in effect by the Acting Minister of Customs and Inland Revenue and it is incorporated in the Bill, No. 76, entitled "An Act to amend the Inland Revenue Act," which is now before Parliament.

6. *On the right of Government Technical Employees to patent processes discovered by them.*—The question of allowing Government employees to patent technical processes discovered by them in the course of their work was brought to the attention of the Research Council in 1917 by a committee of representatives of the staff of the Department of the Interior associated with the Forest Products Laboratory under that department, asking that it be made permissible for technologists to take out such patents. It was pointed out that when a technologist in the service of the Government discovers, while carrying out technical work or research as part of his duties, a new process, or some mechanical device, which, when applied in industry, is of commercial value, he may resign his post in order to be in a position to take out the patent for it in his own name, and as a consequence the staff is continuously losing many of the best of its technologists and researchers, and to prevent this loss the technical officers should be granted the right, unquestioned under certain conditions, of patenting such discoveries and inventions.

The difficulty at present in the way is not in any regulation or Act of Parliament barring this right, for there is none, but the absence of any express regulations or indication of policy in regard to such matters is a deterrent to the would-be patentee. Unless the department concerned is definitely known to be favourable to granting a patent in a particular case the application for it will not be made because it might be refused, in which case the facts of the discovery or invention would be published to the injury of the applicant's interest. The very uncertainty, varying in degree with the different departments, is in effect as prohibitive as a regulation or statute forbidding the granting of such patents.

It must be admitted that the discoveries and inventions made in the course of his duties by an official of one of the Government departments, which pays for his whole time service, should belong to the Government and be free of use to any citizen of the state, which provides the revenue from which his salary is paid. This ideal, however, can never be realized. Salaries in the Government service, even in the positions requiring on the part of their occupants highly special technical qualifications, are low. To achieve discoveries and inventions requires more than unselfish enthusiasm, for they demand time and a steady effort that will tax the utmost patience of the

worker. If the state is not discerning of such service and accordingly does not fitly reward it, why should the worker concern himself with more than his routine duties? Ability will seek the field where the rewards for its exercise are the greatest, or it will not excel mediocrity in achievement.

To stimulate effort and achievement in the scientific departments of the Government service and to keep in that service technologists and researchers of the highest ability, special rewards for such effort and achievement must be offered. Promotions in rank, or increases in salary are rarely possible because of the Civil Service Act, and bonuses from the treasury are inadvisable, as well as difficult to adjust, because the value of a new process or invention can only be determined after it has been tested in the industry where it may be utilized, and several years may pass before this result is reached. There remains, then, the question of allowing the discoverer or inventor to patent his new process or mechanical device under such conditions as will safeguard the interest of the public as well as that of the inventor or discoverer.

The law and the practice in the United States are not consistent. While the Federal Patents Law allows government employees (excepting those of the Patent Office at Washington) to take out patents on their inventions, in certain bureaus of the Government service the employees must assign their inventions and the rights to their processes to the Government outright; in others they are prohibited from taking out any patents; in others, if they may take them out, they must assign them to the public, and in others again they may obtain patents, but the Government reserves the right of free license thereunder. In some instances of the last class this free license is restricted to the bureau in which the invention or new process was discovered and is denied to other branches of the Government service.

The regulations of the British Government, as a rule, permit the departments concerned to take out patents, and in the application therefor the discoverer or inventor participates. In the Admiralty the inventor must obtain permission from his commanding officer, or the head of his department, to apply for a patent before making such application. The inventor must obtain permission from the Admiralty to apply for a patent in any foreign country or British overseas dominion or state. In regard to the action to be taken for Great Britain, there are three alternative courses which are adopted by the Admiralty.

1. It may be assigned to the Admiralty and the inventor will not be allowed to dispose of the commercial uses of his patent if it has any.

2. The Admiralty may be satisfied with an agreement giving the Government and its contractors the right to use the invention or patent, but otherwise leaving the inventor free to dispose of his invention or patent for commercial purposes.

3. The Admiralty may find no use for, and therefore has no interest in, the invention or patent, in which case it leaves the inventor to dispose wholly of his invention or patent as he chooses.

The Research Council, after very full consideration of all the facts, as the foregoing shows, came to the decision that in the matter of allowing employees in the technical branches of the Government service to take out patents on processes discovered or mechanical devices invented by them in the course of the performance of their duties, the permission to do so could be accorded under conditions that would not conflict with public interest. The necessity of granting this permission as a right is an urgent one. It is the only way at present feasible of keeping a number of highly qualified technical men on the staff. Promotion in rank or increases in salary for those making such discoveries and inventions cannot in many cases be affected for reasons already referred to. There is no difficulty involved in allowing the privilege of patenting the discoveries and inventions. It will stimulate effort and encourage ability to achieve its utmost and the service will thereby be made more efficient. Further, if the Government is assigned a share in the interest of each patent thus granted the result from all points of view should be eminently satisfactory.

The commercial value of a patent in Canada, except, perhaps, in a very few lines, the pulp and paper industry for instance, is low as compared with its value in the

United States. In determining the conditions under which a patent is permitted to a Government employee, this fact should be taken into account. The patent rights for abroad, including the United States, should belong to the inventor or discoverer, as has been recognized hitherto, for there was no regulation preventing a Canadian Government employee from obtaining patent in Great Britain and the United States. If now this right is recognized by statute it would be an equitable adjustment of the interests of the Government and the employee if at the same time half of the rights in each patent for Canada is conceded to the Government, the other half going to the discoverer or inventor.

This solution of the question was finally approved by the Research Council, which formulated the result in the following resolution conditionally:—

That experts in the Government service be allowed to patent in their own name their discoveries and inventions provided they assign half of their patent rights in Canada to the Government of Canada—the proceeds from the royalties of which to be devoted to the support of scientific research—the rights outside of Canada to be retained by the patentees.

Copies of this resolution were addressed to the deputy ministers of the various departments which have technical staffs, for the purpose of eliciting their views on the principle embodied in it. It was on the whole favourably considered by them, and, with one or two exceptions, by those to whom they referred the matter.

After further consideration, the Research Council decided to recommend to the Sub-Committee of the Privy Council for Scientific and Industrial Research that legislation be passed giving effect to this resolution. This the Sub-Committee approved of, and Mr. O'Halloran, the commissioner of patents, in consultation with representatives of the Research Council and of the departments above referred to, drew up a Bill embodying the changes recommended by the Council. A copy of a portion of this Bill is given in Appendix "N." It is hoped that this Bill will receive the sanction of Parliament during the current session.

It is to be understood, let it be said again, that the discoveries and inventions of technical officers in the Government service for which the proposed legislation makes provision are only those which are made or developed in connection with the technical work of such employees and in the laboratories or scientific establishments of the Government.

The necessity for such legislation is recognized elsewhere and especially in connection with the Government services at Washington. As already pointed out the practice in the various Departments there, regarding the granting of patents to technical employees varies from Department to Department. In consequence uncertainty prevails because of which initiative and inventive genius are discouraged amongst Government employees and the Government services suffer accordingly. To remedy all this a committee composed of members of the various Scientific Bureaus in Washington, which carefully studied the situation, prepared a draft of a Bill which was submitted to Congress in February of this year. A copy of this draft is given in Appendix "O".

The question of allowing the technical employees of the Dominion the right to patent their discoveries or inventions under equitable conditions is an urgent one and the solution proposed above should be given sanction by Statute at an early a date as possible.

7. *The Utilization of Fish Waste in Canada.*—The question of the utilization of fish waste has been under the consideration of the Research Council for the last eighteen months. The annual amount of this waste in Canada for both the Atlantic and the Pacific coasts was estimated to be about 300,000 tons by Mr. J. B. Feilding who was employed by the Council to make a survey of both coasts to report on the subject. Only at several points was any attempt made to dispose usefully of it and to a very limited extent. A firm at Canso converts the waste derived from the operations of the Maritime Fisheries Corporation plant there

into a brand of glue and another at Anse à Beaufils in Gaspé, under the management of Mr. M. A. Wick, is utilizing that which is gathered in the vicinity, to separate the oil for the preparation of fishliver oil for the foreign market. From the salmon canneries at New Westminster, B.C., and the immediate vicinity the fish offal is transported to Seattle, Washington, for reduction there into animal food, oil and a fertilizer.

In Norway and Sweden and in Germany before 1914, and in the United States fish waste was systematically utilized and the product figured considerably as a source of revenue in the fish industry. In Germany a select portion of it was made to serve as a source of food for human consumption but the greater part of the products consisted of oil and a residue employed to mix with other material (hay, milling offal, etc.) to furnish stock food. In Gloucester, Massachusetts, and at points on the Pacific coast of the United States are plants which convert the product into food for hogs, cattle and poultry, the oil derived therefrom going on the market chiefly to serve for the manufacture of soap.

The value of the fish waste in Canada, if utilized as it is elsewhere, would be very great. The quantity of solids in the three hundred thousand tons annually thrown away, and comprising chiefly fats and proteins is at least one fourth of that amount and if subjected to appropriate treatment it ought, at the prices which prevail, and have prevailed, for the last four years, to be worth $10,000,000 or about one fourth of the annual yield from the fisheries of Canada. The oil, contained in this waste should, if separated and purified, be worth on the market as much as $2,000,000.

This fish offal is produced at a great number of points along both coasts, but more abundantly on the Eastern coast, where the quantity, according to Mr. Fielding's estimate, reaches 240,000 tons. The remoteness of many of these points and the consequent difficulty and cost of collection at central reduction plants of the offal in time to prevent deterioration are serious handicaps in a commercial utilization of the material. Another factor is the shortness of the season during which the offal is produced. On the Pacific coast it is approximately six weeks, while on the Atlantic it does not exceed seven months, and consequently reduction plants would have to be idle during a considerable portion of each year.

There are other difficulties attendant upon the utilization of the offal. The processes employed hitherto are of the experimental stage, and the results have not been always satisfactory. The separation of the fat or oil is carried on by the action of hot water and steam on the minced or ground-up material, the oil collecting on the water as it leaves the mass. This does not by any means remove all the fat, and therefore the residue which should consist mainly of proteins is fat-containing and to a considerable extent. This difficulty intruded itself in the operation of the dog-fish reduction plants at Canso and Clarke's Harbour, N.S. To utilize dog-fish for the production of oil and fertilizer these plants were operated under the auspices of the Department of the Naval Service, but are now closed owing to the failure to make them pay. The residue could not be directly used as a fertilizer because the oil contained therein on decomposition in the soil "soured" it and rendered it more or less unproductive. To dry it the residue was roasted, which caused, however, a loss of a considerable part of its fixed nitrogen, and it was thereby and proportionately to the degree to which the roasting had been carried out less valuable as a fertilizer. For the preparation of a good animal food also the separation of the greater part of the oil is necessary, as the presence of it to any considerable extent in the food tends to give a "fishy" taste to the flesh of the animal fed on it.

The more or less imperfect character of these and other methods of the treatment of fish waste has deterred ventures into this line of industry, and in consequence the fundamental work on which success in it must be based has still to be done.

The utilization, however, of this waste will be of imperative urgency in very near future. Even now there is a very serious deficiency in the world's supply of food, including specially fats. It will take twenty years at least to restore the annual

supply to what it was before 1914, and, therefore, any source of protein and fat at present untapped should, if it is all industrially feasible, be made to contribute its quota of these indispensaible nutrient compounds. The proteins so obtained would, mixed with other foods less nourishing, give a product which, as stock food, would enhance the supply of meat of various kinds, beef and pork, while the fat could be employed to the extent of its supply in the production of the cheaper and commoner kinds of soap for which so much of more valuable fat is used to-day. The consideration of the question of taking measures which might lead to the utilization of fish offal for this purpose ought not to be postponed if there is at all a possibility of employing the waste economically.

The Council, on the recommendation of Professor R. F. Ruttan, Chairman of its Associate Committee on Chemistry, gave full consideration to this question. It collected data on the subject and appointed Mr. J. B. Feilding, who had, in 1915, under the auspices of the Conservation Commission, carried out demonstrational work in this line in a provisional plant at Port Stanley, to make a tour of a number of centres in the United States for the purpose of gathering information regarding the utilization of fish waste elsewhere. The Council ultimately came to the conclusion that a project for the utilization of the offal could be successfully carried out, and that the results would blaze the way to the development of a new line of industry in Canada which would ultimately involve an output of several millions of dollars annually.

There are centres along the Atlantic coast where the quantity of fish offal readily collectible at comparatively low cost, from nearby points, is very considerable and where consequently it is possible on an adequate scale to test the commercial feasibility of a selected process for the treatment of the offal. Such a centre is Canso, N.S., where the quantity of offal accessible daily during the season is at least thirty tons and may be increased, at need, to double or treble that amount. If it was decided to erect a plant for this purpose it was clear than Canso would be the most suitable location for it.

A consideration of all the facts and the information which the Council had gathered on the subject led it to conclude that the utilization of fish waste was an industry which could be made to give profitable returns, and that it was necessary only to demonstrate this on a modest scale by the installation of a plant and the operation of it for a year or so, in order to induce private companies or firms organized for that purpose to undertake this utilization. To provide this demonstration it recommended to the Sub-Committee of the Privy Council for Scientific and Industrial Research that an appropriation of $50,000 should be made to carry on this demonstration for one year under a commission which would control the equipment of the necessary plant and its operation for that period. It was recommended that the equipment be installed in the disused lobster hatchery at Canso, which could be granted for this purpose, and, further, that one of the steam trawlers at the disposal of the Government, and for part of the year not on duty in the fishery service, be available for the collection of the fish waste in the locality and even for catching by trawling of such kinds of fish of the vicinity, skate for example, as are not at present used for food.

These recommendations were also advanced to the Reconstruction and Developmeent Committee of the Privy Council, and were under consideration by that Committee when it developed that the project might be undertaken and carried on by private enterprise. Eventually Mr. J. S. Myers, President of the Peerless Cereal Milling Company of Woodstock, Ontario, organized a company with a considerable amount of capital, which purchased the lobster hatchery from the Department of Fisheries and is now installing in it the necessary machinery and equipment. One of the Government trawlers, or drifters, is, it is understood, to be placed at the service of the company for a limited period in order to provide for the collection of the fish waste and the catching of fish, of the class not used as food. Mr. Myers proposes to use the plant for the production not only of fish oil, but also for the preparation of protein material suitable for mixture with the offal of cereal mills to make special cattle food.

The results of this undertaking will, it is hoped, serve to encourage other ventures of a like character elsewhere, eventually leading to a complete utilization of a very large part of the present amount of fish waste.

The Research Council proposes to give further attention to the utilization of fish waste, because it considers that the last word has not been said either in regard to the processes now followed in this utilization or to the character of the product. The processes involve biochemical problems of a highly intricate nature and the solution of these must greatly enhance the success of the utilization. It may be pointed out, incidentally, that in this utilization cheap industrial alcohol must prove a very valuable factor.

8. *Recommendations regarding the establishment of a National Research Institute for Canada.*—The Research Council early in 1918, as shown in the last report of the Administrative Chairman, after full consideration of the question of the right organization to provide for systematic research on the natural resources of Canada and on the problems which concern the development of Canadian industries, came to the conclusion that this organization should be that of a national research institute, constituted to deal with standards of all kinds, like the Bureau of Standards at Washington and to have also the function of providing facilities for research carried on and maintained by associations or guilds for research formed in the various lines of industry.

Since then the council has placed before the Sub-Committee of the Privy Council for Scientific and Industrial Research, and the Reconstruction and Development Committee of the Government, a report recommending the establishment at the earliest possible date of such an institute and that an appropriation of $500,000 be made for a building, of the laboratory type, for such institute to be erected on a fifty-acre site near Ottawa and further that $100,000 for its scientific equipment and $100,000 for salaries of the staff during the first year be also provided. The memorandum embodying this report is reproduced in Appendix " J." The report has been accepted by the two committees but has not as yet been approved by the Government. The subject is now under consideration by a special committee of the House of Commons appointed " to consider the matter of the development in Canada of scientific research, with power to call for persons, papers and records, to examine witnesses under oath and to report from time to time."

The question of establishing such a National Research Institute is discussed in Section II.

The Council has given consideration to the question of the control of this Institute which, it holds, should be vested in the Research Council and subject to approval and supervision of the Sub-Committee of the Privy Council for Scientific and Industrial Research. In support of that may be adduced the results of past experience in the matter of direct government control of scientific organizations and the precedents created elsewhere in the case of national research institutes, as, for example, the National Physical Laboratory of Great Britain, the National Research Institute of Japan and the proposed Institute of Science and Industry for Australia, a Bill to establish which is now before the Parliament of the Commonwealth (Appendix " P "). The control of the National Physical Laboratory of Great Britain was vested in the Royal Society which appointed a board of which the President of the Society was the chairman and the executive committee of which constituted the real governing body of the Laboratory. Under the new provisions for the future control of the laboratory this control is still to be exercised by the President and Council of the Royal Society as indicated in the Appendix to the Report of the Executive Committee for 1918 and reproduced as Appendix " Q." The budget of expenditure of the Laboratory will be met, as for the last three years by grants from the Government Department of Scientific and Industrial Research.

To indicate in as concrete a form as possible the views of the Research Council as to the provisions it recommends for the control of the proposed National Physical Laboratory a draft of a Bill to establish this Institute, to be offered for the consideration of the Government is reproduced in Appendix "K". This draft is the result of a long and careful consideration by the Research Council.

9. *Research on Industrial Fatigue.*—In modern industry the question of the efficiency of the worker in relation to the hours of labour in conjunction with the amount of his output and the conditions under which he operates is one to which a great deal of attention has been given in Great Britain, France and the United States, especially during the last four years because of its bearing on production in munition factories. It is a question also which is likely to become enhanced in importance in the near future, for not only does it concern the efficiency of both industry and labour, but it affects also in a large measure the social welfare of all the industrial population. In consequence, organizations were launched in Great Britain and the United States, nearly a year ago, to investigate industrial fatigue in the various lines of industry in a systematic and thoroughly scientific way and already data have been obtained which are of the very greatest value in relation to hours of toil and output in some trades. The results of investigations henceforth to be conducted on comprehensive scale are, it is believed, likely to constitute the final criteria for establishing optimum conditions for industrial efficiency and welfare among the industrial workers in those countries.

Although very much of what may be won from these investigations will be found applicable everywhere, there are some special conditions in Canada, those, amongst others, arising from differences in climate and to a certain extent in food, the operation of which may serve to qualify in some degree the conclusions which may result from the investigations now being carried on by the British Industrial Fatigue Board and under the auspices of the Federal Public Health Service at Washington. This makes it appear advisable that an organization to carry out similar work in Canada should be created, for, although the industrial population of the Dominion is not a large one, a large industrial development is projected and accordingly, we should be ready to advance abreast with the other nations along these lines and obtain whatever benefits may result from it.

The main problems themselves are very largely of a physiological character, but, because mental and nervous factors are also concerned in bodily fatigue, a study of them must involve observations in the fields of experimental psychology. Further the investigations undertaken must have the approval of those whom they immediately concern, the workers on the one hand and the industrial managements on the other. As also the number of women workers in Canada is not negligible, their interests in such an invstigation should be represented by some one or more who have given special attention to women as industrial toilers.

The Research Council in view of all these considerations decided in February to appoint a committee to investigate Industrial Fatigue, composed of a number of the leading Physiologists in our Canadian Universities, one or more specially qualified experimental Psychologists, representatives of the Trades and Labour Council of Canada and of the Canadian Manufacturers' Association and one or two women representative of, and conversant with, the question relating to female labour in industry.

This committee constituted along the lines just indicated has been recently appointed by the Council. It has been organized under the chairmanship of Professor J. J. R. Macleod of the University of Toronto and it has issued a circular letter to the leading industrial firms in Canada, indicating the objects of the committee and asking for suggestions as to the lines of work in which each could co-operate with the committee. As soon as the replies to these circulars are received it will proceed to undertake such inquiries on the subject of Industrial Fatigue as may appear likely to give results of value.

The Committee will also endeavour to co-operate with similar organizations abroad in order to prevent duplication of effort.

10. *Forestry Studies.*—The work undertaken in 1917 by the Forestry Branch of the Department of the Interior with the object of obtaining data regarding the rates of growth in volume of our more important timber trees, notably the white pine and spruce, and the possibilities and successful methods of securing their reproduction,

and to which extended reference is made in the Administrative Chairman's Report for the year ending March 31, 1918, was continued on the cutover area of the Petawawa Reserve last season and a large number of data were obtained which are of great value in determining the lines along which these Forestry Studies are to be conducted in the future.

The results already obtained from this survey have enabled the Forestry Branch to elaborate a system of forest organization which is specially adapted to the conditions which in Eastern Canada and which permit the inauguration of the best silvicultural practice to provide efficiently for reforestation.

In the comprehensive report of the work carried on for last season prepared by the Forestry Branch of the Department of the Interior, a summary of which is given in Appendix "D," it is pointed out that if the organization of the Petawawa Military Reservation is completed and the tract placed under permanent management a concrete example of the value of intensive organization in forestry conservation will be continually available for Canadian lumbermen. It is also urged in that report that if the Government can develop such a system and make it a financial success lumbermen should not hesitate to adopt in the management of their own areas a similar system of intensive organization for conservation of their lumber supplies.

The expenses involved in these investigations under the control of the Forestry Branch were met by a grant from the Research Council amounting to $6,214.57. A grant has been made to cover the expenses of the investigation for the season of 1919.

The Research Council regards these investigations as of fundamental importance in determining the data which must be ascertained regarding the rates of growth in volume and the possible quantity of reproduction of our more valuable timber trees, in order that a comprehensive and successful attack on the problem of reforestation in Eastern Canada be undertaken. Without such data it will be impossible to take any effective measures to prevent the exhaustion of our lumber supplies, especially of white pine and spruce.

11. *The Establishment of Bursaries and the Provision for Training Research Students in Canada.*—Early in 1917 the Council recognized the fact that there is a very limited number of highly trained researchers in Canada and that it was necessary to increase the supply of such if the application of research to Canadian industrial problems is to be successfully fostered. To accomplish this object more quickly, it established twenty Studentships and five Fellowships, with the understanding that the numbers of both should be increased when the supply of candidates for them should be sufficient to justify this action.

The cardinal qualification of a candidate for a Studentship is the possession of initiative and independent action in prosecuting research on some special scientific problem, a qualification the possession of which he can demonstrate only by having carried on to a successful termination a research of some distinction. He must, indeed, have also other qualifications. He must, for example, be a university or college graduate, with a special knowledge of the science to research in which he is to devote himself and have a good general knowledge of the cognate sciences. These are, however, not in themselves enough, for without the initiative and the capacity for independent thought no student may ever become a researcher.

The Fellowships are awarded to those who, as holders of Studentships for one or two years, or independently, have shown in a high degree capacity for research.

Now the demonstration on the part of any candidate for a Studentship, of his capacity for research, implies a year or so spent in post graduate study, during which he must attempt some research work. As a rule there are few of those who have just graduated in a position to afford the additional expense and consequently they may be unable to qualify for Studentships. The Council decided to institute Bursaries, ten in number, for such to be awarded for 1919-20 to as many graduates whose attainments in science and whose expressed aims are such as to justify their being awarded such Bursaries. A Bursary, which is $500 in amount, is tenable only for a year, and

if the holder of one during that time demonstrates the possession of a capacity for research he will be awarded a Studentship for the following year.

The regulations governing the award of these Bursaries are given in Appendix "F."

It is hoped, with the aid of these Bursaries, to select amongst the best of each year's graduates, in science, of the universities those who may develop into excellent researchers, but who without such help may be unable to obtain the necessary preliminary qualification for entering a career of scientific research. The fact that such Bursaries will be available at graduation to distinguished students will be a spur to ambition to excel, and the thoughts of many of them will be turned to the possibilities of a scientific career. That will eventually bring a return in value to the country far exceeding the amount spent in such Bursaries.

So much for Bursaries, Studentships and Fellowships. Where are, however, the holders of these to receive the special training which they require? The question is not very immediately urgent for the twenty to twenty-five students, fellows, and holders of Bursaries can be accommodated in four or more of the leading Canadian universities, but if, as is contemplated, the number of Studentships and Fellowships is increased to fifty, and, ultimately, to one hundred, where are these to be trained? Already the Scientific Departments of one of the leading universities are taxed to the utmost to accommodate those students and fellows who have elected to work therein and the accommodation and facilities of another is or will be soon, engaged to the same extent. Shall the excess be sent to the universities of the United States or of Great Britain? To ask this question is to answer it in one respect. It is, however, a problem the solution of which depends on the adoption of a policy demanding the recasting of some of the present aims of our leading universities and a very considerable increase in their resources to make the revised aims effective. The kernel of this problem is the fact that not one of our leading universities is staffed and equipped in science to compare with any one of the ten leading American universities.

12. *Central Information Bureau.*—There is in certain Departments of the Dominion Government and of the various Provincial Governments a large amount of information regarding the natural resources of Canada which is not readily available to those who may desire data regarding the character and distribution of one or more of these resources in the Dominion, with the view to undertaking their development. The inquirer may be forced to go from department to department in Ottawa to get the information he seeks, but in the end may find it also necessary to go to the provincial capitals to complete it, and in consequence a lot of time is thus wasted, which is a handicap and a deterrent to enterprise. The Council believes that the facilities for obtaining readily all this information should be provided in some bureau in Ottawa, organized for this purpose, in which all the data regarding the natural resources available, published or contained in manuscript, documents or memoranda, in the various Dominion and Provincial Government Departments should be pooled, as it were, in a form that will permit an inquirer regarding a subject to ascertain what is known concerning it in a few hours. The Organization Committee of the Council has approached certain of the Departments for the purpose of initiating amongst them a movement to bring about at an early date the establishment of such a Bureau of Information regarding the Natural Resources of Canada.

In this connection the Associate Committee on Mining and Metallurgy passed the following resolution:—

> "Whereas, in the present critical period of industrial readjustment and expansion it seems most important that all information concerning national resources which has been so painstakingly gathered by Government Departments in Ottawa should be quickly and completely available to responsible inquirers planning to build up various industrial enterprises based on the exploitation of these resources; and

"Whereas, such information necessary for the development of a single enterprise often lies in the records of more than one of the Government Departments, so that vexatious and dangerous delays frequently occur in the collection of the necessary data for important projected developments;

"Resolved, by the Associate Committee on Mining and Metallurgy of the Honorary Advisory Council of Scientific and Industrial Research that it is highly necessary that a Central Information Bureau should be established by the Government in Ottawa wherein all the different departments should co-operate to make readily available complete up-to-date information regarding all the natural resources of Canada except those relating strictly to agriculture."

13. *Affiliation with the British Research Council.*—During the past year the Research Council has been in relation with the British Research through attendance at its meetings, as assessors, of Professor J. C. McLennan, O.B.E., F.R.S., and Professor F. D. Adams, F.R.S., members of the Canadian Research Council who have been engaged overseas, the one in directing research work under the Admiralty, the other in directing university courses of instruction for students in the Canadian Army in England and France. Through this connection the Research Council has received the benefit of the experience, on a number of important matters, of the British Council, and it desires to express its appreciation of the privileges accorded its representatives by the latter.

II. THE ESTABLISHMENT OF A NATIONAL RESEARCH INSTITUTE FOR CANADA.

In the report of the Administrative Chairman for 1917-18 the question of the establishment of a Central Research Institute for Canada was discussed at considerable length and the results were summarized in the following extract therefrom:—

"In consideration of these facts which are advanced to show the general agreement as to the urgency for each state to provide for organized research by the establishment of institutes or bureaus for research to assist the development of the industries of each, and also because of the special need in Canada of one such, the Research Council has approved of the proposal that a Central Research Institute be established at the earliest possible date, whose functions will be that of carrying on research not only in pure science in relation to standards of measurements, quality and composition of material, but also in science applied to the industries of Canada."

The Council has had this question under consideration at every meeting held since that report was published and every aspect was thoroughly discussed. It is a question which cannot be ignored, or lightly considered, or postponed, and in consequence it felt that it was necessary to emphasize the urgent need of a Research Institute which would play the part in Canada of a great organization for research like the Bureau of Standards at Washington, or the National Physical Laboratory at Teddington near London. The Council believed that the establishment of a Central or National Research Institute would constitute a factor of overwhelming importance in determining the development of scientific and industrial research in Canada, and that this development must be provided for before anything else in order to enable the Dominion to carry the burden of debt which the war has imposed on it. The Council was of this view over a year ago but it now believes that the question of instituting the proper form of organization to guide research in Canada on its resources and their right and adequate utilization transcends in importance any other question that is before the public to-day.

In view of all this the Council desires to emphasize the necessity of determining what this organization should be. It should be adapted to do what it is designed to achieve. A failure in that respect would entail a double penalty, for not only would resources for the purpose be wasted but, what is more important, the time lost would be irreparable. Several years spent in an unprofitable experiment would put the Dominion behind several decades in the world competition and rivalry in trade and manufacture and, therefore, any scheme of organization that is adopted must be constituted to secure certainty in the attainment of its object.

The Council is strongly of the opinion that the primary and essential part of any organization that should be established would be a National Research Institute which would have as its function not only those of a Bureau of Standards but also those of an institute like the Mellon Institute at Pittsburgh Pa. An institute with such functions would meet the most pressing requirements for the development of our natural resources and make provision for assistance to the industries of Canada in the way of applying the most advanced scientific methods to increase, cheapen, and improve production. It is only in this way that Canada can acquire the means to meet her obligations and consequently the functions referred to are of cardinal importance.

The Council formulated its report on this subject to the Sub-Committee of the Privy Council and to the Reconstruction and Development Committee of the Cabinet in a document which is reproduced in Appendix "J". It recommends the establishment of a National Research Institute for Canada, with the functions as indicated below, located near Ottawa where city water supply and electric power are available and on a site of at least 50 acres to provide space for subsequent expansion and also for additional laboratories which may be required in experimental work on a semi-commercial scale. The building to be provided for on this site should be of the laboratory type, of four stories in addition to basement and of dimensions 200 by 60 by 70 feet in which, besides corridors and office and administration quarters, there would be at least 50 laboratory units of 25 by 25 feet dimensions. This would suffice for immediate needs and for a number of years.

The cost of this building which should be of solid (or steel) construction with cement floors and including heating plant, power equipment, the ventilating outfit, and the water, gas and drainage plumbing, would, it is estimated, be $500,000. The scientific equipment of the building, including the scientific instruments required in the various lines of investigation which would be undertaken, would approximate $100,000. The salaries would require $100,000 per annum for the first few years but only a part of this would be needed during the first year and one of the first appointments made should be that of the Director in order that the plans of construction may be carefully supervised and adapted to the work which the institute may be called upon to do.

The functions in detail of this institute should be:—

(*a*) The investigation and determination of standards and methods of measurements, including length, volume, weight, mass, capacity, time and heat, light, electricity, magnetism and other forms of energy; and the determination of physical constants and the fundamental properties of matter.

(*b*) the standardization of the scientific and technical apparatus and instruments for Government service and for use in the industries of Canada and of the materials used in the construction of public works;

(*c*) the investigation and standardization of the materials which are or may be used in the industries, and of the products of the industries;

(*d*) researches undertaken with the object of improving the technical processes and methods used in the industries and of discovering new processes and methods which may promote the expansion of the existing industries or the development of new Canadian industries;

(*e*) researches undertaken to promote the utilization of the natural resources of Canada.

The institute also should have charge, direction or supervision of the researches which may be undertaken by or for single industrial firms under conditions to be determined in each case, or by such organizations, to be known as Trade Guilds for Research, which may be formed in the various industries with the view of improving the processes of production or the products of those industries, as may desire to avail themselves of the facilities offered for this purpose by the institute.

Such a National Research Institute would have all the functions of a Bureau of Standards and it would provide, as indicated in the foregoing paragraph, free accommodation, light and heat in its laboratory units for the research staffs of those co-operative associations for research formed in the various lines of industry, known as Trade Guilds for Research, which choose to avail themselves of such accommodation on conditions to be determined in each case. It would give the various lines of industry, at a cost which they could afford to pay, opportunities for the application of research to their problems the results of which would enable them to meet the foreign competition in their home markets and permit them to develop and maintain markets for their products outside Canada. It would encourage co-operation for research amongst the firms in each line of industry, to avoid failure or the compulsion to fuse with larger firms which would lessen competition and create powerful trade organizations and combines. There are very few individual firms in Canada, that can provide enough funds to undertake research each on its own problems with the hope of obtaining commensurate results. The rest cannot annually provide, perhaps, on the average, more than would pay the salary of a stenographer but with all such in a particular line of industry co-operating and pooling their funds for research, the Guild for Research so formed, would be in position to profit greatly, if its research staff were housed in one of the laboratory units of the institute and carried on research there under the supervision of the highly qualified technical staff of the institute. Each guild would thus be assured of results of value beyond what its limited resources would otherwise assure it. The free accommodation offered it would be in lieu of very direct financial assistance, such as that given by the Imperial Department of Scientific and Industrial Research to the Trade Associations for Research formed in the same way in Great Britain, a large number of which receive a grant from that department sometimes as much as pound for pound of their own funds. The number of such Trade Associations for Research formed, and in the process of formation, so far number twenty-five and the number of companies involved exceed eight houndred. The majority of these Trade Associations equip and maintain their own laboratories.

An institute with the functions of determining such standards as are referred to above, is urgently needed in Canada. There is no organization that even in a minutely fractional degree meets that need. At present the standardization of scientific apparatus, such as thermometers, pyrometers, electrical supplies and of quality in raw material and manufactured products is done for Canada almost wholly by the Bureau of Standards at Washington. That is the nearest testing house for this purpose and because of that it is resorted to intermittently and unsystematically, whereas if there were one in Canada its very activities, directed to the service of the industries of Canada would in a few years engage the interests of all these and give their products a grading that would make them acceptable in markets abroad. The age of standardization in manufactured products of all kinds is near at hand and to-day foreign governments are preparing for it, purposely in some instance, unconsciously in others, by the establishment of institutes or laboratories to determine standards.

The Dominion Government should, therefore, establish at as early a date as possible a National Research Institute with the functions as outlined. It is necessary to perform a function which private organization or institutions cannot, by reason of its magnitude, perform. It will be of an immense service to the industries of Canada in enabling them to meet successfully the pitiless competition in manufacture and trade in which the great nations must and will engage to pay their debt charges and replenish their resources so seriously reduced by the war.

The state can no longer be indifferent to the necessity for nationally organized research in science. Scientific research is to be henceforth all important in the development and maintenance of national prosperity and it is the State only which can provide for it adequately. The organization required should be what experience abroad has indicated and it should be begun on a more or less modest scale but on a plan that will permit expansion as required. The establishment of a National Research Institute along the lines indicated would accordingly be the first step in the inauguration in Canada of a policy which will ultimately provide for the fullest scientific development of all her resources to enable her to face the future and all its perplexities with some degre of equanimity and prepardness.

APPENDIX A.

ABSTRACT OF THE PROCEEDINGS OF THE FIRST MEETING OF THE ASSOCIATE COMMITTEE ON CHEMISTRY OF THE HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

This meeting was held on May 20, 1918, in Ottawa.

Fifteen out of the eighteen members of the Associate Committee were in attendance. Dr. R. F. Ruttan, the Chairman, presided. The sessions were also attended by Dr. A. B. Macallum, Administrative Chairman; Dr. A. S. Mackenzie, member of the Advisory Council, and Dr. A. McGill, Chief Analyst of the Department of Inland Revenue.

The Chairman gave a brief account of the organization of activities of the Advisory Council, referred to the Studentships and Fellowships instituted by the Council and the various assisted researches. He mentioned that no fewer than 87 questions had been submitted from manufacturers and others. A list of these questions is appended. These inquiries have been largely answered, but many of them required special investigation.

The first regular paper on the programme was given by Dr. John Bates, of the Forest Products Laboratories, on the "Utilization of the Waste Liquors of Pulp Mills for the Production of Ethyl Alcohol and Toluol from Sulphite Turpentine." He pointed out that the process as worked out in other countries gave a yield of about 0·7 per cent of alcohol by volume of the sulphite liquor waste and the process was a comparatively simple one. He pointed out that the turpentine in the wood was largely converted into cymene. A recovery plant for the turpentine of a mill would not cost more than one hundred or two hundred dollars. The average yield was about ·75 U.S. gallons for one ton of sulphite pulp which yields about ·45 U.S. gallons of Toluol per gallon of crude cyamene.

Mr. Wardleworth read a paper on industrial alcohol, its preparation from materials other than foodstuffs and the importance to the industries of the country to have it manufactured and distributed free of duty. After a very full discussion, in which nearly all the members of the Committee took part, together with Dr. A. McGill, who was present to represent the Department of Inland Revenue, the following resolution was unanimously passed:—

> "Whereas the fact that alcohol for industrial purposes, free of duty, has contributed much to the prosperity of several countries, and as Canada has a number of distilleries now lying idle, and as new processes are now available for making alcohol from non-edible materials, and as the Dominion has an

unusual opportunity of extending its industries in many directions, and as a new source of motor fuel is desirable, and as alcohol is not now an unimportant source of revenue,

Be it resolved that the Government be petitioned to permit the use of duty-free alcohol, subject to restrictions which would protect revenue and public safety."

Dr. A. F. L. Lehmann gave an account of the occurrence and value of the Tar Sands deposits of Alberta. The Committee made several suggestions regarding lines of investigation, demonstrating the commercial value of these tar products.

Dr. W. L. Goodwin gave an account of the new methods which were now being tried in order to utilize titaniferous iron ores, of which there are enormous beds throughout Canada. In Eastern Ontario alone there are millions of tons which cannot be utilized by present methods. Dr. Goodwin described certain experiments that had been carried on with a view of preparing pure titanic acid and valuable titanium salts, and also methods for recovering vanadium from ores carrying this material.

Dr. MacLaurin gave an account of his research on the "Utilization of Waste Straw for Gas Production." He pointed out that the gas so obtained had a value of about 400 B.T.U's per cubic foot and that 1,000 to 1,500 cubic feet of gas could be obtained in one operation lasting not longer than thirty minutes. He was investigating at that time the various forms of steel which would be used for the retort.

Dr. Birchard, Research Chemist for the Dominion Grain Laboratory, pointed out the value of introducing a small amount of casein into war bread and bread for the soldiers, increasing in this way, very cheaply, the nutritive value of the bread. After discussion it was resolved to bring this matter before the Food Commission, with a strong recommendation that it be carefully investigated.

At the evening meeting of the Committee, Dr. Bates introduced a discussion regarding the best methods of bringing about co-ordination of the scientific work of the various departments in Ottawa and the advisability of allowing scientific investigators engaged in Government work to patent their inventions. The following resolution was passed after a very thorough discussion, in which the policies of other governments was explained:—

That experts in the Government service be allowed to patent in their own names their discoveries and inventions, provided they assign half of their patent rights in Canada to the Government of Canada, to be devoted to scientific research—the rights outside of Canada to be retained by the patentee."

At the request of the Chairman, Dr. Macallum, Administrative Chairman of the Research Council, brought up for the Committee's consideration, the advisability of establishing in Canada a Central Research Institute analogous to similar organizations which were to be found in Great Britain, United States, Germany, France, Italy and Japan.

Dr. Ruttan pointed out the advantage to the universities of the country and to research in general which would result from the establishment of such a bureau.

Dr. Goodwin expressed a view that the research work should be carried on chiefly in the universities with liberal endowment by the Dominion Government.

Dr. Ellis pointed out the necessity of the universities confining their functions to fundamental matters connected with science, rather than the industrial applications of science.

Dr. MacLaurin, Dr. McGill, Dr. Bates, and several other members of the Committee thoroughly endorsed the general principle of the establishment of a Central Research Institute.

Dr. F. M. G. Johnson pointed out the advantage of a concise inventory of the Canadian chemical industries, their locations, raw materials they use, their products and by-products, so that it might be possible to make a chemical map of Canada. He contended that those in control of the industries of Canada involving chemical

processes were for the most part ignorant of what was going on elsewhere in the country. It was decided to prepare a census of the chemical industries of Canada along lines suggested by Dr. Johnson and that this should be carried out by co-operation between the Society of Chemical Industry, which had already some years ago prepared such a census of the industries, and the Bureau of Statistics at Ottawa.

Dr. Ellis brought forward the question of the establishment in Canada of Fellowships in connection with the Ramsay Memorial Fund which England and the various parts of the Empire were now engaged in collecting. The Honorary Advisory Council was requested to interest themselves in the project. It was decided also to bring the matter before the Conference of Canadian Universities and the Royal Society of Canada.

LIST OF QUESTIONS ANSWERED BY THE ASSOCIATE CHEMISTRY COMMITTEE.

The following questions were received during the year and answered by the members of the Committee on Chemistry with the help of others. Some of them required much time and lengthy correspondence. Over sixty inquiries received the attention of the Committee:—

Composition of gums used on envelopes and stamps.
Condensation of acetylene to benzene.
Utilization of crude argols from the manufacturing of grape juice.
Value of carbon from peat.
Separation of potash salts from certain springs in New Brunswick.
Utilization of saw dust in New Brunswick.
Manufacture of cocoanut oil from copra.
How toluene can be prepared from Cymene and turpentine of pulp mills.
The Grillo process for the manufacture of sulphuric acid.
How to improve the manufacture of fly paper glue.
Use of substitutes for cane sugar in ice cream.
Uses of casein from milk refuse.
How to make a waterproof glue for out door use.
Effect of boiled oil in improving the value of sole leather.
Commercial sources of rare earths for gas masks.
How potassium salts can be obtained from shale used in brickmaking.
Value of alloys of lithium.
Commercial value of an alloy of copper with other metals.
Opinion on value of salts found in a lake in Alberta.
Fibres used in making gas mantles.
Food regulations regarding use of glucose and saccharin.
Manufacture of nitro-cellulose from pulp.
Potassium salts from cement works.
Poison in rubber sealing bands for preserve jars.
Manufacture of picric acid directly from benzene, using nitric acid and mercury.
The kind of kilns in use for burning lime with wood.
Occurrence of radium in waters above Banff.
Utilization of statical electricity for the removal of seeds of weeds from clover, alfalfa, etc.
Amount of cane sugar refined in Canada and crude sugar employed.
Could beet root be grown profitably in Canada?
How to produce smoke signals.
How to make an adhesive that will withstand alcohol and petrolic spirit.
How sandpaper is made.
Manufacture of milk substitutes, chocolate and other food products from soya beans.
Production of oil from walnuts.
Plant required to manufacture anhydrous ammonia.
A stabilizer for an emulsion of oil and milk powder.
How to manufacture aluminum from clay.
The market for acetic acid and sodium bichromate in Canada.
Cause of rancidity of oil in sardines.
Enamelling finish on cement.
Over twenty letters regarding methods of utilization of fish waste and waste fish.
Application of a radio condenser for detecting and indentification of bodies of ore, etc.
How to clean iron-stained granite.
Where to procure hydrogen gas in Canada.
Manufacture of methyl chloride as a refrigerating agent.
Utilization of confiscated opium as a source of morphine.
Value of mixed bessemer slag and ground feldspar as fertilizer.
Where to obtain good iron oxide paint in Canada.
Value of citric acid-soluble potash as a fertilizer.
The course of deterioration of white shellac.
Manufacture of flowers of sulphur from iron pyrites.
Should chlorine be grouped with bromine and iodine and placed on the free list for importation.
Utilization of calcium bimalate (sugar sand).
What are the substitutes for turpentine.
Manufacture of wood veneer and process of veneering.

APPENDIX B.

REPORT OF THE ASSOCIATE COMMITTEE ON MINING AND METALLURGY.

This Committee was organized in the autumn of 1917 but it was impossible to get its members together until March 5, 1918, when two very interesting meetings were held at the Windsor hotel, Montreal, prior to the annual meeting of the Canadian Mining Institute. Seventeen out of a total of twenty-five members were present, and a number of valuable suggestions were submitted to the Advisory Council.

Unfortunately, the Chairman of the Committee, Dr. F. D. Adams, F.R.S., went overseas soon afterward and the Vice-Chairman, Prof. S. F. Kirkpatrick, resigned from the Council, but in spite of these drawbacks the work outlined at the meeting was largely accomplished, although no further meetings were held during the year.

The second annual meeting was held in Montreal on the 4th and 5th of March, 1919, again in connection with the annual meeting of the Canadian Mining Institute. Three sessions in all were held, with an attendance of thirteen members. Owing to the fact that the chairman was still overseas, Dr. A. B. Macallum, Chairman of the Research Council, acted as convener and presided at the first session, at the close of which Dr. J. B. Porter was appointed Acting Chairman to hold office until the return of the chairman.

The following brief statement of the work of the Associate Committee to date may prove of interest.

(1) *Research Council.*—At each meeting a report on the work of the Council was submitted by the Chairman and discussed at length with a view to giving the Council the benefit of the views of the Mining and Metallurgical interests as represented by the Associate Committee.

(2) *Lignite.*—The work of the Lignite Utilization Board was also laid before the committee in the form of a report personally submitted by the Secretary, Mr. Leslie Thompson, and was similarly discussed.

(3) *Peat.*—It has been recommended that the excellent work done by the Dominion Department of Mines on peat and peat products be extended, and a special committee has been formed to take up this matter. The report of this Committee has been received and is being prepared for distribution.

(4) *Iron Ores.*—A Sub-Committee under the chairmanship of Mr. J. G. Morrow has been formed to consider the Canadian ore situation and to recommend such further investigations and developments as may seem advisable. This Committee is now studying the subject and an early report may be expected.

(5) *Refractory Material.*—A sub-committee on Refractories under the chairmanship of Mr. Theo. Denis has been formed, with especial reference to Canadian magnesite and other suitable materials. This committee may be expected to report at an early date.

(6) *Powdered Coal.*—A Sub-Committee under the chairmanship of Mr. O. E. S. Whiteside has been formed to consider the question of the use of Powdered Fuels, and to make recommendations as to the expediency of having special investigations carried out under government auspices, instead of leaving the matter as at present solely to private enterprise.

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(7) *Committee on Co-ordination of Effort.*—A Sub-Committee on Co-ordination was appointed to make recommendations from time to time as to work which it would be advisable for the Associate Committee to undertake.

(8) *Local Committees.*—The members of the Associate Committee were asked to constitute themselves into local committees in the several mining districts to inform the Main Committee as to matters of local interest which required investigation.

(9) *Natural Resources Bureau.*—The question of the advisability of establishing an Information Bureau on the Natural Resources of the Dominion was discussed, and it was resolved that:

> Whereas, in the present critical period of industrial readjustment and expansion it seems most important that all information concerning national resources which has been so painstakingly gathered by Government Departments in Ottawa should be quickly and completely available to responsible inquirers planning to build up various industrial enterprises based on the exploitation of these resources, and
>
> Whereas, such information necessary for the development of a single enterprise often lies in the records of more than one of the Government Departments so that vexations and dangerous delays frequently occur in the collection of the necessary data for important projected developments;
>
> Resolved, by the Associate Committee on Mining and Metallurgy of the Honorary Advisory Council of Scientific and Industrial Research that it is highly necessary that a Central Information Bureau should be established by the Government in Ottawa, wherein all the different departments should co-operate to make readily available complete up-to-date information regarding all the natural resources of Canada except those relating strictly to agriculture.

(10) *Reference Libraries.*—The Committee called attention to the importance of getting together reference libraries in the various centres of industry and recommended that such libraries, or, in their absence, catalogues of reference books already available in public and private libraries should be placed at the disposal of all persons interested in research.

(11) *Standard Reagents.*—The Committee called the attention of the Department of Mines through the Advisory Council to the importance of being able to obtain in Canada standard reagents and standardized samples for metallurgical analysis. Early action has been promised in this matter.

(12) *Steel Making in British Columbia.*—At the suggestion of the members from British Columbia it was recommended that the advisability of establishing a local steel industry in that province be considered. This has been done by the British Columbia Government, and a printed report covering the matter is now available.

(13) *Utilization of Sawdust.*—The possibility of utilizing the immense quantities of sawdust produced in British Columbia and elsewhere has been discussed and brought before the proper authorities.

(14) *Anhydrite.*—The possibility of utilizing anhydrite has been discussed and referred for consideration.

(15) *Barite.*—The possibility of finding a market for Canadian Barite has been similarly discussed and referred.

(16) *Galvanized Scrap Iron.*—Recommendations looking to the use of scrap galvanized iron and tin plate have been acted on by the Advisory Council.

(17) *Other Business.*—Many other matters of interest to the Mineral Industry have been considered and informally dealt with.

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APPENDIX C.

REPORT OF THE BRITISH COLUMBIA HONORARY ADVISORY COMMITTEE OF THE RESEARCH COUNCIL.

(Reported by the Chairman, R. F. Hayward, M.E.I.C.)

At the present time there is no iron and steel making industry on the Pacific coast, but it appears to be the opinion of those in the iron and steel business that there is room for one plant, provided that that plant is assured of the whole of the Pacific coast market, including United States and British Columbia.

Before the United States entered into the war an investigation was being carried out by interests connected with the Utah Copper Company. In the year 1916 they had some large parties in the field making examinations of ore bodies and prospects. They also spent a large amount of money investigating the market and the best site for the establishment of blast furnaces and rolling mills. Such information as they secured is not available, but as far as I can learn they decided that a location in the neighbourhood of Seattle would be best for the establishment of a blast furnace. I understand that sufficient capital was at that time available for the enterprise at such time that they had determined that the market could be properly secured and that there were sufficient ore bodies to work upon. I presume that more will be heard of this enterprise now that the war is over.

In view of the possibility of the establishment of an iron and steel plant in the State of Washington, it is not likely that a similar plant could be established on a proper commercial basis in British Columbia, and there would not appear to be any reason why the Dominion Government should go into such an undertaking itself.

On the other hand, the establishment of a steel-making plant in the Puget Sound district would help the development of industries in British Columbia almost as much as a plant established on this side.

There is still a very large amount of development work to be done with respect to the ore bodies in British Columbia before any plant can be established on the Pacific coast. The report of Mr. W. M. Brewer, issued by the British Columbia Department of Mines in Bulletin No. 3-1917 states as much as is known of the ore bodies but the report shows that no large quantities of ore have been blocked out at any place.

Prof. Turnbull of our committee has undertaken to make a further compilation and report upon the iron ores.

During the war the Panama Canal, on account of the absence of tonnage, has had no effect on Pacific coast business but as soon as shipping is available it will have a profound effect on transportation costs. It will doubtless enable the manufacturers of pig iron to ship their product from the Eastern part of Canada, as well as from the United States to British Columbia at a very low rate, and until it is known to what extent this will reduce prices of pig iron and other steel on the Pacific coast it will be very unwise to enter upon any large iron and steel undertaking.

The iron and steel business in British Columbia must grow from small beginnings and gradually build up.

Small rolling mills have already been established to work up scrap and these will develop with the demand into larger affairs.

The steel and wooden ship building is making large demands for this kind of product and is also filling the boiler shops and machine shops with work of all kinds.

The ship building will, in course of time, drop off to an extent though we believe it will continue as a permanent thing, and the foundries and machine shops, which are

now manufacturing winches and other machinery for ships, will gradually enter into the manufacture of logging machinery, mining and other machinery required for the development of British Columbia and the Pacific North West.

One five ton electric furnace is now producing pig iron from scrap, and a second will shortly be put in service for the same purpose. When the price of pig iron is reduced to normal these furnaces will have to turn to producing steel billets.

A two ton electric furnace for making steel castings and producing tool steel is also being erected.

From these beginnings we expect the iron and steel industry to gradually grow to larger things. We hope it may be possible to start an electric smelting furnace for the magnetite iron ores on a comparatively small scale in connection with other electro-chemical industries as suggested in my report, and if this can be done the iron and steel business will be started on the best possible basis.

The committee on the carbonization of wood waste has not been able to accomplish much as yet. This matter is of very great importance to British Columbia, and should be studied from every possible point of view. I think that any information, of a practical nature, that can be procured should be made available for the people in the lumber and logging industry.

REPORT OF COMMITTEE ON IRON AND STEEL PRODUCTION OF THE BRITISH COLUMBIA HONORARY ADVISORY COMMITTEE OF THE RESEARCH COUNCIL.

Owing to the summer engagements of the members of the sub-committee appointed to report on the economical possibilities of producing iron and steel in British Columbia we have little progress to report.

The British Columbia Committee was requested to take up this question by Dr. Macallum in a letter under date of April 4.

In a letter dated April 17, in reply thereto, your chairman wrote as follows:—

"Investigation into the question of the economical production of iron and steel in British Columbia will probably divide itself into the following heads:

1. Location, quality, and development of the ore bodies, and the probable cost of mining.
2. The coking qualities of local coals.
3. The location, quality and cost of production of limestone and other fluxes.
4. The production and quality of fireclay, firebricks, silica and magnetite.
5. The relative cost of installing steel plants in Vancouver, as compared with other points on the Pacific Coast and Eastern Canada.
6. The cost of labour at the present time and the probable cost in the future.
7. The probable cost of the production of pig iron from blast furnace.
8. The probable cost of the production of pig iron from electric furnace.
9. The cost of power.
10. The market for pig iron on the Pacific Coast and for exportation.
11. The market for rolled section and plates.

At the meeting of the British Columbia Committee on May 16 the following sub-committee was appointed to consider this question:—

Dr. D. McIntosh,
Prof. J. M. Turnbull,
H. R. McMillan,
J. J. Warren,
R. H. Stewart,
R. F. Hayward.

On March 22 there was submitted to the Minister of Mines at Ottawa a memo from a delegation from British Columbia in which is set forth an argument for the establishment of an iron and steel industry in British Columbia. Copy of this is attached. While this memo sets forth clearly the benefits which would ensue if an iron and steel industry could be established in British Columbia, it brings forward no evidence to show that there has been any sufficient development of the ore bodies in British Columbia on which can be based data for the establishment of an iron and steel industry, or that there is any sufficient data of any kind upon which to base the formation of such an industry.

It is clear that a very great deal of expensive scientific investigation will have to be undertaken before any practical consideration can be given to the establishment of the iron and steel industry on a large scale.

The first thing to be done is to determine the extent and nature of the available ore bodies, and any aid that can be given either by the Provincial or the Dominion Government to this work will doubtless produce valuable results.

Such work, however, would take a long time even if a very large sum of money were immediately available, and in the meantime the iron and steel industry in British Columbia can only be expected to start from small beginnings and gradually to grow to larger things.

The most likely direction in which immediate progress can be made is in electric smelting.

There is at the present time only one electric furnace in British Columbia. This is a 5 ton, 3-phase, furnace established at the Port Moody Steel Works by the Aetna Iron and Steel Co., and now being operated by the Columbia Iron and Steel Co. This furnace has been in operation since the end of May. It is producing pig iron from ordinary scrap and the product is being exported to Japan at a price of about $70 per ton. So far the maximum production in any month has been 380 tons, but it is hoped that a steady production of 500 tons per month can be obtained.

The use of an electric steel furnace for such a purpose is clearly only justified by war prices, and high grade steel instead of cast iron will have to be produced after the war.

There is at present no electric steel casting furnace in British Columbia, and in this respect Vancouver is badly behind the times. There is only one steel foundry in Vancouver, and while this is doing good work its product cannot approach the product of the electric steel furnace for castings.

Negotiations are under way, if not concluded, for the establishment of a second electric furnace for the production of pig iron, using part scrap and part ore.

The existing power companies can sell power for melting steel in electric furnaces at a remunerative price which costs the producer about $6 per ton of product for the power used. The amount of power, however, which is required for smelting iron ore is three times as great as is required for melting, and the product for the " after the war " market could not possibly stand a price for power of $6 per ton. On the other hand the existing power supply companies, having been built for general light, power, and street railway purposes, cannot sell power remuneratively at the low price required for smelting iron ore under the conditions of electric smelting which have prevailed up to the present time.

If a high grade steel can be produced in one process directly from the ore, as is being done in the experimental furnace of Dr. Robert in Seattle, it is possible that the electric furnace could pay a price for power which would be remunerative to the existing power companies.

If a process can be made commercially successful whereby the preliminary reduction of the ores can be carried out by reducing gases at low temperature, and reduction can be furnished in the electric furnace, the amount of power required per ton of product will be so greatly reduced that the existing power companies will be able to sell power for electric smelting, on a small scale, at prices which would make smelting

profitable. Furnaces of small capacity could then be established at various convenient points in British Columbia.

If, however, electric power amounting to around 2,000 kwh. per ton of product is required for smelting purposes then it would appear that some one of the numerous power sites on the British Columbia coast will eventually have to be developed for this special purpose.

There are a number of sites on Vancouver Island, and along the coast between Vancouver and Prince Rupert, where power can be developed as economically (considering differences in cost of material and labour), as any power development that has been made in Norway or Sweden. These power sites are situated at tide water where ore, limestone, coke and other raw matrials can be delivered at low cost, and the product can be shipped from the works in ocean going vessels at any time of the year.

Such power, however, cannot generally be economically developed unless the plant is built to the fullest possible capacity at the start. This usually involves an investment that is too large for any small commercial undertaking. If, however, there could be established a group of industries for the electric smelting of iron, ferro-manganese and other metal products, for the production of nitrates, calcium carbide and other electro-chemical products a sufficient demand for power would be created to make it possible to take full advantage of the economical value of the power sites along this coast.

It appears to be quite possible that such an undertaking might be commercially successful either under war, or after the war, conditions, and it is suggested that further investigations along these lines would be of value.

At the instance of the Provincial Minister of Mines, Dr. A. Stansfield, Professor of Metallurgy, McGill University, came to British Columbia in June to make an investigation of the whole subject, and when his report is published there is no doubt that much further light will be thrown upon the problem, and that your Committee will be able to see more clearly the direction in which it could make effective investigation.

APPENDIX D.

THE PETAWAWA FOREST SURVEY FOR 1918.

During the past year the Dominion Forestry Branch continued the detailed forest survey of the Petawawa Military Reservation, which was begun late in the season of 1917. The appropriation for the work was made by the Honorary Advisory Council for Scientific and Industrial Research at the request of the Dominion Forestry Branch of the Department of the Interior. We fully realize the great importance of studying the scientific principles of forestry to determine what may be applicable to Canadian conditions, and the permission granted to the Forestry Branch of the Department of the Interior by the Department of Militia and Defence to carry on silvical studies and silvicultural experiments on a portion of the Petawawa Military Reservation was greatly appreciated. Thus it will be seen that a system of co-operation between the Council, the Dominion Forestry Branch and the Department of Militia and Defence has been introduced by which the military reservation is made a Dominion Forest Experiment Station.

Before a comprehensive plan for the intensive management of the reservation and for the setting aside of experimental areas for the purpose of studying and demonstrating different systems of silviculture can be properly drawn up, full information in regard to the topography and the conditions of soil and forest cover must be secured.

The forest survey is gathering the necessary data through a systematic examination of the area. A map is being prepared showing topographical features, boundaries

of forest, and soil types and distribution of age classes. Careful descriptions are made of the various soil and forest types which are met with; the character of the ground cover is studied; the timber is estimated in cubic feet, cords or board feet; data are being collected for the preparation of volume and growth tables; damage by insects and fungi and from other causes is studied and described, etc.

In addition, a beginning has been made to study, through repeated observations on permanent sample plots which have been laid out, such important subjects as natural reproduction after fire and logging, the effect of thinnings of different methods and grades, and yield in fully stocked stands of various species and ages on different classes of site.

The report of the officer of the Forestry Branch who was in charge of the forest survey during the past season has now been received, and, while no decision concerning the future silvicultural management of the forest reserve can be arrived at before the survey has been completed and all data carefully compiled and considered, it may be of interest to readers of this report to have presented to them in brief how the Petawawa Military Reserve is described by the chief of the survey party.

The Petawawa Military Reservation covers an area of approximately 150 square miles. It is situated west of the Ottawa River and is bounded on the south by the Petawawa and Barron Rivers. The north boundary follows in the main the Chalk River Settlement and Corry Lake.

The whole of the tract has been lumbered over on various occasions. The southern section tributary to the Petawawa River was cut clean and mostly burned over some sixty years ago. The northern section tributary to Corry Lake was logged over 20 to 30 years ago. Practically all of the reserve has been burned over during the last 60 to 75 years. Due, therefore, to lumbering and fires, there is very little mature timber to be found. Except on areas which have recently been fire swept, however, forest cover has been established in a more or less satisfactory manner. The species reproducing are not always the most desirable ones, but the density is, as a rule, fairly good, if not entirely satisfactory.

Topography.—The elevation of the entire tract varies from 475 to 900 feet above sea level. The surface of the tract is rolling. All elevations are capable of good tree growth although on some ridges the soil is very scanty due to repeated fires. Most of the higher altitudes are covered by a fairly complete cover of red oak which does not reach merchantable size, but which preserves and improves the site very well. White pine reproduction appears to thrive under its shade.

There are numerous lakes in the area examined but with two or three exceptions they are all very small and of but little importance.

Forest Cover.—The forest cover is made up of a great number of species. Numerically, the most important are white pine, red pine, jack pine, white spruce, black spruce, balsam fir, aspen, white birch, yellow birch, red maple, sugar maple, beech, red oak, iron wood. Other species found are bass wood, mossy cup oak, black ash, white ash, white elm, hemlock, cedar, tamarack, silver maple, moose maple, large toothed aspen, mountain ash, black cherry, bird cherry.

These species form a number of types which are found more or less intermixed over practically the whole area. The forester in charge of the survey describes the following main forest types:—

1. *White and Red Pine Types.*—Stands of both red and white pine are found almost pure; as well as stands of the two species mixed in all proportions. Practically all stands of this type are less than sixty years old.

2. *Spruce and Balsam.*—Similarly to the manner in which white and red pine are found in all proportions, so spruce and balsam exist. Unfortunately, balsam is numerically superior.

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3. *Tolerant Hardwoods.*—This type comprises those stands the composition of which is largely made up of such hardwoods as maple, basswood, iron wood, yellow birch and beech. These species are prolific seeders and tolerant. Especially is this true of the maple, and it is those qualities that render this type a menace to the reserve. For a great part of the reserve water is the only feasible transport. Consequently, the hardwood species cannot be readily marketed. The tolerance and seeding habits of these species render them difficult to eradicate. They very often reproduce beneath the more open stands on the best sites and gradually usurp the territory.

4. *Jack Pine Types.*—This type is found in the most sandy soils especially in the eastern and southern portions of the reserve. The jack pine is often found in mixture with red pine and sometimes with white pine or with both. Jack pine should be ranked only as a temporary type to be superseded by red pine at as early a date as possible under the plan of management adopted.

5. *Poplar and Birch Type.*—Just as in the case of red and white pine, and spruce and balsam, these two species mix so readily and change their percentage composition so gradually that it is quite impossible to map them separately. Their range of sites is greater than that of any other type, but on the good sites poplar is usually the more numerous, while on the poorer sites birch predominates. Poplar and birch are but temporary types and should be replaced by better species when they are removed. However, their crowns are thin enough to permit even white pine and red pine to seed in beneath if the site is adapted to them. Often a complete cover of spruce and balsam or even white and red pine was found as an undergrowth in this type. The area covered by this type is greater than that of any other.

The site classes are given as follows:—

Site I. *Sand Loam Valley.*—Generally occupied by poplar and birch type. Potential white spruce site, but the spruce is very rare, probably due to fires.

Site II. *Sand Loam Slopes and Low Hills.*—Generally occupied by birch and poplar with undergrowth of white and red pine or by nearly pure stands of white pine. Potentially this is a white pine site.

Site III. *Sand Plain of Dune Sand.*—Jack pine is the dominant species but stands of red pine exist, which show remarkable growth and health.

Site IV. *Ridges*—Stands of white pine. Red oak often takes possession of the soil after fires but white pine seeds beneath it and appears healthy. On the rockiest ridges jack pine is sometimes found in dense stands.

Site V. *Muskegs and Swamps*—Some of the drier muskegs contained valuable stands of spruce or white pine which had been only lightly culled by the loggers.

Underbrush and Ground Cover—With but a very few exceptions the timbered stands have considerable underbrush and ground cover present. The exceptions are overcrowded stands or those of full density. On the drier locations where the stand is open, as for instance in the eastern portion of the reserve, the ground cover is composed principally of bracken, *(Pteris aquilina),* sweet fern *(Myrica asplenifolia),* blueberry, raspberry, strawberry, sheep laurel *(Kalmia angustifolia).* On the somewhat better sites when the stand is open, hazel is found in mixture with bracken. When the stand is dense or fairly dense white pine or red pine, the ground cover is very sparse. The principal plants found, according to the report of the forester in charge of the sample plot work, are wintergreens *(Pyrola secunda, Pyrola elliptica, Pyrola americana, Moneses uniflora),* Prince's pine *(Chimaphila umbellata),* Checkerberry *(Gaultheria procumbens),* Bunch berry *(Cornus canadensis), Maianthemum Canadense,* Partridge berry *(Mitchella repens), Linea borealis, Waldsteinia fragarioides,* June berry *(Polygala paucifolia),* and a few others.

In fresh or moist situations and hardwood stands are found hazel, striped maple, moose maple, arrow-wood *(Viburnum),* leatherwood or moose wood *(Dirca palustria),*

Dogbane *(Apocynum),* various ferns, violets, several species of the lily family, among others, Indian cucumber root *(Medeola virginiana),* Solomon seal *(Polygonatum), Maranthemum, Trientalis americana, Clintonia borealis,* several asters, Ginseng and many others.

When no crown cover exists on moist or wet soils, alders flourish in dense thickets from six to twelve feet in height.

Biological and Physical Injuries.—Since most of the stands are comparatively young and quite thrifty, they are to a large extent free from biological injuries. Each species, however, has its enemies present, although the attacks in most cases are very local. White pine is threatened when young by the white pine weevil (Pissodis strobi), especially in pure stands.

Balsam, although at present little affected, is menaced however, by a heart rot. Several cases of extreme infection were noticed but they were in trees approximately sixty years old which had suffered from suppression.

Poplar is also to some extent damaged by heart rot, but the cases are usually found on dry situations where the power of resistance is not very great.

Many attacks on young red pine by a sawfly *(Lophyrus pini),* were noticed. No serious damage appears to have been done however.

The report of the examining forester also contains many tentative recommendations in regard to the silvicultural treatment of the various types and stands. The matter is not however, taken up for discussion by the Forestry Branch this year as it is considered advisable to first complete the survey so that the final report and maps will be available. Furthermore the study of growth and volume must be carried on for another season or two before sufficient data will be on hand on which to base future recommendations in regard to the silvicultural treatment of the individual forest types.

It is expected that the survey will be completed during the season of 1919.

APPENDIX E.

SPECIAL REPORT ON THE OPERATIONS OF THE LIGNITE UTILIZATION BOARD SINCE ITS INCEPTION, OCTOBER 1, 1918.

At the first meeting of the Research Council, held in Ottawa on December 4-6, 1916, a lignite committee was appointed, consisting of Mr. R. A. Ross (Chairman), and Drs. Adams, McKenzie and Murray. The urgency of the existing fuel situation prompted the Research Council to appoint this committee, and the passage of time has but served to emphasize the need for a successful solution of the lignite question among the other Canadian fuel problems. The situation confronting the committee at that time was briefly:—

Western Canada had been importing about 500,000 tons of anthracite from Pennsylvania, at a cost of approximately $5,000,000 per annum. This was in spite of the fact that underlying certain parts of Saskatchewan and Alberta there are immense deposits of lignite coal, which, owing to their peculiar characteristics, had not been scientifically developed. It was becoming increasingly evident that the anthracite supplies in the United States, apart altogether from the question of wartime demands, were rapidly reaching a point where their complete exhaustion was within view. Under such circumstances it would be folly for Canada to expect the United States to ship anthracite beyond its borders indefinitely, and any step to make Canada self-supplying in the matter of fuel would not only tend to satisfy national aspirations, but

would also be a measure prompted by such elementary considerations as climate, exchange, balance of trade, shipping, etc. It had been repeatedly shown in laboratory tests that in spite of their peculiar characteristics, the Saskatchewan lignites were capable of being developed by carbonization and briquetting into a fuel that is a practical equivalent of anthracite. It remained, therefore, for the Research Council to present to the Government figures showing that this scheme contained more than a strong probability of commercial success.

After thoroughly threshing out the whole question, the Committee presented its report to the Research Council, and in June, 1917, the Council brought the matter to the attention of the Government.

The report showed clearly that, making no allowance whatever for the value of any by-products that might be recovered, carbonized briquettes could be produced at the plant for approximately $7 per ton. This figure included overhead charges, depreciation, etc., but did not include any profit. The ruling price for anthracite throughout this region was, in pre-war times, $10 to $15, and when it is remembered that these briquettes will be the approximate equivalent of anthracite in heating value, the saving to the consumer will be self-evident.

The report recommended that a plant having a capacity of 30,000 tons per annum be laid out and erected, with the proviso that for the trial period only one carbonizing oven be installed, thus reducing temporarily the capacity to 15,000 tons, and deferring the purchase of the second oven until commercial tests on the first had demonstrated its entire suitability.

The report further recommended that owing to the nature of the undertaking, the necessary capital should be supplied by the Government, but that the handling of the project should be entrusted to an independent commercial board.

As a result of the above-mentioned efforts of the Research Council, the Government, on the 20th of March, 1918, passed an Order in Council recommending that an agreement be prepared by the Minister of Mines which would unite the Dominion Government and the governments of the two provinces, Manitoba and Saskatchewan, in a joint lignite undertaking. This agreement was drawn up and signed on the 20th of July, 1918. By its terms, the three governments agreed to set aside the sum of $400,000—$200,000 from the Dominion and $100,000 each from the two provinces concerned. The carrying out of the undertaking was to be entrusted to a board of three members without salary, who would have complete charge of the whole project, this board to be known as the "Lignite Utilization Board." The agreement having been signed, the Government, by Order in Council of the 2nd of August, 1918, appointed Mr. R. A. Ross, of Montreal, as Chairman, and Mr. J. M. Leamy, of Winnipeg, and Mr. J. A. Sheppard, of Moosejaw, as the remaining members of the Board.

The first meeting of the Lignite Utilization Board took place in Montreal on September 16th, 1918. At this meeting a rough programme of operations was tentatively adopted. This programme comprised five distinct steps.

(i). A period of investigation into commercial practice on coal distillation, briquetting and other subjects related to the proposed lignite industry. These investigations would also include a thorough examination of each and every scheme or suggestion that had been brought to the attention of the Research Council during the two years preceding the appointment of the Board. Time estimate for this period, 6 to 8 months.

(ii). A designing period, during which the plant layouts will be made, machinery purchased and plant constructed. Time estimate for this period, 12 months.

(iii). A period of commercial adjustment in order to determine the best mixtures, heats, etc., necessary to produce a commercial product. Time estimate for this period, 6 months.

(iv). A commercial operating period, during which the product will be marketed through the ordinary channels of trade. Time estimate for this period, 6 months.

(v). The last duty of the Board will be to present a complete report giving full details of capital costs, operating and fixed charges, etc., etc.

The meeting of the Board was held on September 23rd, and at this meeting arrangements were made to acquire offices in Montreal, engage the technical staff and attend to all matters of business routine. On October 1st, the Board commenced its actual operations, the following staff having been appointed:

R. DeL. French ..... Engineer
Edgar Stansfield ..... Chemical Engineer
Lesslie R. Thomson ..... Secretary

On November 11th, Messrs. French and Stansfield left Montreal on their long tour of investigation, which was undertaken in conformity with the aims laid down in the investigatory period of the tentative programme. It had been hoped that as a result of their investigations, Messrs. French and Stansfield would be in a position to recommend the immediate purchase or design of each piece of apparatus required. But the Board's hopes in this matter were not realized, for though the briquetting difficulties had been practically solved, the knowledge and experience of the commercial carbonization of lignite were very meagre.

As a result of the situation outlined in the preceding paragraphs, and in order to avoid any waste of money on capital equipment ultimately proving valueless, the Board decided to instal in Ottawa a series of small commercial units; and to date, a press and mixer have been purchased and a special type of retort, new in principle, has been developed by Mr. Stansfield and is now partially completed. This experimental work is being carried on in a special shed erected by the Lignite Utilization Board in connection with the Fuel Testing Station, through the courtesy of the Mines Branch, Department of Mines.

The present situation may be epitomized in a word or two. The Board is determined not to spend one dollar on capital equipment until its experimental investigations in Ottawa demonstrate clearly the success of any proposed process or apparatus. To that end, it has initiated in its experimental plant in Ottawa investigations on the following matters:—

1. The weathering and storing qualities of lignite.
2. The heat of carbonization.
3. Rate of carbonization.
4. Atmosphere in retort during carbonization.
5. Special retort of new type developed by the Board.
6. Briquetting investigations covering:
   (*a*) Material
   (*b*) Degree of fineness
   (*c*) Binders
   (*d*) Mixers and presses.
7. Smokelessness.
8. Tests of finished briquettes.

In spite of long delays in delivery of certain apparatus, it is hoped that by August 1st results will have been obtained in a sufficient number of the above listed experiments to enable the Board to carry out its original programme of letting contracts and starting building operations before the winter of 1919-20. To date, the work is progressing satisfactorily, and results of great value have already been recorded.

In closing this summary, the undersigned wishes to record the Lignite Board's appreciation of the co-operation of the Mines Branch, Department of Mines.

(Signed) LESSLIE R. THOMSON,
Secretary.

Montreal, May 17th, 1919.

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APPENDIX F.

GENERAL REGULATIONS

GOVERNING

The award of Bursaries instituted by the Honorary Advisory Council for Scientific and Industrial Research.

1. These Bursaries are intended, not to facilitate attendance on ordinary collegiate studies, but to enable students, who have passed through a college curriculum and have given distinct evidence of general ability, and, especially, have won distinction in scientific study during their undergraduate course, to continue the prosecution of science with the view to aiding its advance or its application to the industries of the country. These Bursaries are open to men and women. Only ten will be awarded for the year 1919-20.

2. The Bursaries are each of the value of $500 for one year.

3. A student holding a Bursary who shows distinct evidence of capacity for original research may be given a studentship at the end of his tenure of the Bursary.

4. Application for a Bursary must be made by the candidate to the Advisory Council. He shall, with his application, submit a complete record of his academic career and recommendations from the president of his university or institution, the head of the department with which he was connected, and the chief scientific instructors under whom he studied, showing that in their estimation he promises to be worthy of training for scientific research. He shall state the institution at which he prefers to study and the general line of work to be followed. The application will be considered and decided upon by the Advisory Council or by a special committee appointed by the same.

5. The candidate must be a British subject, resident in Canada and a graduate in Arts or Science of a recognized Canadian University or college and must be between the ages of nineteen and thirty. He must have attained a high general academic standing, and especially in the scientific subjects of his undergraduate course.

6. The departments of science in which excellence in scientific study will be considered are: Biology, Chemistry, Physics, Mineralogy, Geology, Metallurgy, and Engineering.

7. Bursaries may be held at any Canadian university or institution approved by the Advisory Council.

8. The principal work of the holder of a Bursary must be a research in some branch of science.

9. Holders of Bursaries are required to devote themselves for a period of at least nine months of each year wholly to the objects of the Bursaries, and are forbidden to hold any position of emolument or to engage in teaching.

10. Holders of Bursaries are required to furnish to the Advisory Council reports of their work at the end of each half-year of the tenure of their Bursaries.

11. The Bursary stipend is payable in two equal instalments, on September 15th and February 1st.

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APPENDIX G.

ASSISTED RESEARCHES.

Name.	Subject of Research.	Amount.
Forestry Branch, Dept. of Interior	Petawawa Forest Survey	$6,214 57
Prof. W. P. Thompson	Investigation on genetics of wheat	4,500 00
Prof. A. Stansfield	Investigation on reduction of iron ores by gases at low temperature and the electric furnace.	2,500 00
Prof. V. K. Krieble	Investigation on character and amount of sugars in sulphite liquor from pulp mills, with a view to utilization of thess sugars in manufacture of industrial alcohol.	200 00
Prof. C. V. Christie	Determination of the dielectric constants and dielectric strength of materials to be used for insulation of high voltage cables and their variations with increased temperature and varied voltage, frequency and humidity.	250 00
Dr. J. B. Tingle	Preparation of acetic anhydrides and polynitro phenols	1,200 00
Dr. J. B. Porter	Flotation of Canadian ores by waste oils from wood distillation.	1,500 00
Prof. L. Bourgoin	Utilization of ultra-violet rays	1,185 00
Dr. L. V. King	Experiments on fog signalling apparatus	500 00
A. T. Stuart	Investigation on unit storage battery on laboratory scale of the oxy-hydrogen type.	2.000 00
Engineering Standards Association	Canadian Engineering Standards	2,480 00
Biological Board of Canada	Research on chemistry and bacteriology of fish curing	7,000 00

APPENDIX H.

LIST OF STUDENTS AND FELLOWS.

FELLOWSHIPS.

Name.	Where Held.	Subject of Research.
W. H. Hatcher	Chemistry Department ... McGill University.	Preparation of Pure Concentrated Solutions of Hydrogen Peroxide.
W. F. Seyer	Chemistry Department ..... McGill University.	Properties and Composition of the Substances obtained from Tar Sands together with their commercial application.
O. J. Walker	Chemistry Department ..... McGill University.	Study of Conditions that effect vulcanization of rubber.

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APPENDIX H—*Concluded.*

STUDENTSHIPS.

Name.	Where Held.	Subject of Research.
D. G. MacGregor	Chemistry Department. . . McGill University.	Separation of the Products of Distillation of Coal in the manufacture of coal gas with special reference to separating the phenols and allied substances from weak bases, such as pyridin, etc.
Miss M. Newton	Macdonald College, P.Q.	Resistance of various varieties of wheat to the form or forms of *Puccinia Graminis* found attacking wheat in the grain-growing regions of Canada.
Miss E. Shanly	Pathology Department. McGill University.	Growth at low temperatures of bacteria from frozen fish.
H. A. Braendle	Physics Department Toronto University.	Elasticity of non-isotropic samples of crude rubber along different directions and to determine the relation of this property to the swelling in different directions.
W. W. E. Ross	Physics Department Toronto University.	New method for determining the size of the change on a colloidal particle and the mass of the particle.

APPENDIX I.

PUBLICATIONS OF ADVISORY RESEARCH COUNCIL.

REPORTS.

Report No.	Title.	Author.
1	The Briquetting of Lignites	R. A. Ross, E.E.
2	The Recovery of Vapours from Gases	Harold S. Davis, M.A., Ph. D. and Mary Davidson Davis, B.A.
3	The De-tarring of Gas by Electrical Precipitation	J. G. Davidson, Ph. D.
4	Nicotine and Tobacco Waste	A. D. Hone, M.A.
5	Canadian Waste Sulphite Liquor as a Source of Alcohol.	Vernon K. Krieble, M.A.
6	An Investigation into the question of early Putrefaction of Eviscerated Fish in which the Gills have been left.	Louis Gross, M.D.

BULLETINS.

Bulletin No.	Title.	Author.
1	The Need for Industrial Research in Canada	Frank D. Adams, Sc. D., LL.D., F.R.S.
2	Researches on Sound Measurement	Louis V. King, M.A.D. Sc.,
3	How to Handle Frozen Fish	E. E. Prince, D. Sc., LL.D.
4	Hints on Frozen Fish	E. E. Prince, D. Sc., LL.D.
5	Science and Industry	Prof. J. C. Fields, Ph. D., F R.S.
6	The Heating of Houses, Coal and Electricity compared.	A. S. L. Barnes.

APPENDIX J.

CENTRAL INSTITUTE FOR RESEARCH FOR CANADA.

The Recommendation thereon from the Honorary Advisory Council for Scientific and Industrial Research.

The Honorary Advisory Council for Scientific and Industrial Research has for the last year and a half given careful consideration to the question of founding a Central Institute for Research which would serve as a laboratory for standards and also for investigations of Canadian raw material, industrial processes and manufactured products and thereby greatly aid in the development of Canadian industry and the effective utilization of the natural wealth of the Dominion.

The fact that a number of governments, British and foreign, have founded organizations with similar or approximately similar functions is indicative of their importance as factors in the development of national industry. The Bureau of Standards at Washington, for which Congress annually votes large appropriations, besides serving as a national laboratory for standards of all sorts, physical, electrical, metallurgical and chemical, undertakes research in conjunction with the industries, the development of which it strives to assist by experimental investigations of their raw materials, their processes of manufacture and their products. The National Physical Laboratory at Teddington, near London, which now has an annual budget of over £150,000, nearly parallels the Bureau of Standards and functions also as a laboratory for research for the industries in mechanical, physical, electrical and metallurgical lines. The Royal Physical Technical Institution (Physikalish-Technische Reichs-Anstalt) at Charlottenburg, the Bureau of Standards for Germany, amply supported by the German Government, was of immense service to German industry before the war. A Chemical Institute (Chemische Reichs-Anstalt) at Dahlem, also supported by the same government, concerned itself, amongst other lines of chemical investigation, with researches on the raw materials and processes of German chemical industries.

The foundation of like organizations is proposed by other governments. A fund of $2,600,000 (5,200,000 yen), of which $1,000,000 has been voted by the Japanese Parliament, $500,000 granted by the Emperor, and the remainder given by private parties and institutions, has been obtained for the establishment, at Tokio, of a National Laboratory for Scientific and Industrial Research, which will have all the functions, on the one hand, of the Bureau of Standards at Washington, and, on the other, of an industrial research institute like the Mellon Institute at Pittsburgh, Pa. The French Government has now under consideration a report of the Academy of Sciences recommending the foundation of a National Research Laboratory for France. The Australian Advisory Council of Science and Industry has recommended to the Commonwealth Government the establishment of an institute for science and industry, in which will be comprehended national laboratories "for special purposes of research and experimental inquiry, including a physical laboratory for testing and standardizing purposes," with which the present government laboratories should be co-ordinated.

There is now under consideration a proposal to establish, in the Imperial College of Science and Technology at Kensington, a research department which will concern itself with fuels, wood and coal, distillation products, refractories, ceramics, chemicals and animal and vegetable products.

The existence of a very large number—more than two thousand is one estimate—of research laboratories in connection with large industrial concerns in the United States is also indicative of the importance there conceded to organized research in

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industrial development. There are more than fifty individual firms in the Union each of which annually expends sums ranging from $25,000 to $500,000 for research. The number of research laboratories in connection with the industries in Canada, adequately maintained, is almost negligible, due in large part to the smaller amount of capital employed in the great majority of the Canadian firms.

The interests of Canadian industries, in view of the keen competition from abroad to which they are, and will be, exposed, render imperative the application of the most advanced technical and scientific knowledge derived from research to their own problems of raw material and industrial processes. Their competitors abroad are employing, and will employ, for this purpose all the resources that research can or will furnish. They cannot, therefore, in order to succeed, do less than their rivals. To be wholly effective in this way they must combine, as the British industries, under the auspices of the British Research Council are now doing, to form trade associations or guilds for research, to which the Government should extend aid. The British trade associations for research are, in the great majority of cases, assisted by direct grants from the Imperial Department of Scientific and Industrial Research. The Research Council believes that the assistance which the Government could most wisely give such guilds should be in the form of free accommodation in laboratories of a central research institute, for their research staffs, for the salaries of which they will themselves be responsible.

The formation of guilds in the leading Canadian industries practically depends on the establishment of such an institute, as otherwise they could not find the funds to provide their own laboratories, since all their resources pooled for research would be sufficient only for the staffs for research which they would engage.

The Council accordingly strongly urges the establishment of a Central Research Institute with the functions of a Bureau of Standards, and with such ample accommodation and equipment for research as the various guilds for research, which may be formed in the Canadian industries, may require.

The Council is of the opinion that the building which would accommodate the institute should be constructed to meet immediate needs and yet be planned so as to admit additions or alterations of the basis of its construction or management, such as the future may render imperative. The immediate needs concern all the standards of measurement and materials used in the industries, and also the industries themselves in the various lines of which guilds for research are being promoted, which would require the accommodation the building proposed would provide for them.

The Building which the Council recommends is one of the Laboratory type, of four stories in addition to basement, and of dimensions 200 x 60 x 70 feet, in which, besides corridors and office and administration quarters, there would be at least 50 laboratory rooms of 25 x 25 feet dimensions. This would suffice for immediate needs and would serve for a number of years. In order to provide room for expansion and also additional laboratories which may be required in experimental work carried on on a semi-commercial scale, it should be located on a site fifty acres in area, at or near Ottawa, preferably in the immediate neighbourhood of the Experimental Farm, where city water supply and electric power are available.

The building should be of solid (or steel) construction and with cement floors. The cost of construction, it is estimated, would be $500,000. This would include the heating plant and the power equipment, as well as the ventilating and the water, gas and draining plumbing.

The cost of the scientific equipment of such a building would be approximately $100,000. This sum would be needed to provide the scientific instruments required in the various lines of investigation which would be undertaken.

The salaries would be about $100,000 per annum, but only a small part of this would be needed during the first year. The Director of the Institute should be appointed before construction begins, in order that the plans of construction may be carefully supervised and adapted to the work which the Institute may be called upon to do.

The Governing body of the Institute should be the Research Council, which, subject to the approval of the Sub-Committee of the Privy Council for Scientific and Industrial Research, would make all appointments to the staff and determine the salaries of the same.

In order to make this control complete and provide for the most thorough-going efficiency of the Scientific Staff of this institution, a slight amendment of the Act of Parliament creating the Honorary Advisory Council for Scientific and Industrial Research may be necessary.

APPENDIX K.

DRAFT OF PROPOSED RESEARCH INSTITUTE ACT.

1. This Act may be cited as the "Research Institute Act."

2. There shall be established at or in the vicinity of Ottawa a National Research Institute, hereinafter called the "Institute."

(1) This Institute shall have charge of:

(*a*) the investigation and determination of standards and methods of measurements, including length, volume, weight, mass, capacity, time and heat, light, electricity, magnetism and other forms of energy; and the determination of physical constants and the fundamental properties of matter.

(*b*) the standardization of the scientific and technical apparatus and instruments for Government service and for use in the industries of Canada and of the materials used in the construction of public works.

(*c*) the investigation and standardization of the materials which are or may be used in the industries, and of the products of the industries.

(*d*) researches undertaken with the object of improving the technical processes and methods used in the industries and of discovering new processes and methods which may promote the expansion of the existing industries or the development of new Canadian industries.

(*e*) researches undertaken to promote the utilization of the natural resources of Canada.

(2) The Institute shall have charge, direction or supervision of the researches which may be undertaken by or for single industrial firms under conditions to be determined in each case or by such organizations, to be known as Trade Guilds for Research, which may be formed in the various industries with the view improving the processes of production or the products of these industries, as may desire to avail themselves of the facilities offered for this purpose by the Institute.

3. The technical staff of the Institute shall consist of a Director and such scientific and technical officers as may be necessary for carrying on the work of the Institute. They shall be appointed by the Honorary Advisory Council for Scientific and Industrial Research, hereinafter called the Research Council, and shall hold office on such terms and with such salaries as the Research Council may define or establish, subject to the approval of the Sub-Committee of the Privy Council for Scientific and Industrial Research, hereinafter called the Sub-Committee.

4. The control and direction of the work of the Institute shall be exercised by the Research Council through the Director, or, in case of illness, suspension or absence of the Director, or in case of a vacancy in the office of Director, through an acting Director temporarily appointed by the Research Council.

5. The Director shall devote the whole of his time to his duties as Director of the Institute in its various departments, and shall report to the Research Council on the work of the Institute from time to time or when called upon to do so. He shall have

the right to be present, as assessor, and without the right to vote, at all meetings of the Research Council while matters affecting the work of the Institute may be under consideration.

6. The Research Council may suspend the Director or any officer of the Institute from his office for incapacity, incompetency or misbehaviour, and, after full inquiry and for cause, may dismiss such suspended Director or officer, subject to the approval of the Sub-Committee.

7. The money annually appropriated by Parliament for the work of the Institute, or which the Council may receive through bequest, donation or otherwise, shall be expended under the direction of the Research Council, subject to the approval of the Sub-Committee, for the carrying on of the work of the Institute.

8. The Research Council, established under Chap. 20, 7-8 George V, is hereby constituted a body corporate, capable of suing and being sued, of holding lands, tenements, hereditaments, goods, scientific apparatus, chattels and any other property for the purpose of and subject to this Act. It shall have power to acquire by gift, grant, bequest or otherwise, any such property or money, or securities, for the purpose of this Act and subject to the approval of the Sub-Committee, to agree to any conditions of such gifts, grants or bequests.

9. All discoveries, inventions and improvements in processes, apparatus or machines, made by the members of the Scientific and Technical Staff of the Institute shall be vested in the Research Council and be made available under such conditions and payment of fees or royalties or otherwise as the Research Council may determine, subject to the approval of the Sub-Committee. The Research Council, with the approval of the Sub-Committee, may pay to scientific and technical officers of the Research Institute and to others working under its auspices, who have made valuable discoveries, inventions or improvements in processes, apparatus and machines, such bonuses as, in its opinion, the commercial or industrial value of such discoveries, inventions or improvements may warrant.

10. When for the sake of efficiency or economy, or for the purpose of preventing overlapping of effort in the scientific work of the various departments of the Government, or in the scientific work of the various commissions and boards constituted by the Government, it may be found desirable to provide that such scientific work shall be carried on in the Institute under conditions to be approved of by the Research Council, appropriate action thereto in each case may be taken by the Research Council when directed and empowered to do so by Order in Council.

11. There shall be a committee, to be called the Advisory Committee, to consist of not more than fifteen members, constituted as follows: One representative each of the Canadian Mining Institute, the Engineering Institute of Canada, the Canadian section of the Society of Chemical Industry, the Royal Society of Canada, the Royal Canadian Institute, the Manufacturers' Association, organized labour, and such organizations as may be recognized for this purpose by the Sub-Committee and three representatives of the Canadian Universities' Conference. This Advisory Committee shall meet at least annually to consider the work done by the Institute and report thereon to the Research Council and the Sub-Committee such recommendations regarding the work, or the organization, or both, of the Institute as it may deem advisable.

12. All the receipts and expenditure on behalf of the Institute shall be subject to examination and audit by the Auditor General and the Administrative Chairman shall submit a statement of such receipt and expenditure to the Sub-Committee at such times and containing such details as the Sub-Committee may prescribe. A detailed statement of all such receipts and expenditure during each fiscal year shall be laid before both Houses of Parliament within fifteen days from its opening.

13. A report of the work done by the Institute, containing such information and details as the Research Council and the Sub-Committee may require, shall be made by the Director to the Research Council and through the Research Council to the Sub-Committee after the close of each fiscal year, and the said report shall be printed and laid before both Houses of Parliament.

APPENDIX L.

MEMORANDUM FROM THE FORESTRY BRANCH OF THE DEPARTMENT OF THE INTERIOR.

One of the difficulties in handling research work in the Government service is that men who make a success of research work are likely to be offered positions by commercial firms at salaries which are much higher than the Government will at any time be likely to offer. It therefore makes the holding together of a staff for research work rather difficult. On the other hand, if research work is to be carried out successfully it is almost absolutely necessary that the staff should be fairly permanent and should be composed of men who are really keen enough to make thorough investigations and discover new inventions and processes. Most men on the staff of the universities who are doing research work have opportunities for undertaking investigations for commercial firms for which they receive large fees outside of any salary paid them by the university, but the general departmental rules do not permit of Government officials employed in research work following a similar course.

This question has been discussed from time to time at meetings of the Advisory Committee of the Forest Products Laboratories of this department, which, as you know, consists of representatives appointed by this branch and others appointed by McGill University on the approval of the Minister, and it has been concluded that one way of assisting to meet the difficulty would be to make a definite arrangement about the handling of patents for inventions covering discoveries made by the staff of the Forest Products Laboratories.

If any member of the Staff during his research work makes any discovery it is felt, that, consistent with the proper protection of the public interest, he should be permitted to retain some of the benefits of the results of the discovery. On the other hand, many discoveries which would be valuable are not made use of simply because they are not placed before the public insistently enough. Manufacturers may not see the immediate value of them or they may involve changes in equipment that the manufacturers may consider would be so costly that the use of the invention would not make adequate return for the expenditure. Such investigations have at times been adopted by foreign countries and the country where the invention was made has sometimes waked up later to find that it was left entirely behind.

On a consideration of the whole case the Advisory Committee have approved and passed a memorandum a copy of which is submitted herewith, suggesting a method of dealing with the whole matter. It will be seen that it is suggested that the matter should be taken up by the Minister if it is to be taken up in connection with the Forest Products Laboratories only, but if the question is to be considered in a general way in relation to government Departments, it would seem opportune that the matter should be submitted to the committee on technical research which has recently been organized.

I feel satisfied personally that some such arrangement as that proposed is necessary in order to keep up a proper interest in the staff engaged in research work and to ensure a degree of permanency.

OTTAWA, December 21, 1916.

Respectfully submitted,

(Sgd.) R. H. CAMPBELL.

MEMORANDUM RE PATENTS AND INVENTIONS OF CANADIAN GOVERNMENT EMPLOYEES ENGAGED IN RESEARCH.

1. It is desirable that government employees engaged in industrial and scientific research should be given as much incentive as possible to produce new ideas and

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inventions of industrial value. This incentive could be supplied to a very large extent by assuring them of a fair share in the financial returns of any patent which they may bring forth.

2. It is also desirable that such patents should be developed to the point where their value is demonstrated and not remain unused for lack of such demonstration.

3. In all research work opportunities arise from time to time for inventions and improvements in various arts more or less directly connected with the investigations under way. These inventions may be either directly due to research, that is, practically speaking, they may be considered as being one of the objects for which the research was undertaken, or else they may be incidental to the research, being the idea of some one connected with the investigation, though the idea itself is not one which could be considered as being a direct outcome of the research in question. For instance, if a research were being conducted for the purpose of finding means of utilizing a waste product such as the bark from pulpwood and an invention was conceived which did find some new and profitable scheme for utilizing such material then such invention might be considered as being directly due to that research. But if in the same research, one of the investigators should conceive of an invention of a new form of apparatus for measuring the material, then that invention might be considered as one which was merely incidental to the research.

4. It would greatly stimulate the interest of those engaged in government research work and make for greater efficiency if these workers were allowed to participate in the results of any discoveries they might make. It is a great drawback to scientific work of government laboratories that salaries are almost entirely fixed within limits so that there is very little incentive for a man to put forth his best efforts.

Since it would not be fair to the public to allow employees engaged in research supported by the Government funds to appropriate to their sole personal use the results of the work for which they are paid, there should be some ruling whereby the respective rights of the public and the inventor will be judged and their proportionate share in the value of the invention decided. At the present time there is no such ruling in any Canadian Department which will serve as a guide and there is accordingly a disinclination among the men in government service to consider applying for a patent lest they encounter arbitrary rulings and difficulties over their rights.

5. Practically all inventions require the expenditure of money, sometimes in considerable amount, before returns are realized. To warrant the expenditure for the development of a new idea, there must be some protection so that there will be assurance that the invention so developed will be the property of those who invest in it. This consideration is sufficient in a great many cases to completely nullify the value of inventions which are made free to the public; no one is willing to invest the money necessary to develop them commercially and run the risk of losing his investment unless he is assured that in case the enterprise becomes successful he will be the one to reap the benefit. The United States Department of Agriculture has a rule that requires any employee of the department to patent any invention which he may conceive and assign the patent to the Department to be thrown open to the public. In consequence of this, employees of that department are liable to conceal their inventions until they leave the government service or else the patent, if taken out, is made of no value since no one can develop the idea with reasonable security. In the first case the service loses a good man as is shown by the fact that he had the ability to conceive the idea; in the second case the idea remains undeveloped and its value is almost entirely destroyed. Other Departments in the United States are more liberal —some having no ruling at all while others require only that if the Government wishes to use the patent it may do so without the payment of any royalty or commission whatsoever.

6. From these considerations it is suggested that patents and inventions of those government employees engaged in research or scientific work be dealt with in accordance with the following rules:—

(*a*) That a Committee be appointed to consider each individual case on its merits. This might consist, in the case of the Forest Products Laboratories, of a committee appointed by the Minister of the Interior or, in case the same rule is applied to all Departments, the committee might consist of a subsection from the Committee of Council for Research as designated in Order in Council of June 6, 1916, or be appointed by that committee.

(*b*) That government employees engaged on research or scientific investigations be granted patents without the payment of fees.

(*c*) That all such patents be assigned entirely to the committee aforementioned who will have full power to deal with the use of all such patents, as they see fit, being guided in their decision by the conditions of each individual case.

(*d*) That this committee have the power to sell or otherwise dispose of the rights of any such patent and that such portion of the proceeds as rightfully belong to the public be devoted to the furtherance of research and scientific work.

(*e*) That this committee be given authority to develop at public expense such inventions when the ownership of the rights belongs in part to the public.

7. The board of referees should have full power to deal with any invention as they see fit, but in general, it should be dealt with in one of the following ways:—

(*a*) Be thrown open to the use of the public without fee or restriction. This should be done where the invention is the direct result of research and where the invention is one of such a nature that it could be manufactured or the process made use of by any one without the necessity of being dependent on any development expenditure.

(*b*) Be sold or used under license and the proceeds divided between the inventor and the public in proportion to the part of the idea which may be considered due to the inventor as against that part which may be considered as the outcome of work for which public funds have been employed.

(*c*) Be returned to the inventor to be dealt with as he may desire. This should be done when the idea is solely due to the inventor and not to discoveries made during the course of his regular work which is paid for by the public funds.

8. Under this plan the employee would be assured that he would receive remuneration for his idea in proportion to what part of it was really his own; he would know that his invention would not die for lack of proper development on a practical scale and he would know that its value would not be lost by the patent being left open to everybody and so being avoided by all.

The committee by being able to spend the money necessary to demonstrate the value of the invention would provide the very necessary facilities for carrying it from the patent stage to the commercial stage and so protect it through the period in which many valuable inventions are lost. It would be impossible for the inventor to do this himself without leaving the Government employ to secure the necessary capital.

APPENDIX M.

SECTION OF THE DRAFT OF THE AMENDMENT TO THE PATENT ACT, ON THE GRANTING OF PATENTS TO TECHNICAL EMPLOYEES IN THE GOVERNMENT SERVICE, PREPARED BY MR. G. F. O'HALLORAN, COMMISSIONER OF PATENTS.

Every patent granted in respect of an invention made by a person while employed in the public service of Canada and relating to the nature of his employment shall,

notwithstanding anything in the patent or the Patent Act to the contrary contained, be subject to the following conditions which shall be indorsed on such patent, that is to say:

(*a*) The Commissioner may grant to any person applying therefor a license to use the patented invention on terms to be fixed by the Commissioner.

(*b*) In fixing said terms the Commissioner shall have regard to the circumstances under which the invention was made and the right and interest of the Government of Canada therein in consequence thereof, which right and interest said government is hereby declared to have, and shall reduce the royalty payable to the patentee accordingly or apportion the royalty between the patentee and the Government of Canada, but in no case shall the amount payable to the patentee be less than one-half of what it would have been had the inventor not been in the public service when making the invention.

(*c*) The patentee shall not make use of nor allow others to make use of the patented invention without the consent of the Commissioner, who in granting such consent may exact royalty for such use to be fixed by him and paid to the Government of Canada.

(*d*) The Government of Canada shall have the right of action in any court of competent jurisdiction to restrain the unauthorized use of the patented invention and recover damages therefor, which may be apportioned by the Commissioner between the patentee and the Government in such way as to him seems fit.

(2) Any question which may arise as to whether any invention comes within the terms of this section shall be determined by the Commissioner on application for a patent therefor.

(3) On the refusal of such inventor to apply for a patent for such invention after being thereunto duly required by the deputy head of the department in which he was at the time of making the invention employed, such deputy head may in his said quality apply for and obtain a patent for such invention.

(4) Nothing herein contained shall be construed to restrict the right of the inventor to the full enjoyment of his invention outside of Canada.

APPENDIX N.

A BILL TO AMEND THE AMERICAN PATENT LAWS.

Authorizing the Federal Trade Commission to accept and administer for the benefit of the public and the encouragement of industry, inventions, patents, and patent rights, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled:

1. That the Federal Trade Commission be and hereby is authorized and empowered to accept assignment of, or license under; to develop; to issue or refuse to issue licenses under; to encourage the industrial use and application of, and otherwise to administer, on behalf of the United States, under such regulations and in such manner as the president shall prescribe, inventions, patents and patent rights which said commission deems it to the advantage of the public to be so accepted, as these may from time to time be tendered it by employees of the various departments or other establishments of the Government, or by other individuals or agencies; and to co-operate, as necessity may arise, with scientific or other agencies of the Government in the discharge of the duties herein set out.

2. That the Federal Trade Commission be and is hereby authorized and empowered to collect fees and royalties for licensing said inventions, patents and patent rights in such amounts and in such manner as the President shall direct, and shall deposit the same with the Treasurer of the United States; and of the total amount of such fees and royalties so deposited, a certain percentum, to be determined by the President, shall be reserved, set aside and appropriated as a special fund to be disbursed as directed by the President to remunerate inventors for such of their inventions, patents and patent rights contemplated by this Act as may prove meritorious and of public benefit.

APPENDIX 0.

REPORT IN CONNECTION WITH FISH WASTE INVESTIGATION ON THE ATLANTIC COAST.

By J. B. Feilding, *Fisheries Engineer.*

On receiving instructions, I left home for Ottawa on the 24th of April, and on arrival awaited on Dr. Macallum to receive his instructions. Leaving Ottawa on the 27th, I proceeded to Montreal en route for Nova Scotia.

I arrived at Halifax on the night of the 29th, and on the following morning called on Dr. Mackenzie at Dalhousie University and had some discussion on fishery questions generally relative to the Nova Scotia coast. I called on several of the leading fish buyers, but in every case found them out of town.

On the 1st inst. I left for Digby, thinking, after careful consideration, that I had better tour the southern part of the province first. At Digby I picked up some useful information, which resulted in my proceeding down Digby Neck through Centreville, Tiverton to Westport. From here I took steamer to Yarmouth and from this point I worked my way back to Halifax. From Halifax I went direct to Canso via Mulgrave, where I had the pleasure of meeting Mr. Edward Whitman, who has taken so much interest in this question.

From thence I proceeded to Bathurst, N.B., with a view to visiting Caraquet, but failed to get there owing to there being a temporary stoppage in the train service. I therefore proceeded to Campbellton and from thence to Grand River, in the province of Quebec. Here I met Mr. Walsh, district purchasing agent for the Gorton Pew Fish Co., of Gloucester, Mass. From thence I went to Gaspe in order to ascertain how far the fishing industry extended in the direction. From Gaspe I returned to Montreal, arriving on the 21st inst. My trip lasted in all double the time that was originally estimated.

The object of my tour, as I understood it, was to ascertain the quantity and availability of fish waste in economic tonnage and waste or unmarketable fish resulting from the fishing industry. My tour was, of necessity, somewhat curtailed owing to the time at my disposal. Therefore the conclusions I have come to must be accepted as only tentative.

Further, it was understood that I was to consider this problem from the aspect of its conversion to live stock feed, fertilizers, and oils.

I will now deal with the conditions as I found them, over this area, but before doing so I would like to call your attention to the factors that had to be considered.

No. 1.—The number of shore boats, sail and power, in a defined area in relation to their potential value in the scheme under consideration.

No. 2.—The class of trade pursued whether the fresh or dried fish business.

No. 3.—The possible quantity of non-edible fish that might be expected and the average proportion of it to the catch of other fish.

No. 4.—The price at which fishermen would bring fish waste and non-edible fish into port.

No. 5.—The availability of kelp of suitable type in the vicinity that might be utilized in the compounding of fertilizers.

No. 6.—The grouping of fishing villages within such distance that fish waste could be brought to a reduction plant at some central point in a fresh state.

No. 7.—The existing supply of fish waste and oil in such districts that I shall afterwards describe.

I found in this southwest section of the Province of Nova Scotia no individual port that could economically operate a plant as a business proposition, and, therefore, I considered the question of grouping ports within easy distance.

The first district considered and investigated was that lying along the Bay of Fundy between Parker's Cove and Gulliver Hole. Here I found as I did all through this southern district, a large number of boats engaged in the lobster industry, and these I was unable to classify apart from those employed in fishing proper. Between the ports above referred to I found in operation about 297 gasoline boats and 122 sail boats. I also found that the approximate waste on the average catch was about 4,500 tons, while the oil apparently collected in the district, was only extracted from the livers and not from the intestines. The value of the waste irrespective of the oil were it converted into protein concentrate would amount to $97,000 at current market prices. The natural point from which to radiate for the collection of this waste is Victoria Beach, and extends a distance of 10 miles in a southwesterly direction and 14 miles in a northeasterly direction. One 30-ton collecting boat could handle all the waste from this area.

Here as elsewhere I found the fishermen would be prepared to barrel the waste and would expect 20 cents a barrel weighing 200 pounds. Non-edible fish such as skate and dog fish, they would be prepared to bring in at prices ranging from seven to nine dollars a ton.

The next coastal section considered was that lying along the Bay of Fundy between Centreville and Westport, including a small section on the west side of St. Marys Bay, lying between Weymouth and Comeauville. This is an area given over largely to line trawl and hand lining with shore boats which number in all 421 gasoline and 210 sail boats or thereabouts.

I estimate the value of the oil and waste available if treated to amount to $123,000 per annum.

The next district considered was one radiating from the port of Yarmouth extending between Cape St. Mary and Tusket Island. In this area I found there were about 406 motor boats and 68 sail boats operating inshore on the lobster trade and hand line fisheries. The value of the waste and oil were it collected and treated in this district I estimate at $128,000 per annum. The fishermen would handle the material required by a reduction plant on approximately the same terms as before mentioned.

Between this section and the village port of Pubnico the fishermen are largely engaged in the lobster trade, and when that is over they appear to ship on the bankers out of Lockport and Lunenburg.

The next section visited was a district centred on Cape Sable island or more particularly Clark's Harbour. I found in this area that there were between six and seven hundred gasoline boats and from fifty to sixty sail boats employed in mixed fishing. The waste at present existing would, if treated, be worth approximately $104,000 per annum irrespective of the oil.

There are large and valuable kelp beds throughout this district which could be economically worked. Fishermen, I was given to understand, would be prepared to

bring in this kelp at prices varying from $1 to $2 per ton. They would further be prepared to bring in non-marketable fish at from $6 to $7 per ton, and fish waste at around $4 a ton.

At Clark's Harbour I inspected the Government dog fish reduction plant which though very badly cared for appeared to be in working order, and well worth in my opinion retaining for the purpose of the manufacture of fertilizer, though quite unsuitable for the manufacture of food. The plant is very wasteful in operation since I was told by the manager that he would only get one ton of fertilizer from 10 tons of raw material. There are several improvements that could be easily made to reduce this waste, and save labour, and when set in order it certainly should not take more than from 5 to 6 tons of fish waste to make one ton of fertilizer concentrate. This even is not as good a return as an intermittent plant with vacuum drying could accomplish. It is indeed a fault associate with almost all continuous process machines.

From this district in a northeasterly direction the fishing industry is entirely in the hands of the banker, though lobster catching is carried on to a small extent in the coves all along the coast, as far north as Canso.

I proceeded, therefore, direct to Canso; here I found the centre of the greatest fishery on our Atlantic coast by virtue of its close proximity to the Banks. After spending several days here and inspecting the Government late dog fish reduction works and the Robinson glue plant, I came to the conclusion that an area defined as follows would be an economic waste collecting area centreing on Canso: the port of l'Ardoise, in Richmond county, Cape Breton, and Tor Bay, in the county of Guysboro.

The waste now available amounts to approximately 12,900 tons and the oil to 80,000 gallons. Were the former manufactured it would, together with the oil, at current market prices, be worth approximately $424,000 a year.

I ascertained that of the total fish caught in this district by otter trawl 30 per cent was constituted of non-marketable fish, while with the line trawl from 12 to 15 per cent appeared to be the rule. Fishermen would be prepared to bring in their waste fish at from $6 to $7 a ton, while their fish waste could be readily acquired at from $2 to $3 a ton.

After visiting this area I tried to reach Caraquet, but as I said before, was unable to get there. So I proceeded to Grand River, in the province of Quebec. Here, with the able assistance of Mr. Walsh, district agent for the Gorton Pew Co., I was enabled to visit and collect much valuable data at the points on either side, as well as at Grand River. The district centred on Grand River appears to be bounded by the ports of Ance au Beaufils and Paspebiac, extending along a coast line of about 70 miles. This appears to be a thinly populated district with a very rising fishery. The season is a short one and the fishermen are poor, and anything done to help them would be of the greatest benefit. They apparently fish from the 1st of June to the 1st of November—five months in all.

Here I found the worst and most extravagant waste; hundreds, if not thousands, of tons of herring and "ground" fish are gilled and spread out on the land with an intention of fertilizing it. Needless to say, the herring would be much better left in the water if not required for human food, for at least they would provide food for fish of more economic value. In Grand River alone it is estimated from 250 to 300 tons of herring alone are used annually in this way. The fish waste within this area I compute, irrespective of non-marketable fish, to be 7,000 tons, valued, when convertible, at $200,000 a year.

The Bay of Chaleurs appears to be the greatest haunt of ground fish, which could be used to great advantage in the manufacture of edible meals. Fishermen would be only too glad were they offered from $3 to $4 a ton for them, and would be prepared to hand over packed in barrels fish waste at from $1 to $2 a ton.

The number of boats operating in this area must be at least from 800 to 1,000—in the village of Grand River alone there are over 100 well-fitted power boats capable of fishing on the banks 8 to 12 miles out.

On all hands I found a great desire for help in the direction of giving the fishermen more occupation and using up the enormous quantity of available non-edible fish. I should say that by non-edible I include, of course, such fish as are at present unmarketable, though edible.

East and west of this area I found the fishing not sufficiently developed to justify the time and expenses that would be incurred in making investigation.

This terminates a somewhat rough and very cursory survey so far as I was able to carry it out in the time allowed.

There are, however, two important areas to be yet considered, viz., Caraquet and Grand Manan, both in the province of New Brunswick, and from what I have heard are well worth a careful inspection.

It will be noted that I have only lightly touched on the enormity of the available supply of non-marketable fish in certain areas of our Atlantic coast, which could be put to the extreme value much to the benefit of the farmer and the fisherman, and, further, would tend to give winter employment in many of the coast villages where a manufacturing industry would be a God-send. It may fairly and conservatively be stated that 15 per cent of the fishermen's catch consists of fish at present not marketed, and when it comes to the steam trawler this type of product is more often 30 per cent and as high as 50 per cent of the total catch. Much of this fish could be obtained at little cost with a small otter trawl on the mud banks inshore, were the fishing regulations altered to allow such an industry. Were this possible it would give the fishermen practically continuous employment during the months when they would not be prevented by ice.

I would, therefore, recommend every inducement be offered to convert to useful purpose this waste fish as well as the ever increasing fish waste.

By adopting the units of area suggested, small plants of one digester might be erected at little cost as object lessons say, at Canso in the old lobster hatchery, and another at Clark's Harbour or Tiverton, and another, perhaps, at Grand River. These plants could be operated, I am confident, at a profit, since the all-important raw material is there and the market for the finished product is crying out for it. After operation for a short period, these plants, I feel sure, would be readily saleable as going concerns, were it possible financially to organize them. A market for the finished products of a marketable nature at pre-war prices, of course, would have to be shown.

I do not think that more than dehydration could profitably be done at any of the points mentioned, and, further, it would not be advisable since it is all important that if an industry of this kind were built up the manufactured product should be standardized at some central point.

Meal having the nutritive ration of raw fish meal is a dangerous product to put on the market, particularly in the hands of any one in ignorance of its feed value, to say nothing of its storage capability.

Another point to be borne in mind is that, should an industry of this kind develop as it has on the American Pacific Coast, certain legislative regulations should be put into force in order to protect the consumer of the finished product. First, the insistence of the use of fresh and sound fish waste, free from black fish or whale, porpoise or seal flesh, if converted into feed. Second, if converted into fertilizer, fillers of no economic value should be eliminated or regulated. Thirdly, in either case the analysis should be guaranteed. Fourthly, the period of storage should be guaranteed.

Unless some regulations are put into operation, there are bound to be products of exceedingly doubtful origin put on the market as food, as I have myself seen. If such material would be distributed, it would create a want of confidence and thus a valuable protein and ammonia base would be lost to agriculture.

Were a chain of small dehydration plants along the Atlantic Coast in operation, some central point or points should be selected inland, for standardizing the finished product, according to the requirements of the trades, be they feed, fertilizer or oil. It would be fatal in my opinion to overlook this point, were any large scheme put into operation.

The next point to be considered is the type of plant most suitable. There are three fundamental principles at present adopted, viz., what are known as the continuous, the solvent and the intermittent. The latter is of two types, viz., with direct or indirect steam digestion.

Now, if a high class feed is the product aimed at and a sound, neutral, practically foot-free oil, in my opinion the indirect intermittent type is the best. It is true it is not fool-proof, any more than any other type, but it has the outstanding feature of not being wasteful.

Other questions to be considered are those relating to the special methods of fishing which would have to be inaugurated in order that fish that have not hitherto been taken out of the water could be economically delivered to the reduction plant. At present fishermen have no gear to lift flat fish, and would also require instruction in the use of such gear, were it introduced. I am informed that the plant necessary is to be seen in operation out of the ports of Boston and Gloucester, where fishermen very effectively can collect this type of fish at the least possible cost.

Another point to be considered is the cost of operation. First, the cost of gear to the fishermen, the cost of bins, barrels or hoppers for fish waste collection, the cost of reduction plant, also of compounding, standardizing and refining.

The remaining question is that of organization,—first of the districts, and finally the distributing centre of the finished product to the farmers.

These and many other points connected with the question you did not instruct me to look into, nor have I had the time up to the present, to take them up. You will, doubtless give me instructions further in connection therewith.

In conclusion, let me summarize briefly the points I wish to bring to your notice,—

1. The basis of my survey is on information gained direct from the fishermen, and also on my own personal observation.

2. The conclusive fact that there is an enormous and ever increasing quantity of fish waste, and further, in proportion to the catch there is from 15% to 30% of unmarketable fish at present thrown back into the sea dead.

3. That there are centres of fishing areas where there could be collected waste in sufficiently large economic quantities as would fully justify the erection of a reduction plant; and further, that such plant could undoubtedly be run so as to produce good commercial profit.

4. That the question of collection of the waste can easily be solved in such areas as are under survey.

5. That there is a serious demand for another source of protein owing to the great and increasing scarcity of linseed and cottonseed cake in agriculture, independent of the American manufacturer.

6. That there is ample justification for the erection and operation of an economic unit for demonstration purposes, and that such plant, if erected, should be managed on a commercial basis.

7. That it is desirable to study the best means of distribution of the finished product, whether it be through the trade or the farmer's co-operative societies.

8. That it is essential to standardize the feeds, so that harm cannot be done to live stock through want of knowledge of nutritive values.

9. That it is esential that legislative regulations be framed to protect the consumer of this new feed product.

10. That it is essential that steps be taken to interest private capital and co-operation amongst fishermen to promote this industry.

11. That such an industry does not require a large capital but rather small in proportion to the commercal value of the product.

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APPENDIX P.

A BILL FOR AN ACT RELATING TO THE COMMONWEALTH INSTITUTE OF SCIENCE AND INDUSTRY.

Be it enacted by the King's Most Excellent Majesty, The Senate, and the House of Representatives of the Commonwealth of Australia, as follows:—

Part I—Preliminary.

1. This Act may be cited as the Institute of Science and Industry Act 1918.

2. This Act is divided into Parts as follows:—

Part I—Preliminary.
Part II—The Commonwealth Institute of Science and Industry.
Part III—The State Advisory Councils of Science and Industry.
Part IV—Powers and Functions of the Directors.
Part V—Miscellaneous.

3. In this Act, unless the contrary intention appears,—

"Advisory Council" means an Advisory Council of Science and Industry established under this Act;

"Director" means a Director of the Commonwealth Institute of Science and Industry.

"Institute" means the Commonwealth Institute of Science and Industry.

"Officer" means any person employed by the Directors under this Act;

"The Minister" means the Minister of State administering this Act.

Part II—The Commonwealth Institute of Science and Industry.

4. (1) There shall be a Commonwealth Institute of Science and Industry which shall consist of three Directors and in each State an Advisory Council of Science and Industry. It shall be a body corporate with perpetual succession and a common seal and capable of suing and being sued.

(2) All Courts, Judges and persons acting judicially shall take judicial notice of the seal of the Institute affixed to any document or notice, and shall presume that it was duly affixed.

(3) The Institute shall, subject to this Act, have power to hold lands, tenements and hereditaments, goods, chattels and any other property for the purpose of and subject to this Act.

(4) The Institute shall have power to acquire by gift, grant, bequest or device, any such property for the purpose of this Act, and, in the absolute discretion of the Directors, to agree to any conditions of such gift, grant, bequest or device.

(5) The powers of the Institute under the last preceding subsection shall, subject to the regulations and the approval of the Minister, be exercised by the Directors on behalf of the Institute.

5. (1) The Governor General may appoint three persons to be Directors, of whom two shall be chosen on account of scientific attainments.

(2) On the happening of any vacancy in the office of Director the Governor General shall appoint a person to the vacant office.

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(3) The term for which any such appointment is made shall be five years, and every person so appointed shall, at the expiration of his term of office, be eligible for re-appointment.

(4) In case of the illness, suspension or absence of any Director, the Governor General may appoint a person to act as Deputy Director during the illness, suspension or absence, and the Deputy shall, while so acting, have all the powers and perform all the duties of a Director.

6. (1) The Governor General may appoint one of the three Directors to be Chairman of the Directors and on the happening of any vacancy in the office of Chairman of Directors the Governor General shall appoint a person to fill that office.

(2) In case of the illness, suspension or absence of the Chairman of Directors, the Governor General shall appoint one of the other Directors to act as Chairman during the illness, suspension or absence.

7. (1) Each Director shall receive such salary as the Governor General determines.

(2) The salaries of the Directors shall be paid out of moneys appropriated by Parliament for the purpose.

(3) Travelling expenses as prescribed shall be paid to each Director on account of his expenses in travelling in the discharge of the duties of his office.

8. (1) The Minister may at any time suspend a Director from his office for incapacity, incompetence or misbehaviour.

(2) If a Director is so suspended the Governor General may appoint a Board of Inquiry (consisting of three persons, one of whom shall be the Chairman of the Board, and any two of whom may exercise all the powers of the Board) for investigation and report upon the charge of incapacity, incompetence or misbehaviour preferred by the Minister.

(3) If the Director does not admit the truth of the charge preferred against him, the Board of Inquiry shall inquire into the truth of the charge and, after fully hearing the case, shall report to the Governor General their opinion thereon.

(4) If the charge is admitted or is found by the Board of Inquiry to be proved, the Governor General may, if he thinks fit, call upon the Director to retire from his office, and he shall retire accordingly.

(5) If the charge is found by the Board of Inquiry not to be proved, the suspension shall be immediately removed by the Minister.

(6) Save as in this section provided, a Director shall not be removed from office during the term for which he was appointed.

9. (1) For the conduct of business any two Directors shall be a quorum, and shall have, subject to subsection (3) of this section, all the powers of the Institute.

(2) At a meeting of the Directors the decision of the majority shall prevail.

(3) If, at any meeting of the Directors at which only two Directors are present those Directors differ in opinion upon any matter, the determinatiton of the matter shall be postponed until all the Directors are present.

10. The Directors shall devote the whole of their time to the performance of their duties, and no Director shall accept or hold any paid employment outside the duties of his office as a Director, or be a Director of a company.

Part III—The State Advisory Councils of Science and Industry.

11. (1) An Advisory Council representing science and the principal primary and secondary industries shall be appointed in each state and shall advise the Directors with respect to the affairs of the Institute.

(2) The members of the Advisory Council in each state shall be appointed by the Governor General and shall receive fees and travelling expenses as prescribed for attendance at meetings.

12. One or more of the Directors shall meet and confer with each Advisory Council at least once a year.

Part IV—Powers and Functions of the Directors.

13. (1) The powers and functions of the Directors shall, subject to the regulations and to the directions of the Minister, be:—

(*a*) the initiation and carrying out of scientific researches in connection with, or for the promotion of, primary or secondary industries in the Commonwealth;

(*b*) the establishment and awarding of industrial research studentships and fellowships;

(*c*) the making of grants in aid of pure scientific research;

(*d*) the recognition or establishment of associations of persons engaged in any industry or industries for the purpose of carrying out industrial scientific research and the co-operation with and the making of grants to such associations when recognized or established;

(*e*) the testing and standardization of scientific apparatus and instruments, and of apparatus, machinery, materials and instruments used in industry;

(*f*) the establishment of a bureau of information for the collection and dissemination of information relating to scientific and technical matters; and

(*g*) the collection and dissemination of information regarding industrial welfare and questions relating to the improvements of industrial conditions.

Part V—Miscellaneous.

14. The Governor General may arrange with the Governor of any state for any of the following purposes:—

(*a*) the utilization for the purpose of this Act of state research departments and laboratories and experimental stations and farms;

(*b*) the co-operation in industrial and scientific research with state Government departments, universities and technical schools; and

(*c*) the co-operation with educational authorities and scientific societies in the Commonwealth with a view to—

(i) Advancing the teaching of science in schools, technical colleges and universities where the teaching is determined by those authorities;

(ii) the training of investigators in pure and applied science, and of technical experts; and

(iii) the training and education of craftsmen and skilled artisans.

15. (1) The Governor General may, on the recommendation of the Minister, appoint such officers as he thinks necessary for the purposes of this Act.

(2) Officers employed under this Act shall not be subject to the Commonwealth public service 1902-1917, but shall be engaged for such periods and shall be subject to such conditions as are prescribed.

(3) An officer of the Commonwealth public service or of the public service of a state who becomes an officer under this Act shall retain all his existing and accruing rights.

16. All discoveries, inventions and improvements in processes, apparatus and machines made by officers of the Institute shall be vested in the Institute as its sole property and shall be made available under such conditions and payment of such fees or royalties or otherwise as the Governor General determines.

17. (1) The Directors may pay to successful discoverers or inventors working as officers of the Institute or under the auspices of the Institute such bonuses as the Governor General determines.

(2) Bonuses payable under this section shall be paid out of moneys appropriated by Parliament for the purpose.

18. The Directors may charge such fees and may agree to such conditions as they think fit for special investigations carried out at the request of any authority, institution, association, firm or person.

19. The Directors shall, once in every year, make a report to the Minister containing a summary of the work done and researches and investigations made and proceedings taken by the Institute during the preceding year.

20. The Minister shall cause the yearly report of the Directors to be laid before both Houses of the Parliament within thirty days after the receipt thereof if the Parliament is then sitting, and if not, within thirty days after the next meeting of the Parliament.

21. The Directors may publish such information relating to any matter investigated by them as they think fit, except where such publication would be contrary to conditions agreed to under section eighteen hereof.

22. The Governor General may make regulations not inconsistent with this Act, prescribing all matters which are required or permitted to be prescribed or which are necessary or convenient to be prescribed for carrying out or giving effect, to this Act, and in particular for prescribing such additional powers and duties of the Directors as he deems desirable.

APPENDIX Q.

PROVISIONS FOR THE FUTURE CONTROL OF THE NATIONAL PHYSICAL LABORATORY OF GREAT BRITAIN.

1. The name of the Institution shall be " The National Physical Laboratory."

2. The scientific control of the Institution shall be exercised by the President and Council of the Royal Society in the manner provided for in Sections 3-13 of the original scheme as modified by these provisions.

3. The property of the National Physical Laboratory shall be vested in the Imperial Trust for the encouragement of Scientific and Industrial Research.

4. The income of the Laboratory, including receipts from fees, will be vested in and shall be under the control of, the Committee of the Privy Council for Scientific and Industrial Research.

5. The Executive Committee* shall be responsible for the management of the Institution in accordance with the scheme of work and estimate of expenditure referred to below, and shall appoint and dismiss the officials, except the Director. In the case of the clerical staff it may be found conveninent to take advantage of the ordinary Civil Service methods of appointment.

6. The Executive Committee shall present in December in each year to the General Board* a report on the work of the National Physical Laboratory for the current calendar year, and a statement of the work which it is proposed to undertake during the ensuing financial year.

**Explanatory Note.—The General Board consists of forty-two members, four of whom are the President, Treasurer and Secretaries of the Royal Society and twenty-four are nominated by the President and Council of the Royal Society. The Executive Committee consists of the President, Treasurer and one of the Secretaries of the Royal Society and eight others of whom six are appointed by the President and Council of the Royal Society.*

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7. The Executive Committee shall submit to the Committee of Council for approval not later than January 1 in each year, a report on the work of the previous calendar year, together with a scheme of work and an estimate of expenditure, and they shall carry on the work of the Laboratory in accordance with its provisions.

8. The Director of the Laboratory will in future be appointed and may be dismissed by the Committee of Council, but before making any appointment the Committee will invite the President and Council of the Royal Society to nominate some person suitable for the position, and will consult them as to the appointment to be made. Before making their nomination the President and Council of the Royal Society will consult with the Executive Committee of the Laboratory.

9. The arrangements for finance will be those usual in a Government Department.

10. The Committee of Council will be responsible for any legal proceedings which it may become necessary to institute or defend.

11. The Advisory Council for Scientific and Industrial Research will be the Visitors of the Laboratory.

OTTAWA, June 22, 1920.

The Right Hon. Sir GEORGE E. FOSTER, P.C., G.C.M.G.,
Chairman of the Sub-Committee of the Privy Council for
Scientific and Industrial Research, Ottawa.

SIR,—I have the honour of presenting to you my report on the work of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1920, as required by the terms of the Act (7-8 George V, Chap. 20), constituting the Council.

I have the honour to be,

Your obedient servant,

A. B. MACALLUM,
Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research.

7513—1½

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*Appointed to replace Mr. Hobson who resigned during the year.

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REPORT

OF THE

ADMINISTRATIVE CHAIRMAN

OF THE

Honorary Advisory Council for Scientific and Industrial Research.

I. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL.

1. *Meetings of the Council and its Committees.*—Ten meetings of the Council were held during the year, that is, one for every month except August and November which the Administrative Chairman spent in visiting centres in Western Canada to confer there with associate organizations on the work of the Council. The average attendance at these meetings was a high one and a very large amount of work was accomplished, not only on such occasions but also in the intervals between them, by the individual members, in connection with the subjects dealt with by the Council. A number of the various Committees of the Council carried on their work in the intervals also and thus facilitated speedy action on a large number of questions which were referred to them by the Council, and this involved a considerable expenditure of time and energy on the part of the members to which the Administrative Chairman wishes to pay a tribute of appreciation.

The meeting of the Associate Committee of Chemists was held in the Chemical Laboratory of McGill University on May 15, 1919, and was attended by twelve out of the total of twenty members. An abstract of the proceedings of this meeting prepared by the Chairman, Professor R. F. Ruttan, is to be found in Appendix A. Amongst the large number of subjects discussed at this meeting were:—

1. The establishment of a National Research Institute.
2. The establishment of an Employment Bureau for Canadian Chemists.
3. Tax free industrial alcohol.
4. The development of the natural resources of the western provinces.
5. The training of Chemists for the industries.

At this meeting the question of keeping the Committee in thorough touch with the expert professional chemists throughout the Dominion received consideration, and in consequence it was decided that a system of retirement of the members by rotation should be inaugurated. This system of retirement, which was approved by the Research Council, and came into effect in 1919, provides for the retirement annually of five members who are not eligible for reappointment until after the interval of a year. This system will completely recast the membership of the Committee in four years but this may be brought about in a shorter period through deaths and resignations. Reappointments may in a number of cases be advisable which will equate the losses thus sustained and thus provide the continuity of membership necessary to the efficiency of the Committee as an Advisory Organization to the Research Council on chemical questions. In any case it is expected the system of retirement will operate to introduce annually new blood into the Committee and thus keep it in accord with the younger generation of chemists throughout the Dominion.

The Associate Committee on Mining and Metallurgy, met in Toronto on March 9, 1920, with an attendance of eleven out of a membership of twenty-two. A resumé of the proceedings of the meeting is given in Appendix B.

The report of the British Columbia Advisory Committee is given in Appendix C. This Committee has engaged Mr. Horace Freeman as its secretary, who will give special attention to the collection of data bearing on the utilization of the natural resources of British Columbia. He has already presented a report (which appears as Appendix D), on the subject of the utilization of wood waste of that province. He has also given attention to the complex sulphide ore problem which is of special importance to the Slocan district and has recommended that a special investigation be undertaken with a view to finding methods which will render possible the separation of the silver, the lead, the zinc, the copper and the iron of these ores from each other without entailing the loss of either the zinc or the lead in the zinc-lead-silver concentrates from these ores prepared according to the present methods.

2. *The Expenditures of the Council.*—Of the parliamentary vote for the year, $120,000, there was expended $99,872.42, leaving a balance of $20,127.58. The increase over the expenditure of the previous year which was $61,151.62, was due to the fact that, in comparison with that year, the Council was able to carry out a larger part of its programme of work but not to the full extent of its anticipations, for some researches, for which grants were made, could not be undertaken, owing to the lack of qualified research workers although it was able to overtake some of arrears of the programme of the previous year. A larger amount was spent on Bursaries, Studentships, and Fellowships than in the previous year. The number of the holders of these was twenty-six, while for 1918-19 it was only eight. The salaries amounted to $22,034.25, which was less than the amount spent for salaries in the preceding year, which was $22,520.88.

3. *Retirement by Rotation in the Membership of the Council.*—When the Research Council was constituted on November 29, 1916, the appointments to its membership were for an indefinite period, that is, no limit was set to the term of appointment. At the time, it was held by the members that if the Council were to be a permanent body this indefiniteness would have to be reviewed at an early date to guarantee as far as possible that the Council should be constituted to be at all times representative of the interests concerned in scientific and industrial research in the Dominion. It was recognized that members who, for several years after appointment would be able to give valuable service to the Council, might eventually, because of advancing age or declining health or physical vigour, be unable to perform effectively the duties of membership. It was recognized also that it might be advisable to recruit the membership from time to time from the ranks of the younger scientific men of the Dominion who, by reason of the attainments in science, and achievement in scientific research, might be of signal service to the Council as members of it, and be also representative of the oncoming generation of researchers who must be prepared for the responsibilities that they are to assume.

Owing, however, to the pressure of other matters, which concerned the Council at its meetings for the years 1917 and 1918, no action in regard to this was taken, but when, toward the close of 1918, Professor S. F. Kirkpatrick and Mr. T. Bienvenu resigned from the Council, the latter, anticipating a general scheme involving retirement of the members, recommended that their successors, Professor W. L. Goodwin and Sir George Garneau, should be appointed for a term of two years, to which recommendation effect was given by the Order in Council appointing them.

At the twenty-seventh and twenty-eighth meetings of the Council the subject of the retirement of the members of the Council was given extended consideration, and as a result it was decided to recommend to the Sub-Committee of the Privy Council for Scientific and Industrial Research,—

(1) That henceforth appointments to the membership of the Council should be for a three-year term.

(2) That a system of retirement by rotation of the members, based on this limitation of the term of appointment, be at once instituted.

(3) That each member, at the end of his term of appointment, be eligible for reappointment for three years.

(4) That in accordance with this limitation of the term of appointment four members should retire in 1920, three in 1921, and three in 1922, and that thereafter the retirement of the members should follow this order.

In accordance with these recommendations the Council determined the order of retirement of the members according to this plan and included in the list of four who should retire in 1920 the name of Mr. Robert Hobson, M.E., who, because of his duties as member of the Board of Directors of the Canadian National Railways, found himself unable to give much attention to the work of the Council and had, consequently, in 1918, presented his resignation as a member of it, to be accepted as soon as the Council deemed convenient.

The Sub-Committee of the Privy Council approved these recommendations and an Order in Council was passed on March 23 giving effect to them. Accordingly the term of appointment of four members expired on March 31. Three of these, namely Mr. R. A. Ross, E.E., Professor J. C. McLennan, F.R.S., and President Walter C. Murray, were reappointed for three years, and Mr. Lloyd Harris was appointed also for a term of three years to succeed Mr. Robert Hobson, who had resigned.

The system of retirement of the members of the Council by rotation will, it is believed, maintain its efficiency and permit the introduction, as occasion may require, of new members who will be in touch with all the questions involved in the development of scientific and industrial research in Canada. It will provide an opportunity for service to younger scientific men who have won distinction in research.

Since the Council was established three members have retired by resignation, that is, nearly one-third of the membership has changed. It is possible that others may, to the regret of their colleagues, find it necessary to retire and this will, with the retirements due to rotation, very considerably affect the membership of the Council.

4. *Assisted Researches.*—The total amount expended by the Council to assist approved researches was $33,315.53, of which $10,764.47 was for investigations approved in the previous year (1918-19), but which had not then been undertaken because of difficulties in getting the services of assistants or the materials and apparatus required. The number of researches thus aided was fourteen. No part of any one of these grants was expended in paying for the service of the investigator who undertook or superintended the research.

A list of these grants is given in Appendix I. Of these a number deserve special attention. One, that of $1,200, to Professor Alfred Stansfield, of McGill University, was to enable him to continue the research begun in the previous year with the aid of a grant from the Council, on the reduction of iron ores by gases at low temperature and the electric furnace. A full reference to the character of this research is given in the Report of the Administrative Chairman for 1918-19. Professor Stansfield has experimented with the reduction of hematite and magnetite ores by solid reducing reagents (charcoal) and gaseous reagents such as carbon monoxide, hydrogen, water gas and producer gas, both alone and with charcoal. The results so far obtained with the solid reducing agents are very satisfactory and will form a valuable basis for further attempts either on a laboratory or a work scale to construct continuous reducing appliances for iron ore. On some of these findings patents are being applied for in order to permit of their commercial development in Canada.

It cannot be too strongly emphasized that methods which will make the low grade ores of the Dominion economically utilizable are desiderata of the utmost importance

to Canada at the present time. The iron ore, iron and steel and their products annually imported into Canada exceed $150,000,000 in value. Such methods would render the greater part of this importation unnecessary. The Council in supporting such investigations as Professor Stansfield is carrying on is of the opinion that some of the problems which must be solved before such a utilization can be successfully achieved must be attacked on a larger scale than hitherto attempted and it would if it had the funds at its disposal make a provision for such an investigation commensurate with its importance.

A grant of $1,500 was made to Professor C. W. Drury, of Queen's University, to permit of the determination of the most suitable slag for smelting iron ores containing vanadium, in other words the recovery of vanadium and pig-iron together from iron ores containing vanadium (and titanium) by a simple smelting process, instead of by the complicated wet method at present in vogue for producing the alloy ferro-vanadium.

Ores containing vanadium are found at certain points throughout Canada but more especially and in considerable quantities in Central Ontario, where they contain also titanium, the removal of which is difficult and consequently these ores have not been utilized hitherto. The investigation aims at removing the titanium in the slag and obtaining the vanadium in the pig-iron produced in the operation and ultimately vanadium steel, a product with qualities which distinguish it amongst the alloy steels.

A grant of $1,850 was made to Dr. J. A. Gray, of McGill University, to aid in an investigation to determine the character of the most penetrating type of Röntgen Rays and their application as compared with the penetrating rays from radium. This research involves an exploration of a new field and will concern pure Röntgen Rays of definite wave length out of all those which are a mixture of a fairly long spectrum. The ever-increasing importance of the X-rays not only in medical work but also in industrial lines (as for example in study of flaws in metals) render such investigations of great importance.

For a research on the grading of dairy products (cream and butter) a grant of $1,000 was made to Professor Wilfrid Sadler, of the Department of Dairying of the University of British Columbia. This investigation was undertaken to correlate, if possible, the grading of cream and butter with the bacterial content of the milk or cream used in the preparation of these products. It is very probable that the data which will result from this investigation will make possible a uniform and standard system of grading which will determine the keeping qualities of cream and butter from various sources, all in relation to special bacterial forms present. The number of the different forms of bacteria which can and very often do occur in cream after pasteurization, and in butter made therefrom is very great (more than 250) and this recontamination is of critical importance to the dairying industry.

A grant of $5,000 was made to Professor J. C. McLennan for assistance in investigating the properties of helium to determine its uses for lamps of various kinds, amplifying valves, high resistances, etc. This investigation will also involve the liquefaction of the gas for the purpose of investigating the properties of matter at the temperature of liquid helium, the lowest yet obtainable by any means. It is understood that a large grant from the appropriation for research of the University of Toronto is also available to extend the scope of the work and to permit experiments on the liquefaction of the gas to be carried out on a larger scale. The gas to be used for these experiments will, in large part eventually, be obtained from the Bow Island natural gas supplied to the city of Calgary. The results of this research, it is hoped, may point the way to the immediate utilization of the helium for purposes other than of inflation of lighter-than-air craft and thus encourage efforts to promote the conservation of the supply of helium which, large in amount in the Bow Island natural gas, is now being wasted at the rate of 1,000,000 cubic feet a month.

Professor J. C. McLennan received another grant also, of $1,000 for an investigation on the application of the Piezoelectric effect obtainable with crystals of tourmaline and quartz to the measurement of pressures generated by the exploding of

explosive compounds or mixtures. This research will have a bearing on the improvement of internal combustion engines and on the use of explosives generally.

A grant of $1,000 was given to Captain F. M. Dawson to enable him to undertake researches on the microscopic character of cement in relation to its hydration and its physical properties. This is a line of research which has not hitherto been undertaken. It is an attempt to apply the methods of examination that have been employed in the study of the minute structure of steel, alloys, etc., which have thrown a great deal of light on the effects of stress on metals in relation to microscopic structures.

Studies on the character of cement, whether microscopie or chemical or both, have to-day an importance that they did not have hitherto, simply because disintegration, through the action of alkaline soil waters, has become a serious menace to cement structures in the western provinces, where the loss is estimated in millions of dollars annually. Cement structures which in Eastern Canada will outlast many decades, in the West, when in contact with soils charged with alkali waters, last in the majority of cases for less than a decade, and this entails their replacement, not once, but several times in a generation. How this disintegration occurs is, as yet, not fully understood. The degree of hydration which occurs when the cement is first made may possibly be a very important element in the process of disintegration, as may also be the microscopical physical condition. Researches carried on under the Reclamation Service at Washington, with the co-operation of the Bureau of Standards, and by cement companies and engineering associations on the causation of the disintegration in cement structures in the Western States, where soils impregnated with alkali waters also prevail, have so far not thrown much light on the subject, and further investigation, it is understood, is to be undertaken to solve the question of the causation of the decay. The problem in Western Canada is, it would seem, much more important than it is in the Northwestern States, for there are few areas in the three Prairie Provinces in which the soil is free from alkaline infiltration, and in consequence the investigation of it must be undertaken on a scale and along lines that will ensure determinative results. This the Council proposes to do if the proper expert organization required can be constituted, and if, also, it can, out of its modest parliamentary appropriation, provide the necessary grant to meet the expenditures which will be thus incurred.

The investigation undertaken in 1918 by Professor W. P. Thompson, of the University of Saskatchewan, to produce a variety of wheat which will ripen earlier than the Marquis, the staple wheat of the western provinces, be resistant to rust and have good milling and baking qualities, was continued during the last year with the assistance of a grant of $2,500 made in the preceding fiscal year. A large portion of the work for 1919 was concerned in the breeding of rust-resisting varieties of wheat of commercial value, and it was found that varieties of wheat cultivated in a district and found to be immune to the rusts prevalent there, when grown in another district may not be resistant to the rusts of that locality. It has further been demonstrated that when a single wheat plant is inoculated with the rusts from different sources it is susceptible in a greater or less degree to some of these, while it usually is more or less resistant to the rest. This has made it clear that there are strains of rust which differ in their virulence, just as there are differences in strains of a bacterium which is pathogenic to the human or animal organism as revealed by the virulence or mildness of the attacks of the individual cultures. Whether, however, virulent strains of rust may, like virulent pathogenic forms of bacteria, develop from non-virulent ones, is as yet not definitely demonstrated.

Professor Thompson and his associates have produced a number of hybrids which have proved resistant to the rust strains investigated up to the present, but, judging by past experience, they do not expect them to prove resistant to strains not yet studied. This makes it necessary, before any decisively valuable results may be

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obtained in the production of commercial rust-resistant hybrids, that there should be a thorough investigation to determine the total number and characters of the rust strains of all the districts in the western provinces and to ascertain whether new ones are continually originating and if so under what conditions. The attempts to produce new varieties of wheat by hybridization must, therefore, to be successful, wait till such an investigation is completed.

The completion of this preliminary work will, because of its magnitude, entail a larger programme than that hitherto attempted. Professor Thompson alone bravely began this work three years ago, but it must now, it would appear, be undertaken by an organization of biologists to each of whom should fall a special part of the work in order that the result hoped for may be achieved in a few years. It is a task that must be accomplished, for otherwise rust will be an abiding menace to the cultivation of wheat in the West, on which it takes a toll that is measured in millions of dollars annually. It is hard to conceive of a type of fatalism that will accept this menace perpetually, and efforts should be made to lift it now, for human ingenuity, based on the results that research on this line may furnish, should just as readily in this generation as in any later one, devise measures which will, if not abolish wholly the toll, reduce it to a scale that will greatly decrease its importance to wheat growing in Western Canada.

5. *Studentships, Fellowships and Bursaries.*—The Bursaries, Studentships and Fellowships awarded by the Council for 1919-20 were six, nineteen and seven respectively. Before the beginning of the academic session three of those awarded Bursaries, four of those awarded Studentships and two of those awarded Fellowships had resigned them. Two of the Fellowships, including the Ramsay Memorial Fellowship, are held in England (Cambridge and Manchester), while the other students are engaged in research in Canadian Universities (McGill, Toronto, Queen's, McMaster, Western, Saskatchewan, and British Columbia).

In order to provide for the training of a larger number of researchers for the immediate future and thus to meet in some measure the demand, which even now is developing, for capable researchers whom the progressive industries require, the Council decided to award twenty-five Studentships and ten Fellowships for 1920-21. These and the Bursaries, ten in number, at present established, will enable the Council to increase the number of students in training for a career in research from twenty-six to forty-five. This, it is believed will be sufficient to meet all the qualified applications for such assistance, but, it must be confessed, a very much larger number of such aids to students in training for research must be provided in the following year. How urgent this matter is, is indicated in another section of this Report, but it may be pointed out here that if the National Research Institute, the foundation of which has been urged by the Council, should next year be an accomplished fact, the constitution of its staff would render the demand for highly qualified scientific research men of Canadian origin specially urgent. Indeed, one of the most serious difficulties the governing body of this Institute would have to face for at least a decade would be that of obtaining in Canada a sufficient number of highly trained researchers to fill the more technical positions on its staff. It is, however, not in Canada alone that this scarcity is felt. Complaint has been voiced both in the United States and England that research men of the right type are all too few, but the scarcity of such in Canada is greater than in those countries. The supply can be increased to meet the demand only by the provision of a larger number of Bursaries, Studentships and Fellowships for highly trained potential researchers during the next few years. There is no other way by which the need of Canada in this respect can be met. It is necessary to emphasize this, for there is a general belief, current even amongst those who ought to know, that there are enough scientific men of the research type to fill all the positions which call for such. This belief is in part due to the supposition that a

graduate in a special course of science of a university is thereby qualified to undertake research in some line in the science in which he specialized in his undergraduate course.

Two, three and four decades ago it was possible for such a student if he exemplified the type of mind and had the initiative required to undertake research and become a successful investigator, but the research of the last forty years has so greatly increased scientific knowledge that the science taught in the most highly specialized undergraduate course is but an elementary introduction to what is now comprehended under the term, even in a single department of it. A much more advanced knowledge is, consequently, necessary to research in any one field of science and to obtain it the student must prolong his studies into postgraduate years and at the same time undergo a training in the methods of research which is absolutely essential to him if he is to prove a success subsequently as a researcher. Two, three, and it may be even four years, after graduation, may thus be necessary and because of the expense involved few students are in a position to undergo unaided this training. The Bursaries, Studentships and Fellowships will permit those whose means are limited and who are of the type required, to prepare for a career of distinction in scientific research.

6. *Patents for Results Obtained in Assisted Researches.*—A majority of the researches to meet the expenses of which the Council has made grants of money involve industrial problems the solution of which may give results of practical application in industry and, therefore, in some cases at least, commercially valuable. Some of the researches already completed have given results of this character and, in connection therewith, the question arose as to the right of each researcher to take out a patent or patents for the discoveries he had made on the new process which his work had brought forward.

In determining the answer to the question a number of factors had to be taken into account. There is first of all precedent. The Imperial Department of Scientific and Industrial Research, to which the British Research Council serves as an advisory body, has decided that no worker under the Department may patent a discovery except with the leave of the Committee of the Council and where leave is given the patent is taken in the joint name of the inventor and the Imperial Trust for the Encouragement of Scientific and Industrial Research. The Department further reserves to itself complete discretion in the administration of the patent rights after consultation with the inventor and when a worker, engaged in a research under a Committee or Board of the Department, or in receipt of a grant from the Department, desires to take a patent he must do so in conjunction with the Imperial Trust, but in these cases the Trust reserves the right to refuse to be a party to the patent.

There are also the conditions on which the Research Council makes grants for research. These are not given to compensate the worker for the time or energy he may expend in the research but to pay for the material or apparatus he requires and the salaries of the assistants he may engage. His time and energy are given gratis and therefore he receives, so far as the research is concerned, no part of the grant. The investigation may be a tedious one and the supervision of it may require a very high degree of expert knowledge as well as capacity to lead the investigation to successful conclusions but the results, though of value, as scientific achievements may not be of practical application and accordingly his only reward is the consciousness that he has added something of value to the scientific record and to that extent enhanced his own reputation as a researcher. If, however, the results may be of commercial application, to whom do they belong? Not by any means wholly to the organization which makes the grant to defray the expenses of the investigation, for the grant may be much less than the equivalent of the energy and time which the researcher has expended in the work. Further the Council or the Patent Office should the right to take patents for the results be accorded either, is not in a position to develop the use of patents. This development can only be effected through publicity, through the inventor getting into touch with the industrial firms which can profitably use the processes patented and demonstrating

to their satisfaction that these are, if utilized, likely to prove of great advantage in reducing the costs of production or in increasing the output.

To refuse to have a process or invention patented is, except in a few cases, equivalent to consigning it to neglect. An invention that is unpatented, of course, may be used by any manufacturing firm but as the utilization of a process may and very often does involve the installation of new machinery or additions to the plant which may have to be altered as experience determines in order that the firm may profit from the application of the process, it is unwilling to make this venture as the results will be known to competing firms which are, therefore, in a position to avoid such mistakes and thus undertake the application of the process without any handicap. This serves as a deterrent to enterprise in this line. If, on the other hand, a possibly valuable process is patented the patentee may induce a firm to utilize it because, if it is eventually found to be successful it will not be handicapped by competition with other firms which have ventured nothing in the development of the invention. To provide, therefore, for the successful development of an invention or a new process in the industrial line it is necessary that it should be patented and that the patents should be held by some one who can promote its application in industry.

These considerations were all given due weight by the Research Council and, in consequence, it formulated the rule that when an assisted research results in the discovery of new processes, or in the development of inventions of industrial application, the investigator shall, under conditions to be determined in each case, be granted the right to take patents on the same after the Council has given its approval. The discoverer or inventor may thus reap the whole or a portion of the benefit from the results of the research, the extent to which he participates in this benefit being determined by the part that the grant in aid of the research played in bringing it to a successful conclusion or by the character of the results obtained which may be of limited application.

It will be noted that this principle is not quite in line with that laid down by the Council* in the case of inventions or processes discovered by technologists in the Government service. In the latter case it was recommended that the inventors or discoverers should be allowed at least half interest in each patent taken for Canada, the remainder of the interest to be held by the Government, while they should be allowed to patent their discoveries abroad in their own names. The reason, however, for the difference is that the salary of the technologist in the Government Service is met out of the Civil Service while the worker in charge of a research assisted by a grant given by the Research Council, who is not in the service of the Government, does not personally receive any portion of the grant, which must be spent only in meeting the cost of the material or apparatus used or in paying for the service of his assistants in the investigation. The two classes of researches are on a different footing and this dictates a difference in the rights which may be accorded either in the matter of patents.

In thus deciding concerning the rights in regard to patents of a private worker who has been given a grant to meet the expenses of his investigation, the Council reserves to itself the power to revise its position on the subject in any particular case in which special conditions obtain or in which the public interest predominates.

If a National Research Institute for Canada is founded in the very near future, according to the recommendations of the Research Council, it is contemplated that different regulations will be framed dealing with the discoveries and inventions of commercial value which may result from the researches of the members of the technical and scientific staff of the Institute.

7. *Industrial Alcohol.*—In the report of the Administrative Chairman for 1918-19, the question of removing the handicap on the production of industrial alcohol or "denatured" alcohol which the Inland Revenue Act at present imposes on it was discussed at considerable length and it was urged that the Act should be amended

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*See Administrative Chairman's Report for the year 1918-19, p. 16.

so as to make the production of industrial alcohol as free from restrictions as it is in Great Britain and the United States. According to the provisions of the Act, alcohol can be denatured for industrial or other purposes only in Ottawa. Methylated spirits for consumption in British Columbia must at present, therefore, be conveyed to that province from Ottawa, a distance of two thousand five hundred miles, at a charge for transportation which, unless borne by the Inland Revenue Department, adds seriously to the price at which the consumer obtains it, while there is at least one distillery in that province which could, under amended regulations, provide all the industrial alcohol required there. The handicap which the consumers experience in the other provinces are only less serious because the distances of these from Ottawa are less than in the case of British Columbia but the effect is the same, that is, it tends to limit the use of denatured alcohol except in a few industrial lines in which, though the cost counts, it is indispensable for manufacturing purposes. This effect of the Act was of course not intended because its provisions are a survival of the times when Canada consisted of only five provinces and when also the industries, which used denatured alcohol, were very few in number and with a limited output. The misfortune was that the Act was not modernized at least soon after Congress had freed the manufacture of industrial alcohol in the United States from the legislative restrictions under which it operated till 1907.

What the removal of these restrictions on the production of denatured alcohol in Canada would mean may be gathered from the results of their removal on the production in the United States. Before the Act of 1906, which permits denaturing of alcohol at any distillery under conditions easily observed, the quantity of denatured alcohol used anually did not exceed 1,500,000 proof wine gallons, but after 1907 the consumption of it rapidly increased and reached 16,953,353 proof gallons in 1913 and 90,644,722 proof gallons in 1918, while the total amount of denatured alcohol made in Canada in 1917 was only 252,000 proof gallons. If the quantity consumed in Canada were in proportion to population it would amount to 6,000,000 proof imperial gallons.

Denatured alcohol is all important in a large number of lines of industry. This may be gathered from the enormously enhanced consumption of it in the United States since 1906 and from the annual consumption in Germany of more than 200,000,000 proof imperial gallons in the year ending August 31, 1904. Further, its use either alone or when mixed with benzol and xyol, as a motor fuel is increasing, and it is confidently predicted in certain quarters that it will be the sole motor fuel in two or three decades from now, that is when the oil supply of the United States will, it is claimed, be completely exhausted.* The high price of petrol in Great Britain even to-day makes it necessary to prepare to resort to alcohol as a substitute. The development in Canada therefore of cheap denatured alcohol not only for power purposes in the immediate future but also at present for use in the industries to the success of which it is vitally necessary, makes it imperative that the restrictions which hamper its production in Canada should be wholly removed.

Through representations on the subject made by the Research Council, the Canadian Branch of the Society of Chemical Industry, the Canadian Institute of Chemistry and the Canadian Manufacturers' Association, the Department of Inland Revenue, in May of 1919, took steps to amend the Act dealing with the production of industrial alcohol in Canada and towards the close of April, 1919, a Bill (No. 76) entitled "An Act to Amend the Inland Revenue Act" was introduced into Parliament which, with some alterations, might have passed but it included amendments dealing with subjects of Inland Revenue taxation other than alcohol and difficulties in the adjustment of the taxation of one product, acetic acid (including vinegar), delayed parliamentary action on the Bill till the last few days of the session when

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*The Unmined Supply of Petroleum in the United States. By David White, Chief Geologist U.S. Geological Survey. Paper presented at the annual meeting, February 4-6, 1919, of the Society of Automotive Engineers.

it was crowded from the programme of agenda. This made it necessary for the various organizations concerned in the production of cheap alcohol for manufacturing purposes in Canada to review once more the situation and to endeavour to assist the Department of Inland Revenue in promoting legislation which would remove all the restrictions at present imposed on the use in Canada of alcohol for industrial purposes. The matter was again remitted to the Committee of the Council dealing with industrial alcohol which in February last presented a draft Bill to the Hon. Martin Burrell, Minister of Customs and Inland Revenue, embodying all the amendments in the Act which, in its opinion, would place the production of industrial alcohol on as favourable a basis in Canada as in the United States and more especially in Great Britain. A copy of this draft Bill is given in Appendix K. It is expected that the majority of the changes in the Act which the draft includes will be incorporated in the Bill on the subject of industrial alcohol which the Minister, it is understood, will introduce at an early date in the House of Commons.

The legislation desired is urgently necessary. The Department of Inland Revenue sells the denatured alcohol it prepares at 95 cents a gallon, but it cannot supply enough of it, and in consequence the price of methylated spirits on the market is $3.50 per imperial gallon, by the barrel, while the current market price of methylated spirits in the United States is $1.25 per imperial gallon.* Not a few industrial firms using methylated spirits on a large scale find it impossible to maintain on hand an adequate supply. If the manufacture of industrial alcohol were relieved of the present restrictions the distilleries of Canada would be readily able to supply the market in Canada with denatured alcohol as their capacity for production is about 8,000,000 proof gallons per annum at least. If in a few years this supply were not sufficient for consumption it would encourage the utilization of the sugar of the sulphite liquors of the pulp mills of Canada which could be made to yield probably an additional supply of as much as 10,000,000 proof gallons.

The Research Council in the draft Bill referred to suggested a provision for duty-free alcohol for use in certain existing or new industries in which its use is indispensable. The clause in which this is dealt with reads as follows:—

> "Alcohol without any denaturant shall be sold or delivered, free of excise duty, under such conditions and in quantities, as the minister by regulation may prescribe to specially licensed manufacturers of such products in the preparation of which pure alcohol is essential as an agent solvent or precipitant but in which the finished product contains no alcohol."

This clause is in effect but a reproduction in other words of section 8 of the Imperial Finance Act, 1902, which reads as follows:—

> 1. Where, in the case of any art or manufacture carried on by any person in which the use of spirits is required, it shall be proved to the satisfaction of the Commissioners of Inland Revenue that the use of methylated spirits is unsuitable or detrimental, they may, if they think fit, authorize that person to receive spirits without payment of duty for use in the art or manufacture upon giving security to their satisfaction that he will use the spirits in the art or manufacture, and for no other purpose, and the spirits so used shall be exempt from duty:
>
> Provided that foreign spirits may not be so received or used until the difference between the duty of customs chargeable thereon and the duty of excise chargeable on British spirits has been paid.
>
> 2. The authority shall only be granted subject to a compliance with such regulations as the Commissioners may require the applicant to observe for the

*The price of methylated spirit in the American market was one year ago 60-62 cents per gallon (imperial measure). The price in February, 1920, was less than 85 cents per gallon. The increase in price to $1.25 is no doubt due to the dwindling of the stock of alcohol in bond, through operation of the Volstead Act.

security of the revenue, and upon condition that he will, to the satisfaction of the Commissioners if so required by them, render the spirits unpotable before and during use, and will from time to time pay any expenses that may be incurred in placing an officer in charge of his premises.

3. If any person so authorized shall not comply with any regulation which he is required to observe, he shall, in addition to any other fine or liability, incur a fine of fifty pounds.

The importance of allowing duty-free pure ethyl alcohol to be used for certain industrial purposes may be gathered from the fact that large quantities of synthetic compounds and also of alkaloids are used in Canada annually, all of which has to be imported because tax-free pure ethyl alcohol is necessary in their production. Further certain of the vitamines,* those compounds the absence of which from human diet causes scurvy, rickets, beri-beri, marasmus, osteomalacia, etc., are soluble in a pure form from fresh fruits, vegetables, animal and vegetable fats, etc., only by the aid of pure alcohol. None of the denatured alcohols can be used because the denaturant is prone to absorption on the final product and would make it objectionable and with the great majority of denaturants used, toxic. Some of the vitamines have been prepared in a concentrated form for research purposes in scientific laboratories but only with the aid of pure ethyl alcohol, of course duty-free. There will arise very shortly an ever increasing demand for them, in considerable quantities not only for treatment of deficiency diseases of childhood but also for admixture with foods for ordinary consumption and no artificial difficulties should be imposed on their production in Canada.

It is also to be noted that the separation of fat from fish waste is at present effected by crudely empirical methods and the product is useful only in the manufacture of soap. If this fat could be extracted with pure alcohol on a large scale the fat might ultimately be obtained in a form suitable like pure and tasteless codliver oil for human consumption and as such it would be more valuable. If ethyl alcohol could have been used free from excise duty it would long ago have been extensively used in the extraction of fat from a number of sources for use as food. Extraction with denatured alcohol leaves the denaturant in the fat from which it is difficult to remove, and the product is, therefore, impossible as a food.

There are other lines in which the use of pure ethyl alcohol would be of great service industrially and in which denatured alcohol could not be employed. The examples given are sufficient to indicate that provision must be made in Canada for the use of duty-free alcohol in certain lines which because of their fundamental importance to nutrition cannot be ignored.

8. *Conservation of Natural Gas.*—The Council has given attention to the question of the conservation of the supply of natural gas in Canada. It is a subject in which Canada is not alone interested.

In the United States there has been a criminal wastefulness of the supply, which the public has treated as if it were inexhaustible. Exhaustion of the supply is now threatening in a number of American cities, for example, Cleveland, Toledo, etc., and, as a result of the awakening of opinion, which this has produced, a public conference of governors, public utility commissioners, state geologists, home economic experts, natural gas companies, owners and officials, and appliance manufacturers was called by the Secretary of the Interior, Mr. Lane, to meet under the auspices of the Bureau of Mines at the Interior Department Building, Washington, on January 15, to discuss the waste and determine how to conserve to the utmost the supply.

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*The knowledge of these exceedingly important constituents of diet was obtained in researches carried on at first by British Biochemists from 1911-1916 and later chiefly by American Biochemists. The war prevented the dissemination of this knowledge through Germany and Austria and this accounts in a very large measure for the appalling prevalence of rickets amongst the children in Vienna and certain other cities of the Central Empires.

As a result of the work of experts of the Bureau of Mines, it has been determined that in the consumption of natural gas an efficiency only of about 13 per cent from a gas cook stove, 25 per cent from a house heating furnace and 10 per cent from a hot water heater was obtained although in good practice the efficiency could be readily trebled, in other words, that one-third of the natural gas consumed daily would be sufficient for all the present purposes and the supply, therefore, could be made to last three times as long.

This meeting took place on the date indicated and a committee of ten was appointed to consider the wastes now going on in natural gas, and the relation between the natural gas companies and the consuming public. The Committee will formulate a programme looking forward to the application of those engineering principles which, it is known, will minimize the waste of natural gas now taking place and prolong the supply of gas to the consumer

The gas supply in southern Ontario is rapidly diminishing and within a generation it will be but a memory. The supply in Alberta is still voluminous but it is wastefully used. At Medcine Hat it is consumed as if it were inexhaustible, but the reported increasing occurrence in it of the hydrocarbons heavier than methane indicate that the exhaustion of the supply there is not far distant. The exhaustion of the supply of the Bow Island gas is predicted by the fact that the pressure is lessening. Consideration of the conservation of this supply is a question of urgent importance. Economy in the use of the gas at Medicine Hat means that the prolongation of certain favourable conditions for industrial enterprise there will be maintained correspondingly. The conservation of the supply of natural gas in Calgary means cheaper domestic lighting and heating for cooking purposes.

This question has been brought to the attention of the Research Council by Mr. Wm. Pearce, who has long been urging measures looking to economy in the use of the gas.

It is a matter that must be dealt with locally at Medicine Hat and at Calgary, but the Research Council would like to emphasize the necessity for immediate action on this subject by those concerned. This generation will not be justified in the verdict of the next, if the present wastefulness is not greatly curtailed, and the Research Council thinks it is incumbent upon the authorities of the cities of Medicine Hat and Calgary, and also upon the Canadian Pacific Railway Company, to consider the situation and how to evolve a system that will provide against this wastefulness.

There should be a conference of all concerned like that held at Washington on January 15 last, to consider all the aspects of the questions and take measures accordingly. It may be pointed out that the greater proportion of the gas-bearing lands of the three Prairie Provinces are privately owned. Further, the positon of the grantees of gas lands in the other provinces is that of a contract. There are few gas wells in the Dominion under public control, and, in view of this, it may be necessary to make provision for such control in all future leases, and, especially, in those for northern Alberta where the next largest supply of natural gas it is expected, will be tapped.

9. *The Conservation of the Supply of Helium in Canada.*—Helium is a gas of peculiar properties. It is extremely inert, does not combine with any other element and its weight is, with the exception of hydrogen, the lightest of all the gases. Its inertness and other physical properties would seem to indicate that it is extremely serviceable for electric bulbs, as it does not promote alterations of any sort in the films of the same. Its inertness also and its lifting power qualify it for filling balloons, the motors of which may be attached inside of the balloon or dirigible envelope, with none of the risk involved in the use of hydrogen for inflation of these lighter-than-air craft. It is likely to be used in aviation, because of its physical properties, and in electrical appliances, bulbs, etc. It would probably have been used very extensively in aviation, for observation balloons and offensive dirigibles, had the war been prolonged a year or two more. It is the subject of investigation, also, in relation to

refrigeration and the production of very low temperatures, a line of work in which the development must surpass, it is believed, ordinary immediate expectations.

Canada is the only portion of the British Empire which furnishes this gas. It is, of course, abundant in the supply of gas from certain of the gas wells in Kansas, Oklahoma and Texas, and in certain of the gas wells of southern Ontario and in the gas well at Bow Island, Alberta. The supply of natural gas at Bow Island contains 0·3 per cent of helium, and, on this basis, the amount of helium lost through the use of natural gas in Calgary amounts to about 12,000,000 cubic feet a year, which, computed at 10 cents a cubic foot, a low valuation, would make the value of the helium so lost amount to $1,200,000 a year. The quantity of helium in the gas of the gas wells of southern Ontario is much less, probably not more than one-tenth, of the quantity of the Bow Island supply.

The possibly approaching exhaustion of the gas wells in Ontario, and especially of the Bow Island gas supply for the city of Calgary makes it imperative that measures should be taken to conserve the helium in this supply and also in the supply from other gas wells which may be opened up. Once exhausted, there is no renewal of the supply of helium, unless some important discovery, involving extensive mutation or decomposition of the atoms of a chemical element, may make it available. It is, therefore, urgent that what Canada has of this supply should be conserved to the utmost.

How this can be done with the Bow Island supply remains to be seen, but the control of this gas has passed out of the hands of the Department of the Interior, as the lease given the company concerned is all-comprehensive on this point. There is a possibility that the company may find it profitable to assign the extraction of the helium to corporations which may export it, and for a time there was a suggestion that an American company had been organized with a view of acquiring the right of extraction of the helium from the Bow Island gas supply.

As the Federal Government of the United States has prohibited the export of helium from the United States, it is obvious that it is in the interest of Canada to preserve for its own use any helium that it may have and that efforts should be made to prevent its export.

The Council carefully considered this subject and recommended that in all future leases issued by the Department of the Interior it should be provided that all rights to helium in the gas should be reserved so as to enable the Government to extract this gas from such supplies. The resolution which the Council passed on the subject is as follows:—

> From the surveys which have been made of the natural gas supplies of the British Empire it would appear that the natural gases obtainable from the wells in Southern Alberta and from those situated along the Grand River valley and in the Niagara peninsula of Western Ontario, are the only ones which contain helium in amounts which at present would justify the expense of extraction.
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> The amount of helium obtainable from the wells at present in operation in Southern Alberta would appear to be 1,000,000 cubic feet a month, while the amount obtainable from the wells located in Western Ontario would appear to be about one-tenth of that amount.
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> In the war it was shown that had helium been available for observation balloons and other lighter-than-air craft, our effectiveness as a military nation would have been very much greater. The war would probably have been shortened and many lives would have been saved. It would seem desirable, therefore to conserve all supplies of helium within the Empire for future uses and emergencies. It is understood that this is the view taken by the Governmental authorities of the United States which is reported to have bought up from the natural gas companies the right to extract helium gas from all the gas produced.

It would seem desirable therefore that the Government of Canada should (possibly after consultation with the Government of Great Britain and Ireland) take the necessary steps to reserve to itself, in all future gas production leases granted by the Government, all rights to the helium in the gas, and that consideration should be given to the question of securing the right to extract helium from those supplies of natural gases in Canada for which leases have already been granted.

A copy of this resolution was communicated to the Minister of the Interior, who informed the Council that "all petroleum and natural gas leases issued on and after the 2nd day of March, 1914, contain the following provision:—

"The Minister may at any time assume absolute possession and control of any location acquired under the provisions of these regulations, if in the opinion of the Government of Canada such action is considered necessary or advisable, together with all buildings, works, machinery and plant upon the location, or used in connection with the operation thereof, and he may cause the same to be operated and may retain the whole or any part of the output, in which event compensation shall be paid to the lessee for any loss or damage sustained by him by reason of the exercise of the powers conferred by this provision of the regulations, the amount of the compensation, in case of dispute, to be fixed by a judge of the Exchequer Court of Canada, provided that the compensation in any case shall not exceed the profit which the lessee would have earned in the working of the location and the disposal of the produce thereof, had possession and control of the location and of the building, works, machinery and plant not been assumed."

Under this provision, it was held that the Government might assume absolute possession of nearly all the petroleum and natural gas leases issued in Saskatchewan and Alberta and might retain the whole or any part of the output, by way of compensation. This clause, thus rightly interpreted, could no doubt enable the Government to make an arrangement with the lessees, whereby it might secure the right to extract the helium from the flow of natural gas.

This clause in the leases issued since March 2, 1914, however, in the opinion of the Deputy Minister of Justice, can only be made effective, so far as the extraction of helium is concerned, when the Government assumes the possession and control of the location as provided in section 41 of the regulations under which the leases were issued.

In consequence of this interpretation of the clause in the leases referred to, the Department of the Interior has prepared a clause for insertion in all future petroleum and natural gas leases, reserving to the Crown the right to the helium in such gas as may be discovered, together with full power to install machinery and extract such product from the gas.

The supply of the Bow Island gas is diminishing as the pressure under which it flows into the city mains lessens. It is possible that a well in the same district, sunk at the centre of the field but not to the same depth, may renew the supply, but eventually this supply must diminish to a vanishing point.

It is not certain, however, that in such a supply there will be much helium, because though it is lighter than the natural gas itself, and diffuses readily the conditions favouring diffusion may not obtain over the whole field and, possibly, the whole supply is in the gas already tapped at Bow Island. It is, therefore, a matter of wisdom to utilize, as far as possible, the present supply. It is unthinkably uneconomical to allow it to be wasted as it is at present, and measures should be taken to extract all the helium from the gas before it is consumed in Calgary.

How this conservation may be effected is a matter for consideration on the part of the company in control of the Bow Island gas supply, and also by the Dominion,

which ought not to look with indifference on the exhaustion of this, amongst the rarest of all the gases, and which may be in the future of exceedingly great industrial value.

It may be noted that extensive provision is being made by the Federal Government of the United States for the conservation of the helium in the gas supply of Texas. The Army and Navy Departments arranged jointly to allot $5,000,000 for this purpose, including the construction of a new pipe line and additional units at the Lynde plant installed at Fort Worth, Texas, for the extraction of helium. The additional plants under construction there will provide for the extraction of 50,000 cubic feet of helium a day.

It may be pointed out that, if a helium extracting plant were installed on the main pipe line supplying Calgary, the helium could be removed and the natural gas turned into the city mains from the plant under the same pressure as the latter received it, and there would be no inconvenience experienced by the consumers as a result of this extraction.

If the ownership of the natural resources of Manitoba, Saskatchewan and Alberta is given over to the Governments of these provinces, it may be necessary for them to make provision for the conservation of the helium supply, wherever issuing with the natural gas.

The exportation of helium from the United States is prohibited, without special permit, in the draft of a Bill which has been submitted to Congress in February, 1920, by the Secretary of the Navy. The President is authorized, by the Bill, to prescribe appropriate rules and regulations governing the exportation of helium. Exportation without such a permit is to be punishable by imprisonment for not more than five years and not less than one year, or by a fine of not less than $5,000 or by both. The Secretary of the Navy, in recommending the adoption of the measure, wrote to the Chairman of the Inter-State and Foreign Commerce Committee, as follows:—

> "The sources of supply of helium in the United States are not numerous and the quantity obtainable is very much limited. This gas is non-inflammable and is, consequently, of inestimable value for balloons of all kinds, and, especially, for those of the dirigible types, that the Navy Department is endeavouring, under authorization by Congress, to develop and bring to a state of the greatest efficiency. It is manifest, therefore, that the public interests imperatively require conservation of the supply of this gas, as the demand for it abroad is insistent and great enough to consume, in all probability, within a short time the available supply in this country."

10. *Associate Committee on the Problems Affecting the Fox-breeding Industry.*—In April, 1919, the Council was requested, by a number of those engaged in the fox-breeding industry in Prince Edward Island, to investigate some of the difficulties which the fox-breeders of the island encountered in the breeding and rearing of foxes. These foxes are of the "black" or "silver" kind, and their pelts are exceedingly valuable, in some cases a pelt selling for as much as $1,000, while others are sold for prices varying according to their variation from the standard "black" or "silver" kind.

The difficulties, the breeders felt from their experience, arose from diseases, parasites, malnutrition, early mortality, etc. As the value of the pelts sold annually in Prince Edward Island, it was estimated, amounts to about $1,000,000, the Council decided that the subject deserved careful attention, and it deputed Dr. Andrew Hunter, Professor of Biochemistry in the University of Toronto, to proceed to Prince Edward Island to examine the conditions which affected unfavourably the fox-breeding industry.

Professor Hunter spent some six weeks visiting all the ranches accessible, and finally presented a report, the substance of which was subsequently published as a

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bulletin.* This report, which has found a circulation, not only in Prince Edward Island, but in Nova Scotia, New Brunswick, Manitoba and, through a French edition, in Quebec, points out that from 40 to 60 per cent of the foxes born never reach maturity, and though the average number at birth is not less than three and is often from five to seven, those raised to adult age do not exceed 1.25 per pair. The mortality is, therefore, very great. In ranches where great care is taken, though determined on wholly empiric lines, the yield is over 2·5 and, in some cases, it exceeds 4. The report points out, further, that it would be hard to say what might be the practical limit of improvement, but, if the actual yield were now 1·5, and the generally attainable set not higher than 3, it would not seem unreasonable to hope that the revenue from the industry might, by scientific management, be at least doubled, that is, the returns instead of being $1,000,000 would be $2,000,000 a year.

Amongst the factors causing this high mortality were infectious diseases, parasites, food poisoning and imperfect nutrition. Infectious diseases and parasites may be provided against by care on the part of those concerned. At present a very considerable amount of lore is available on these two subjects and, further, the Health of Animals Branch of the Department of Agriculture has been giving attention to this subject, so far as Prince Edward Island is concerned.

Food poisoning, however, and imperfect nutrition are at present more or less obscure subjects. The diet administered is not constituted according to scientific principles and, further, the composition of it varies from ranch to ranch. Food poisoning, it would appear, rarely occurs. In some cases the horse flesh used, it is suspected, was tainted, and it has been suggested that the flesh came from animals that had been dosed with arsenic for therapeutic reasons and the flesh, therefore, impregnated with arsenic, was more or less toxic to the foxes.

The diet of the foxes is not, as already stated, constituted on scientific lines. Even where the diet, as in certain ranches, gives favourable results, it is based on purely empiric experience, but it does not necessarily follow that, where it appears to be successful, it is as valuable as a diet based on scientific principles. The proper diet of the fox is not known. There has been no investigation of its metabolism, such as has been carried out in the case of the dog and certain other domestic animals. In consequence, one diet is regarded as good as another until it proves to be impractical or gives untoward results, and it is thus that the empiric diet has been evolved.

Dr. Hunter recommended that an investigation of the metabolism of the fox should be undertaken, in order that its diet should be placed on an unassailable basis. This recommendation the Council accepted and it appointed a Committee to superintend an investigation on the nutrition of the fox, of which committee Dr. Hunter was appointed Chairman. This committee was instructed to work in co-operation with the Health of Animals Branch of the Department of Agriculture.

The committee has, in co-operation with the Department, decided to conduct the investigation on the nutrition of the fox at the Biological Research Laboratory at Hull, where the Department has installed quarters for the investigation and also pens and kennels for six pairs of foxes. A grant of money has been made to meet the expenses of this investigation. An investigator, a biochemist, has been appointed to carry on the investigation on the animals, and it is hoped within two years to obtain the data which will enable the fox-ranchers to formulate a diet that will be physiologically sound, and, if carried out, will lower the mortality which at present is believed largely due to mal-nutrition.

The character of the committee itself, consisting of physiologists, biochemists, veterinarians, etc., promises that the investigation will certainly be of a character that will result in data which will dispose of mal-nutrition of the fox as an untoward factor in fox-breeding.

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*Bulletin No. 8, "Some Problems of the Fox-Raising Industry," published by the Honorary Advisory Council for Scientific Research, 1919.

11. *The Manufacture and Use of Nitrogenous Fertilizers in Canada.*—In 1917 the Research Council had its attention called, by the Dominion Food Controller, to the necessity of increased crop production in Canada, and, associated with this question, was the increased use of nitrogenous fertilizers.

An inquiry at the time showed that the production of ammonium sulphate, resulting from the coke production and in the various gas plants throughout the Dominion, was about 14,000 tons, which was almost wholly exported to the United States and to the West Indies. There was, therefore, very little used in agriculture in Canada. In some provinces, in the West particularly, the use of such fertilizers was not considered necessary because the soils were virgin, and this led to a waste of the ammonia of some of the gas plants, notably that at Winnipeg, which until recently turned the ammonia liquor resulting from the manufacture of gas from coal into the city drains.

The quantity of ammonium sulphate now produced in Canada amounts to about 17,000 tons, which, with the exception, as in 1916, of a few hundred tons, is wholly exported. It is also to be noted that about 60,000 tons of calcium cyanamide, made at Niagara Falls, Ont., is, with the exception of a few tons, wholly exported. This fertilizer can under certain conditions replace ammonium sulphate in certain soils.

There are certain parts of Canada in which nitrogenous fertilizers are necessary, in order that the crop production may be kept up to the standard obtaining elsewhere. If more fertilizers were used, and particularly those of the nitrogenous kind, the crop production, in Ontario, for instance, would greatly exceed what it is now. The fact is that in certain agricultural sections of the Dominion there is an inclination to ignore, or refrain from, measures which will increase soil fertility and thus bring down the cost of crop production.

In the agricultural sections of Germany, where the land has been tilled for centuries, and which, to begin with, was of a poor character, the wheat production was raised to 31-33 bushels per acre, as compared with 22-25 in Ontario for the same time. The difference is due to the fact that the German farmer freely applied fertilizers to the soil, recognizing that such application rewarded him, ultimately, handsomely.

In certain portions of Canada the soil has been undergoing a process of exhaustion for two, and even three generations and little has been put back into it. In other words, it is "mined." This process is going on in the West to-day, and within ten to fifteen years the result will be shown, even under otherwise most favourable circumstances, in a greatly decreased yield of crops. If the recognition were general, that the application of fertilizers would result in greatly enhanced crop yields, the total amount of ammonium sulphate and of the cyanamide produced in Canada would be retained for use on the farm lands which have now suffered more or less of exhaustion in their nitrogen-holding constituents. If such extensive use of fertilizers were resorted to, it would entail the consumption of four or five times the quantity of ammonium sulphate and calcium cyanamide produced in Canada. The production of these would be readily quadrupled if the market for them in Canada were enlarged by their use in the sections of country where they are needed. The various gas works producing gas from coal distillation, which now do not utilize the resulting ammonia to form ammonium sulphate, could, by this enlarged market, be made to utilize, instead of wasting it, the ammonia of the liquor which is now thrown away.

Further, as a result of the work of the Lignite Utilization Board, in demonstrating the briquetting of the poorer lignites of Saskatchewan, there may develop a large number of plants erected for this purpose in Saskatchewan and Alberta. The ammonia liquor resulting would yield a very large amount of ammonium sulphate. An increase in the amount of cyanamide produced may be expected from the fact that a large part of the water-power of Canada is still undeveloped.

These facts make it evident that the increased production and use of fertilizers in Canada is a matter of national importance. Their use depends upon a system of education in the agricultural sections of the country on the value of fertilizers appropriately applied.

The Council, accordingly, has undertaken to call the attention of leading agriculturists and those concerned in the work of the various experimental stations through the Dominion to the importance of the use of fertilizers as a means of increasing the wealth of the country. It has issued a circular, calling attention to many of the facts here referred to, which suggests methods of co-operation between different organizations to educate the farmers as to the advisability of the increased use of fertilizers.

A copy of this circular is published as Appendix L.

It may be pointed out that since 1900 the food supply of the world, according to publicists dealing with the subject, has been steadily decreasing. At that time the supply of food was sufficient for six months ahead. In 1914 it was only sufficient for about three months ahead. It has been claimed that the food supply of 1919 was only about two months ahead, and, if the old wasteful methods of consumption were then employed it would not last six weeks. It has also been claimed that it will take twenty years for the food supply to reach what it was in 1900. In the meantime, conditions throughout the world may bring hardships approaching those of famine, and, in consequence, the production of food from the soil may be not only a duty to the State but also to humanity.

12. *Exploration and Survey of the Oil Shales of the Dominion.*—The Council had its attention called to the importance of this subject by the representative of an English firm of capitalists desirous of investing large sums of money in Canada, who had come to Canada in November, 1919, to report upon the possibilities of successful development in Canada of the oil shale industry and of the production of potash from any potash holding deposits.

After several weeks in Ottawa this representative reported to the Administrative Chairman that, although there were extensive deposits of oil shales in the Dominion, the character of these had not been fully determined, to justify the investment of capital in their development. In some cases the surveys are of a very indefinite character, and consequently, any attempts at undertaking their development might involve very considerable risk, possibly failure, unless secured against such by thoroughly ascertaining at the outset all the factors which would promote success.

Some of these deposits are more or less well-known, those, for example, in Pictou county, N.S., and in Albert county, N.B., but even in regard to these there is an indefiniteness as to their extent and the possibilities of their being successfully mined, which deters investment in them. About the other deposits, and especially those of the Pasquia Hills district of northeastern Saskatchewan, only the most general or superficial knowledge is available, as no systematic scientific surveys of them have been made.

The extent of the deposits in the Pasquia Hills district is probably very great, but the yield of oil and of ammonium sulphate which they may furnish has not been at all determined, although specimens obtained at different points from these regions gave, on analysis, indications of a high yield. These data are not sufficient, however, as the extent of the deposits of which the specimens analysed were samples was not determined. What is required is a knowledge, not only of the extent of the oil shales and their possible yield in oil and ammonium sulphate at any one place, but also the range and character of these deposits from point to point all over the areas where they are found.

If this information were available for all the deposits, it would assist greatly in the development of these oil shales before the world supply of oil from oil wells approaches exhaustion, which, so far as the United States is concerned, will occur within twenty years.* The approaching exhaustion of this supply of oil in the United States will compel the development of the extensive oil shale deposits in the Western States.

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*According to an estimate made by Dr. White of the U.S. Geological Survey, the oil supply of the United States will be exhausted in about sixteen years.

The Council, in view of these considerations, passed the following resolution:—

> "That the Department of Mines be urged to undertake a comprehensive investigation of the oil shale resources of the Dominion, and particularly those of Western Canada, and that a report embodying the results of this investigation be published at as early a date as possible."

A copy of this resolution was placed before Sir George E. Foster, Chairman of the Sub-Committee of the Privy Council for Scientific and Industrial Research, and also before the Hon. Arthur Meighen, Minister of Mines.

The Department of Mines, it appears, accordingly arranged to make provision during 1920 for this survey, but, owing to the resignations from the staff of the Survey, and also from the Mines Branch, it felt itself unable to carry out this programme for the year, but it hopes that in the next year it will be in a position to undertake this survey on an extensive scale.

The Council believes that the oil shales of the Dominion may yet prove a source for a large supply of oil fuel and gasoline, and holds that the development of these shales should be systematically encouraged.

13. *The Formation of Associate Committees.*—The Council during the year appointed a number of Associate Committees to superintend special lines of research.

Amongst these is the Physics and Engineering Physics Committee, constituted to deal with all questions concerning researches in pure physics and also in physics on the engineering side. This committee is composed of the leading professors of physics in the universities of Canada and it also contains in its membership a number of others who are engineers with special attainments in physics.

An Associate Biological Committee was constituted of the leading biologists, physicists and biochemists in Canada, to encourage research on problems in marine biology and physiology.

An Associate Committee on Food Research was appointed to superintend researches on the newer food problems, including in that the constitution and functions of the vitamines, which are now known to be absolutely necessary in diet, the absence of which from diets cause what are known as deficiency diseases, amongst others, scurvy, rickets, beri-beri and possibly pellagra. The importance of these problems has been revealed by the war in Central Europe, where children reared on diets considered sufficient according to the knowledge current before 1913, have been the victims by thousands of rickets, marasmus, etc.

The significance of the problem may be gathered from the fact that it affects everywhere the diet of children and even of adults, and it is associated more or less closely with the question of milk as food. The importance of the problem is likely to be greatly enhanced in the near future, because the part that these vitamines play in the growth and in the well-being of the individual is to-day only partially indicated, and it is not unreasonable to suppose that questions of hygiene are profoundly associated with their action in the body.

The committee is composed of a number of biochemists whose work will be the investigation not only of these vitamines but also of any problem which concerns the nutrition of the human subject.

A Fuel Research Board was also appointed to deal with the standardization of coals throughout the Dominion. The necessity for this arose through representations made by the Hon. Mr. Stewart, Premier of Alberta, who had had under consideration the question of standardizing the coals of Alberta, because of the injury done to the coal trade of Alberta by the marketing in Winnipeg and other places of inferior coals, which had been represented as standard Albertan coals. This precipitation of inferior coal on the market led to a curtailment during the last year of the consumption of Albertan coal in Winnipeg and other places. It was claimed that, if the coals were standardized as to ash content, heat value and their use for domestic furnaces, the

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consumers would buy according to the standard, and thus they might resort to Albertan coals of the better character and so obviate the necessity for the importation of coal, other than anthracite, from the United States.

This board is constituted of four representatives from the Prairie Provinces, including President Tory, of the University of Alberta, and one from Eastern Canada, and its work will for the present be carried on in association with the coal laboratory instituted at the University of Alberta. Its function will be to standardize the coals from the various mines of Alberta and publish the results of its work, to guide the market in the use of these coals.

An Associate Air Research Committee was appointed to initiate and superintend researches in problems connected with aviation. This committee, which is under the chairmanship of Professor A. S. Eve, F.R.S., head of the Department of Physics of McGill University, is working in close co-operation with the Air Board of the Government, representatives of which, with Col. O. M. Biggar, the Vice-Chairman of the Board, attend the meetings and take part in the work of the committee. With this committee are associated a number of experts in aeronautics who will give attention to problems which will be referred to them. In Appendix H is given an account of the activities of the committee to the end of March, 1920.

14. *Central Information Bureau.*—In the Report of the Arministrative Chairman for 1918-19, the subject of the establishment of a Central Information Bureau, to disseminate information regarding the natural resources of Canada for the purpose of promoting their development, was discussed and the establishment of such a Bureau was urged.

The subject had then arisen through a resolution adopted by the Associate Committee on Mining and Metallurgy at its meeting on March 5, 1919, which read, as follows:—

> Whereas, in the present critical period of industrial readjustment and expansion it seems most important that all information concerning national resources which has been so painstakingly gathered by Government Departments in Ottawa should be quickly and completely available to responsible inquirers planning to build up various industrial enterprises based on the exploitation of these resources, and
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> Whereas, such information necessary for the development of a single enterprise often lies in the records of more than one of the Government Departments so that vexations and dangerous delays frequently occur in the collection of the necessary data for important projected developments.
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> Resolved, by the Associate Committee on Mining and Metallurgy of the Advisory Council for Scientific and Industrial Research that it is highly necessary that a Central Information Bureau should be established by the Government in Ottawa wherein all the different Departments should co-operate to make readily available complete up-to-date information regarding all the natural resources of Canada except those relating strictly to agriculture.

There is, it may be stated once more, a large amount of information collected, not only in certain of the Government Departments, but also in the Scientific Bureaus of the various Provincial Governments, information which, if centralized and collated, would be of the greatest value in stimulating the development of these resources. At present the information can only be obtained by those desiring it, in a piecemeal manner and by correspondence which may at times be tedious and protracted, and when it is obtained there is still the suggestion that it is more incomplete than it should be, were the information systematically gathered by a bureau specially organized for this purpose. This is a serious handicap on the development of those natural resources.

There are organizations in Ottawa which aim at giving information regarding the natural resources, for example, the Natural Resources Intelligence Branch of the

Department of the Interior, the Mines Branch of the Department of Mines, and the Mines Department itself. These are, doubtless, in a position to give, on some subjects, a considerable amount of information in response to requests for it, but there is not co-operation between these organizations and the various Provincial Bureaus, except perhaps of a more or less uncertain character.

Further, the Natural Resources Intelligence Branch, as it is not directly connected with the exploration of these resources, has to gather this information by extraction from publications and, very largely, by correspondence, as it may be required in any particular case, and this necessitates delay in cases in which it may have a discouraging effect.

The Bureau that the Council proposes is one which would have all the information available anywhere up to date, regarding all the resources of Canada, and it could, therefore, supply reports to any inquirer on any subject within twenty-four hours after a request for information would reach it.

The Council, influenced by these considerations, adopted the following resolution at its meeting, held on December 12:—

> "That this Council is of opinion that a Central Bureau of Information should be constituted at Ottawa at an early date for the purpose of rendering promptly available, and of disseminating, all information which might facilitate the utilization of Canadian natural resources and the development of Canadian industry."

Copies of this resolution were forwarded to Sir George E. Foster, Chairman of the Sub-Committee of the Privy Council for Scientific and Industrial Research, and to the Hon. Arthur Meighen, Minister of the Interior and Minister of Mines.

It may be pointed out that when the natural resources of Manitoba, Saskatchewan and Alberta are given by the Dominion to these Provinces, there will be, more than ever, a need for such a Central Information Bureau. The exploration of these resources will then, very probably, be undertaken by these Provinces, and much less in the way of such work will be done through the Dominion Government departments, such as the Department of Mines.

In consequence, there will be less information available in Ottawa because of the decrease of activities in such exploration on the part of the Dominion Government. There will then have to be some organization, whose functions it will be to collect from all the Provincial Governments the information that their scientific staffs may acquire through exploration and observation.

The ability of the Dominion to bear its huge burden of debt will depend on the rate of increase, annually, in the next few years of the wealth developed from these resources, and, therefore, the Dominion is specially interested in assisting every agency and organization that aims at utilizing the natural resources. The Dominion, therefore, should constitute an efficient organization which will disseminate all information on these resources, that may assist in making them available for development.

In thus emphasizing the necessity for a Natural Resources Information Bureau, it may be pointed out that the Council does not pronounce upon the character of the organization itself or as to whether any of the present organizations should be taken as the nucleus of such a Bureau. It urges the formation of this Bureau simply because it regards its constitution as a measure of immediate importance to the development of the natural resources of the Dominion.

15. *The Utilization of the Iron Ores of Canada.*—The utilization of the iron ores in Canada, to which reference is made in the Section on Assisted Researches, is one of the subjects to which the Council is giving careful consideration because of its national importance. A Committee of the Council, under the chairmanship of Mr. Lloyd Harris, appointed to report as to measures which should be taken to promote

the development of these deposits, as one of the results of its activity recently, formulated its position in a memorandum which was unanimously endorsed by the Council and subsequently submitted to the Sub-Committee of the Privy Council and to Sir Henry Drayton, Minister of Finance. This memorandum was as follows:—

> The question of the utilization of the native iron ores of Canada has at various times been before the Honorary Advisory Council and they have collected many data concerning these ores and have subsidized researches bearing on various phases of the question; but the importance of the matter is so great and the necessity for the development of a basic steel industry in Canada so pressing that the Honorary Advisory Council respectfully wishes to bring the matter before the Government in the hope that they may give consideration to the whole question.
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> The Honorary Advisory Council would respectfully suggest the following as a line of procedure:—
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> 1. The Advisory Council to support researches on the treatment of iron ores which appear promising.
>
> 2. The Department of Mines to collate and concentrate all available data relating to known iron ore deposits in Canada and to follow this by instituting immediately further surveys in Canada where favourable indications of iron deposits have been obtained.
>
> 3. The Government of Canada to consider the adoption of a policy such as will stimulate research and development on the part of individuals and corporations and so result in building up in Canada a basic iron and steel industry.

16. *The Utilization of the low-grade Lignites of Western Canada for domestic fuel.*—The report of the operations, for the last year, of the Lignite Utilization Board appears as Appendix E. In this report the difficulties which the Board has had to meet in the carbonizing and briquetting of these lignites on a commercial scale are fully set out and it is satisfactory to note that these difficulties are in great part overcome and that the work of installing a plant near Estevan in Saskatchewan has gone so far as to make it certain that in September or October next it will begin operations on a scale to turn out about 30,000 tons of briquettes per year.

The report emphasizes the fact that the cost per ton of the briquettes to be produced is likely to exceed the estimate given in the Report No. 1 of the Council, "The Briquetting of Lignites", prepared in 1917. The increase is due to the increase in cost since that year of all the items which had to be taken into account in making this estimate. It is, however, certain that the price in Manitoba and Saskatchewan of anthracite, to which the briquettes of carbonized lignite will be approximately equal, ton for ton, in heat value, will very considerably exceed the price current in 1917 and in consequence the briquettes will be much in demand. With a decline in their cost, which will undoubtedly result eventually from a reduction in the cost of the raw materials and the operating processes the demand for them will increase, more especially as the price of anthracite, it is exceedingly probable, will go still higher or the quantity of it which will reach Western Canada will be exceedingly limited.

As the report points out the commercial success of the demonstration of the briquetting lignites will inaugurate the development by private capital of the briquetting industry on a very large scale in the next few years in Western Canada.

17. *The work of the Committee on Industrial Fatigue.*—The work of this Committee, a report of which is given in Appendix G, has been carried on on a tentative basis during the year, with the object of determining along what line ultimately the activities of the Committee should be most profitably directed. The work of the British Industrial Fatigue Board has resulted in a large amount of information of value as applied to British industries, and investigations carried on under the Federal Health Department at Washington, at Harvard and John Hopkins Univer-

sities, indicate the nature of the problems concerned in American industries, but in either case the ground covered is not all-comprehensive and it appeared possible for the Committee to select several of the problems, the investigation of which would not involve duplication of the work done abroad. This necessitated some preliminary survey which the Committee began on the following:—

(*a*) The present situation in regard to industrial hygiene and social welfare in certain representative industries.

(*b*) The amount of lost time due to sickness and the amount of labour turnover.

(*c*) The incidence of occupational diseases in certain industrial lines.

The work so far on these problems has been chiefly confined to the first, (*a*) and it is expected that during the coming year enough of data will be obtained to enable the Committee to concentrate its energies on a line of investigation distinct from any of those lines undertaken abroad and of special importance to industrial conditions in Canada.

The Committee has asked that its name be changed to that of the Committee on Industrial Hygiene. Soon after it was appointed it was recognized that the name "Committee on Industrial Fatigue" postulated a too limited function, for it was found that all the factors of industrial fatigue are associated very intimately with the health and diet of the worker and the hygienic conditions or otherwise of his environment, not only during his working hours but also of his life outside the factory or workshop. In consequence the change of name appears justified but the reason for the change has raised a question which concerns the future of the Committee.

Public hygiene is one of the functions of the Dominion Department of Health recently established and accordingly to have investigations on subjects in certain lines in industrial hygiene carried on by a committee outside of and not responsible to that Department is contrary to the policy of the Research Council, which has scrupulously avoided any duplication of the work or the functions of a department in the public service. When it appeared that the work of the Committee would inevitably include investigation in industrial hygiene the Administrative Chairman made representations to the Deputy Minister of Health urging that the Department should take over and carry on the work of the Committee which legitimately belongs to it. While recognizing that industrial hygiene is under the control of the Department the Deputy Head of the latter is at present unwilling to assume this control owing to its limited budget which no more than suffices to meet the programme of work of the department.

There is, however, hope that perhaps next year the department may be in a position to carry on this work on an adequate scale as it should be and for the present the Committee must continue the work it has undertaken, the results of which will blaze the path for that department when it assumes responsibility for it.

18. *Forest Studies.*—In Appendix F is given the report of work and investigations carried on, during the season of 1919, on the Petawawa Reserve by the Forestry Branch of the Department of the Interior. This work, it may be recalled, was begun in 1917 with the aid of a grant from the Research Council and continued, similarly supported, in 1918. In those two years the portion of the reserve surveyed was about 55 square miles. The grant for 1919 was $6,282.32 and the work then done practically completed the preliminary survey of the remainder of the one hundred square miles approximately of the reserve. The final report of this preliminary survey, which will be available shortly, will render a complete account of the work of the last three years.

The object of this survey, it is stated in the report for the year 1919, "is to delineate and describe the various forest conditions; to gather data in regard to topography, soil, distribution of age classes, growth, available supply of saw timber, etc.; in short to collect all such information as will be of help in planning the organization and management of the experimental area." All this information is to be used to

determine ultimately the scientific conditions on which effective reforestation may be carried on in Eastern Canada.

The data so far thus obtained are numerous and of value but the survey and the necessary investigation associated with it must be continued on a much larger scale, for at least ten years further, in order to command all the information necessary to attain the ultimate object of these studies.

The reserve, in many respects, is admirably fitted to serve for such investigations. It was originally covered with white pine and other important timber trees and its capability for such timber growth has thus been shown. There is now a young forest of these trees covering the greater part of the area, thus furnishing the material on which to make the initial measurements necessary for the determination of rates of growth in volume and the possibilities of reproduction of these trees. The area is also large enough and the character of the soil and its conditions varied enough to represent all the conditions which occur either singly or together in other areas which it may be desirable to reforest. Further the reserve is under the control of the Dominion Government, through the Department of Militia and Defence and being easy of access from Ottawa the work carried on there may be readily kept under supervision by the Forestry Branch during the whole of each year.

The Research Council has hitherto, so far as its parliamentary vote permitted, assisted these forestry studies because the problem of reforestation, in view of the threatened depletion of our forest resources, is amongst the questions of the first order of importance to Canada and because also they must be pursued in order to provide the knowledge absolutely necessary for successful reforestation on a large scale. The Council has, further, provided a grant of $8,000 to continue the studies in 1920. It, however, recognizes that, begining next year, the survey must be carried on on a large scale and on a plan that will provide for systematic and co-operative investigation throughout each of the succeeding ten years. This will entail the erection of stations and a laboratory on the reserve and the maintainance there almost continuously of a staff of expert observers. This will involve a large expenditure, quite beyond the means of the Council to meet, and in consequence, and as such work is a function of the Forestry Branch, it is of the opinion that an appropriation to be expended by the Branch to cover such investigations for the next five years should be included in the estimates for 1921. The Council believes that it is only in this way that the studies already begun can be carried to a conclusion with results that will guarantee successful reforestation in Eastern Canada.

19. *The Establishment of a National Research Institute for Canada.*—The Research Council early in 1918 presented to the Sub-Committee of the Privy Council for Scientific and Industrial Research, and to the Reconstruction and Development Committee of the Government, an urgent recommendation that this Institute be established at an early date, with the functions of a Bureau of Standards and to provide facilities for research carried on and maintained by associations or guilds for research formed in the various lines of industry in Canada. This recommendation led on April 24, 1919, to the formation of a special committee of the House of Commons "to consider the matter of the development in Canada of Scientific Research, with power to call for persons, papers and records and to examine witnesses under oath, and to report from time to time." This Committe consisted of the following members of the House of Commons: Messrs. Béland, Cronyn, Elkin, Keefer, Kennedy, Lemieux, McCrea, McCurdy, McGibbon (Muskoka), Maclean (Halifax), Nickle, Nicholson (East Algoma), Reid (Mackenzie), Ross, Sheard, Sinclair (Antigonish and Guysborough), Sinclair (Queen's, P.E.I.), Stevens, Thompson (Yukon), Tweedie, and Whidden.

This Committee, under the chairmanship of Mr. Hume Cronyn, held ten sessions at which hearings on the subject of the promotion of scientific and industrial research in Canada were accorded to a number of members of the Council and of the scientific

staffs of various Canadian universities and to representatives of a number of the Scientific and Technical Societies and Institutes of the Dominion, of certain Government departments, and of the Canadian Manufacturers' Association. Dr. S. W. Stratton, Director of the Bureau of Standards at Washington, Mr. W. A. Hamor, Assistant Director of the Mellon Institute of Industrial Research of Pittsburgh, Pa., and Professor Dayton C. Miller, of the Case School of Applied Science, Cleveland, Ohio, also appeared before the Committee and gave very interesting and valuable addresses on the methods to be taken to promote scientific and industrial research.

This Committee in a report to the House of Commons on July 1, summarized its conclusions in the following:—

> "Your Committee feel that the time has arrived when further steps must be taken and additional financial support be available if this country desires to make a proper use of its potential assets and to attain or maintain its standing in the commonwealth of nations.
>
> "The attention of your Committee has been directed to the fact that there does not exist in this country any institution corresponding to the Bureau of Standards at Washington. As a result, Canada is dependent on the neighbouring republic or on other countries for information and guidance in matters which vitally concern her industries. A study of the evidence submitted will convince any impartial student of the weakness of our position in this regard and of the need for a speedy remedy. Your Committee, therefore, recommend to the consideration of the Government the establishment of a Dominion Bureau of Standards.
>
> "Your Committee further recommend that concerted and continued efforts be made to place before the people of Canada the facts regarding scientific research and the far-reaching advantages to be derived from national support thereto. It is plain that outside of a limited circle even the best informed and most influential citizens are sadly lacking in knowledge on this important subject.
>
> While your Committee, as above stated, are unanimous as to the need of co-operation and national support of Scientific Research, yet a majority of its members, owing to the lack of time and pressure of other parliamentary duties, feel they have been unable to so consider and digest the evidence adduced and the other material brought to their attention as to advise the House at this time what may be the best methods of aiding and encouraging Scientific Research throughout Canada."

This report, which was unanimously adopted by the House of Commons on July 3, included a recommendation that the Committee should be reappointed as early as possible in the next (regular) session to give further consideration to this matter and to report to the House of Commons for consideration proposals dealing therewith.*

In support of the proposal to found a National Research Institute for Canada there has been a gratifying unanimity of opinion amongst a large number of Boards of Trade, of Canada, Kiwanis and Rotary Clubs, Institutes, and of branches of the Canadian Manufacturers' Association, as shown by the resolutions which they have sent to the Committee and to the Research Council. This indicates quite clearly that the necessity of founding a National Research Institute for Canada is widely recognized.

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*This Committee was reappointed on March 23, 1920, and has reported recommending the establishment of a National Research Institute for Canada and that an appropriation be made of $600,000 to meet the cost of the site of the Institute, of the construction of the building required and of the scientific equipment of the same, and of $50,000 for the salaries of the staff during the first year. This report was unanimously adopted by the House of Commons on May 7.

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The Council would again call attention to the urgency of this Institute as a measure of national importance to Canada. Such an Institute is necessary not only for providing the Dominion with the equivalent of a Bureau of Standards, but also to enable Canadian industries to meet the competition from abroad, aided as this competition is now and will be, by all the resources that scientific research, of the most advanced character, will place at its command.

The Bureau of Standards at Washington has established an Industrial Research Institute in the recently completed building, erected for a War Service Department, which has been presented to the Bureau by President Wilson. In this Institute researches on an extensive scale will be undertaken in all the lines of industries which may choose to avail themselves of the facilities offered by the Institute. This Institute is bound to be of the very greatest service to the industries of the United States and this has a significance to Canada that cannot be too strongly emphasized.

Owing to the importance of the subject, a special portion of this report (section II) is devoted to the part that the National Research Institute will play in assisting research in Canadian industry and more especially through the formation of Associations or Guilds for research in each line of industry. A very considerable number of such Associations have been formed in the British industries and their formation in the United States is being promoted by the National Research Council. The formation of Guilds for research in the Canadian industries depends as indicated in section II on the establishment of a National Research Institute.

II. INDUSTRIAL CO-OPERATION FOR RESEARCH.

The organization of the industries to promote research on the problems which they have to solve in order to meet competition is a subject to which much attention is now being given in Great Britain and the United States and it is one of special interest to all who are engaged in promoting measures which will enable Canadian industry as a whole to move to a position at least abreast of the more progressive element in British and American industry.

The subject was given extended consideration by the Research Council in 1917 and 1918, but the solution offered depended for its success on the establishment in Canada of a National Research Institute and in consequence the Council during 1919-20 specially directed its energies to the achievement of the latter very urgent object. Now that the establishment of this Institute is in more or less immediate prospect it is advisable that the scheme of organization of the Canadian industries for research which the Council recommended should be again emphasized and that a campaign of education on the subject should now be undertaken in the various lines of industry with the object of promoting the right organizations for this purpose.

To facilitate this propaganda it is necessary to discuss the subject once more and especially in the light that the developments of the last two years have thrown on it.

In the report of the Administrative Chairman for the year 1917-18 the way in which scientific research, as an aid to the development of industry, could be applied effectively and on a large scale was discussed at some length and it was shown that this aid could be most efficiently rendered through the formation for this purpose of a co-operative Association in each line of industry in Canada to consist of all the firms or companies engaged in each such line. Each such Association or Guild, as it was called, would provide funds by assessing its members, and the funds so collected would be used to meet the expenses of the researches it would undertake as well as to provide for other objects of the Guild. The funds each Guild so provided could be expended by a committee or board appointed by the Council or the Guild, and the results of the researches obtained would be available for the benefit of each firm in its membership. The members could be accorded other advantages as this arrangement might admit. Amongst such, it was suggested, were:—

1. The right to recommend specific problems for research, which would be passed on by the board or committee, and, if approved, carried out without cost to the firm recommending that the research be undertaken.

2. The right to a periodical service of information for the purpose of keeping a firm in touch with all the technical developments in the industry, even to the extent of receiving copies of articles, translated if originally in a foreign language, bearing on any subject concerned in the industry.

3. The right to the free use of all patented or secret processes which may result from the researches undertaken by, or at the expense of, the Guild.

It was also indicated that firms in an industry not members of the Guild would be excluded from all these privileges and especially from the use of the patents granted to the Guild and that all information as to secret processes would be withheld from them.

The report referred to, then dealt with the question of how far the State should assist such Guilds as follows:—

"How far aid should be extended to such Guilds must be determined by the conditions attendant upon each line of industry. Ordinarily, when given it should not, except under special circumstances, be in a direct form but in such a way as to stimulate to the utmost private effort and enterprise in industrial research. If a Guild were provided with ample resources of its own for this purpose, it would be in a position to provide its own laboratories and maintain them and a staff for research to the extent required. For Guilds less well circumstanced such establishments are impossible, for the erection and equipment of small independent laboratories will be beyond their means. To reduce the burden to such and to enable them to concentrate their resources on their necessary researches, it would be advisable for the State to provide them room accommodation in a large laboratory with free light, heat, and, where necessary, motive power, and in which they could place research staffs maintained by them. Relieved thus of the initial cost of laboratory construction and of the expense of the maintenance of the laboratory rooms, each Guild could devote all its funds for research to the solution of its immediate and urgent industrial problems."

The laboratory would be that of the National Research Institute for Canada. The staff of this Institute, in addition to the duties it would have of directing and carrying on research in its own proper sphere, would serve in an advisory capacity to research staffs appointed by the Guilds to investigate their own problems. Moreover, with common heating and lighting equipments, the overhead expenses of such united Research Institute and Guild Laboratories would be reduced to a minimum.

In advocating the formation of such Guilds for Research in the various lines of industry in Canada the Research Council followed the example set by the British Research Council, which as early as 1916 began to advocate formation in the various lines of industry of Trade Associations for Research with, approximately, the same function as those outlined, as above, for the Guilds for Research. The reasons for the constitution of these co-operative associations in Canada are the same as those which influenced the Imperial Department of Scientific and Industrial Research to promote the organization of the Trade Associations for Research. There is the fact, for instance, that the great majority of the firms in a line of industry are, individually, unable to provide for expenditure for research on a scale that would insure adequate results. Improvements in processes of production over those now employed, and in the products themselves, can only be obtained through new knowledge that research brings. This research involves very considerable expenditure if it is to be at all of value. Laboratories have to be established and maintained and a staff highly qualified and trained in research must be employed continuously.

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This means an annual outlay in the great majority of cases of more than, and perhaps, in some cases, much in excess of, $30,000, an amount that is out of question except with firms with a large amount of capital and a very considerable output in production.

It must also be emphasized that firms which cannot avail themselves in some fashion of the resources that research of the right kind furnishes must in the end be seriously handicapped in competition with rivals which do generously provide for research. All their technical processes of manufacture based on knowledge of the empiric kind or on scientific methods may be known to their rivals while those of the latter may be secret or be patented as a result of the researches for which they are able to provide. There can in the long run be but one outcome of such competition.

That such competition is likely to develop abroad may be predicted with certainty. Already there are some sixteen Trade Associations for Research formed in Great Britain under the auspices of the Department of Scientific and Industrial Research and it has been announced that some eleven or twelve more are either in the course of formation or in the inception stage of the same (*vide* Appendix M). Further, the National Research Council at Washington has been for the last year, and is now, active in the promotion of such Trade Associations for Research in the United States and some success has already attended its efforts along this line. Research Associations on alloys, cotton, glass, baking, etc., are projected or in the course of formation. There are indeed many firms in the various lines of industry in the United States which, individually, have thoroughly equipped laboratories with staffs for research of the most highly qualified kind, and in consequence they do not require to become members of such Trade Associations, but there are very many more each with a moderate amount of capital, for which co-operation is the only way in which they can avail themselves of the benefits of research. That such Trade Associations will be of the greatest service to its members is not open to doubt, and it is likely that under the influence of the National Research Council a considerable number will be constituted in the next few years. The membership in each will be large, for the number of firms in each line of industry, with a few exceptions, is much greater than in Canada, and in consequence the funds for research which such Associations will command will be quite ample to undertake research on a very large scale. One of those now formed—that concerned in petroleum—has already at its disposal more than $1,000,000. With such resources the Trade Associations of the United States will be able to provide their own laboratories and engage researchers whose training, attainments and achievements will be a guarantee that the results which they will obtain will greatly benefit the industries concerned. With more than thirty such Trade Associations functioning in the United States a new era in industry will begin, as, for the same reason, it has already begun in Great Britain.

The funds at the command of the British Trade Associations put their successful operation beyond peradventure. They are obtained by assessing firms in the membership according to some basis agreed upon at the time the Association is formed, but if they are not in any one case sufficient to cover the necessary expenditure the Department of Scientific and Industrial Research will contribute annually for a period of years an amount, to be agreed between the Council of the Association and the Department, but except in cases which call for special consideration the annual contribution of the Department will not exceed £5,000 at most, or the amount raised by the assessment of the firms in the membership of any particular Association. The provision which may thus be made to secure adequate funds for research for the various Associations should enable these to prosper and to become permanent foundations.

The formation of such Trade Associations in Great Britain and the United States is of unmistakable significance to Canada. The industries of Canada cannot remain indifferent to the part they will play in changing the conditions of produc-

tion in favour of their competitors abroad, and they must organize to promote to the same extent research as an aid to their own development. They must also form Co-operative Associations or Guilds for Research. (*Vide* Appendix N).

There are a number of lines of industry in Canada in which such Guilds could be formed and amongst these may be mentioned the tanning, the textile, the pulp and paper, the furniture, the rubber, the fisheries, the canning, and the clay products industries. These are all important to the industrial development of the Dominion and if the firms in each of these lines were brought to form such Guilds with ample funds at their disposal, the results eventually obtained would be greatly to their advantage in their struggle to win against outside competition, assisted though it will be through research.

The number of firms, however, in any Canadian industry, are fewer and, with some exceptions, of smaller capital and output than those in Great Britain or the United States and consequently the funds which they may pool for research cannot be of a magnitude to compare with the funds of the Associations formed abroad. They cannot, therefore, hope to engage in research work on a sufficiently large scale unless aid is extended to them from some quarter. It is doubtful if public opinion would sanction direct public grants to them such as have been made by the Department of Scientific and Industrial Research to the British Trade Associations for Research. Any assistance extended to them must be of an indirect character and sufficient to relieve them of a considerable portion of the expenditure for research which, without such assistance, would be beyond their means. The cost of the erection, equipment and maintenance of laboratories is a very considerable item in such expenditure and might readily be as much as half of the whole. If relief could be extended so as to cover this portion of the expenditure all the funds of the Guilds pooled for research would go to the payment of the salaries of those engaged to carry on research on their problems and they would thus get the maximum of service for their expenditure. A Guild with an income of $30,000—$50,000 derived from assessment of its members could thus do much in providing for research as a British or American Trade Association with twice the same income. It could thus engage and maintain in its service a fairly large staff of the most highly qualified research type.

To extend this relief will not be difficult if the proposed National Research Institute for Canada is founded in the next year or two. The first laboratory building of this Institute, of the size suitable for the earlier years of its activity, besides providing administration offices, would contain more than fifty laboratory units a dozen or more of which could be placed, for some years, at the service of the Guilds, rent-free and with free light, heat and, where necessary, motive power. The assistance so given, while of a negligible cost to the Dominion, would be of inestimable value to the industries which organized Guilds for Research.

Some advantages, it may be pointed out would result to the public from this centring of the research staffs of the Guilds in the proposed National Research Institute. It would bring the staff of the Institute into intimate contact with the industries of the country and this would tend to focus the attention of the researchers on many of the very problems which concern the industrial development of the Dominion which the Institute would be founded to promote. There would thus ensue an intimate association between the Institute and the industries that would greatly increase the effectiveness of the former as a national institution.

Such an association is now being brought about in the Bureau of Standards at Washington. A new building, of very large capacity and of the most solid construction, erected in the immediate vicinity of the laboratories of the Bureau and designed for war service, but completed only in November of 1919, was given to the Bureau by President Wilson and is to be used for industrial research on a large scale, for which it is admirably fitted. It will parallel in many respects the Mellon Institute for Industrial Research at Pittsburg which has already been of great service to certain lines of industry in the United States. The addition to the present activities and

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functions of the Bureau of Standards of such as those which the new Industrial Research Institute will exercise will at once very greatly enhance the value of the Bureau itself to the nation and profoundly affect ultimately the development of its industries.

The accommodation of the research staff of the Guilds for Research in the proposed National Research Institute would greatly promote their efficiency. In some lines of industry there are common problems or problems closely related and there are, therefore, possibilities of duplication or overlapping and accordingly unnecessary expenditure. With the research staffs of such industries working under the same roof this can be readily prevented and the activities of each may be guided so as to bring about a co-operation in all the researches undertaken.

A very great advantage to the industries would accrue from the research staffs of the Guilds being in close association with the staff of the Institute. This staff must be composed of a number of very highly expert specialists in research in the various fields of pure and applied science. The members of the staff would, therefore, be qualified in the highest degree, each in his own line, to act in any advisory capacity to one or more of the research staffs of the Guilds housed in the Institute, not occasionally but continuously. This and the association, under the same roof, of the research staffs of all the Guilds would promote, amongst them, a spirit of emulation in research that would make every researcher keen to achieve the utmost of which he may be capable. The Guilds would thus get a service which it would be impossible to provide them if they were not associated with the Institute.

The formation and the successful working of such Guilds in Canadian industries, therefore, depends on the establishment of a National Research Institute. Through such Guilds only can the great majority of the Canadian industries be assisted to meet the needs in Scientific research which the conditions of to-day impose on them. Without the new knowledge that research will bring them they will not hold their own in competition with their rivals abroad who are organizing to apply research of the most advanced kind to the solution of the problems which concern their very existence.

The establishment of a National Research Institute which primarily is necessary to promote a great increase of the developed wealth of Canada is, therefore, also necessary to the development of the industries of the Dominion and to enable them to hold their own not only in the home markets but also abroad. *The urgency of the establishment of this Institute is, therefore, of the first order of importance and every year lost in effecting this establishment will increase the difficulties which Canadian industry will face in competition with industry abroad, aided by all the resources that scientific research will place at its command.*

The Council, therefore, once more urgently recommends the immediate establishment of the National Research Institute to enable Canada to develop its wealth, and its industries to hold their own, not only in the home markets but also in the international field.

Pending the hoped-for result of this recommendation the work of promoting the formation of Guilds for Research must be of the first order in the programme of the Council during the next two years.*

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*In order to facilitate this promotion the Circulars of the British Research Council indicating the procedure followed in the formation of the Trade Associations for Research in Great Britain are reproduced as Appendices.

APPENDIX "A"

REPORT OF THE ASSOCIATE COMMITTEE OF CHEMISTS.

The annual meeting of the Associate Committee of Chemists of the Honorary Advisory Council for Scientific and Industrial Research was held in the Chemistry Building of McGill University on May 15, 1919. Thirteen of the eighteen members were in attendance. The Chairman, Dr. R. F. Ruttan, briefly reviewed the activities of the Advisory Council for the year 1918, so far as they were specially interesting to chemists. He stated that the "Census of Chemical Industries of Canada", which was recommended at the last meeting of the Associate Committee had been prepared and was ready for distribution. He reported that a system of bursaries for distinguished graduates, who had not had an opportunity for showing their ability for research, had been established, of the value of $500 per annum. The Advisory Council had also arranged that those holding Fellowships, etc., as well as those engaged in researches assisted by the Advisory Council, would be able to patent their discoveries, if of commercial value, under very favourable conditions.

The difficulty of obtaining publication of important scientific papers was discussed, and the Chairman announced that the Advisory Council would probably subsidize the Royal Society of Canada to cover the cost of printing the more important papers in the Transactions of that Society.

After referring to the various researches which were being carried on with assistance from the Advisory Council, the Chairman reviewed the proposed legislation in favour of establishing a National Research Institute and stated that this question would be up for consideration before a committee in the House of Commons during the next Session.

The development of an industry in connection with the utilization of fish waste had not made the progress hoped for by the Research Council, but the publicity given to the question by the Council had led to the formation of a private company to utilize the fish waste at Canso, N.S., by manufacturing from it a high-grade cod-liver oil, stock and poultry food, as well as fertilizer.

In discussing the points arising from the opening address, the Committee heartily endorsed the idea of a Research Institute and also the idea of extending the system of Fellowships so as to include the Ramsay Memorial Fellowship, entitling the holder to conduct chemical research in England.

Dr. Macallum fully described the proposed system of Trade Associations or Guilds for co-operative research in the main industries.

The question of establishing an employment bureau for chemists, similar to that in the Chemists' Club, New York, was brought forward by Professor Cameron, of the University of New Brunswick, and was fully discussed, a resolution was passed to take steps towards establishing such an employment bureau, which was asked for by both chemists and employers.

Two papers were read on the training of chemists for industries, one by Dr. McIntosh and one by Dr. Ruttan. These papers led to prolonged discussion, the general result of which was to emphasize the value of research in fundamental problems of chemistry in the universities, in preference to problems involving the application of chemistry to industries. It was also recognized that the training of chemical engineers should involve a certain number of months of instruction in chemical works, and it was thought advisable to thoroughly investigate the possibility of applying to Canada the plan adopted by the Massachusetts Institute of Technology, of giving to students, before graduation, four or five months of experience and train-

ing in chemical industries, under the supervision of a university professor. In this connection, Dr. Macallum brought forward the advisability of limiting the university training for B.Sc. degree to three years, and reserving the fourth year for graduate work.

It was decided to have the members of the Committee retire annually in groups of five, thus permitting each member to serve for four years on the Committee. The order of retirement is as follows:—

To retire in 1919.

Dr. W. H. Ellis, University of Toronto.
Dr. W. L. Goodwin, School of Mines, Queen's University.
Dr. Milton Hersey, President, Milton Hersey, Ltd.
Dr. R. D. MacLaurin, University of Saskatchewan.
Dr. M. A. Parker, University of Manitoba.

To retire in 1920.

J. B. Bell, Jr., M.Sc., Can. Explosives Co., Ltd.
Professor Adam Cameron, University of New Brunswick.
E. A. LeSueur, B.Sc., Consulting Chemical Engineer.
Dr. E. Mackay, Dalhousie University.
H. W. Matheson, Can. Electro Products Co., Ltd.

To retire in 1921.

J. W. Bain, B.A.Sc., University of Toronto.
Dr. F. J. Birchard, Dominion Grain Laboratory.
Dr. F. M. G. Johnson, Can. Consolidated Rubber Co., Ltd.
Dr. D. McIntosh, University of British Columbia.
E. Bernard Smith, Dom. Tar & Chemical Co., Ltd.

To retire in 1922.

Dr. John S. Bates, Price Bros., Ltd., Kenogami, P.Q.
Dr. A. F. L. Lehmann, University of Alberta.
I. C. Mackie, Dominion Steel Corporation.
T. H. Wardleworth, Nat. Drug & Chemical Co., Ltd.

The second session of the Associate Committee was opened by a discussion on excise duties charged for acetic acid and alcohol. It was pointed out by Mr. Matheson, of the Electro Products Company of Shawinigan, that the present regulations regarding excise duties on acetic acid would prevent the sale of glacial acetic acid in Canada for commercial purposes, and it was resolved, that in the opinion of this Committee, the restrictions regarding the use and sale of acetic acid should be removed, and that Article 366, of Bill 76, be changed with this object in view. It was decided to appoint a committee, consisting of Dr. Ruttan, Dr. Macallum, the Administrative Chairman, and Mr. Wardleworth, to again interview the minister regarding the importance of industrial free alcohol in the development of chemical industries in Canada.

Professor MacLaurin gave an interesting address on the develpoment of the natural resources of Canada, calling attention to the waste of coal, both in mining and in utilization, also to the development of the oil, bitumen and gas deposits in Canada. He called attention again to the vast quantities of iron ores existing in the Dominion, of which only a small percentage is being used. The loss of fertilizers, resulting from the waste straw, was also thoroughly demonstrated. He called attention to the fact that it would be possible to obtain economical gas, for use in farmers' houses, from the utilization of straw, the resulting carbon also would have a commercial value.

DEVELOPMENTS RESULTING FROM THE ACTIVITIES OF THE ASSOCIATE COMMITTEE OF CHEMISTS.

The fish waste industry during the past year has been developed by a private company, controlled by American interests, as it was not found possible to obtain Canadian capital. The results of the few months' trial demonstrated that a valuable cattle food could be prepared by mixing fish waste products with flour mill refuse and other by-products resulting from the manufacture of cereals, etc. Several carloads of pure cod-liver oil were shipped to Boston, which met with the requirements of the British and American Pharmacopœia. It is now proposed to increase the original plant to such an extent as to produce five times the product obtained in 1919. This will involve an additional outlay in plant of about $300,000.

"The Census of Chemical Industries" was so greatly sought after by manufacturers that the first edition published in June was exhausted during the summer and another is in course of preparation.

In May, 1919, at the time of the meeting of the Associate Committee of Chemists, and largely aided by them, the chemists of Canada became united under the name of "The Canadian Institute of Chemistry," and a tentative constitution was drawn up which will be confirmed at the next annual meeting. This new Institute was represented by Dr. Ruttan at the meetings held in London and Brussels in July, 1919, for the establishment of the International Union of Pure and Applied Chemistry, and subsequently declared its adhesion to the International Union. A representative will be sent to the first annual meeting in 1920.

On the recommendation of the Associate Committee, the Institute of Chemistry has undertaken the establishment of a bureau of employment and technical information for the chemists of Canada.

The following chemists were recommended by the Committee and appointed by the Advisory Council to replace those retiring in 1919:—

Fred J. Hambly, F.I.C., Electric Reduction Co., Buckingham, Que.

Robert Job, A.B., Milton Hersey Co., Ltd.

Arthur C. Neish, M.A., Ph.D., Queen's University,

Prof. J. W. Shipley, M.A., Ph.D., Manitoba Agric. College,

Harold Van der Linde, Van der Linde Rubber Co., Toronto.

(Sgd.) R. F. RUTTAN,
Chairman.

Upwards of eighty inquiries regarding the chemical manufactures have been received and replies sent. To some inquiries it was possible to give the information at once, but in the majority of cases the inquirer was referred to some authority for fuller details. The Chairman wishes to thank the members of the Associate Committee for their assistance. To give some idea of the variety of questions submitted, the following list has been compiled:

Acetic acid and bichromate of sodium, market for.
Alcohol for motor fuel.
Alcohol from sulphite liquors.
Alcohol from wood waste.
Aluminium from clay.
Ammonium chloride in Canada, market for.
Anhydrous ammonia plants.
Arsenic in Canada, market for.

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Bent wood furniture, manufacture of.
Birch oil, sources and nature of.
Bone charcoal, sources of supply of pure carbonate of lime, infusorial earth.
Calcium carbide, lime for.
Casein, products of.
Cotton seed oil in manufacture of sardines.
Drying of foodstuffs.
Ethyl benzoate, market in Canada for.
Fish oils, purification and market for. (Several letters.)
Fish waste, its manufacture and use. (Extensive correspondence.)
Flax fibre uses in the paper industry. (Several inquiries.)
Glazing for interior of refrigerators.
Granite, cutting and cleaning.
Gypsum, uses and products of.
Humidity in air of room, regulation of.
Hydrogen manufacture in Canada.
Iron oxide paint for asbestos.
Kaolin, utilization of.
Kelp as source of potash and sodium.
Lime, manufacture of.
Manufacture of fertilizer from nitro-glycerine and T.N.T.
Methyl alcohol, use in making collodion.
Methyl chloride and ethyl chloride as refrigerating agents.
Oxylinoleic acid action on sole leather.
Paper from cotton, high-class.
Pine tar, composition of.
Potash from feldspar.
Pyridine, sources of.
Radio-active minerals.
Radio-active process of detection of ores, etc.
Salt in syrups.
Shellac, deterioration of.
Solid alcohol, how prepared.
Sulphur dioxide, market for.
Sulphur flowers from iron pyrites.
Utilization of confiscated opium.

APPENDIX B.

REPORT OF THE ASSOCIATE COMMITTEE ON MINING AND METALLURGY FOR THE YEAR 1919-20.

The chief work undertaken by the Associate Committee on Mining and Metallurgy during the present year was an extended study of the information now available with reference to the iron ores of Canada. A sub-committee, under the chairmanship of Mr. J. G. Morrow, of the Steel Company of Canada, collected all published information with reference to Canadian iron ores, and also secured from various companies and private sources a large number of most valuable confidential reports by competent geologists and mining engineers with reference to the iron ores of Canada.

This whole body of information is now being studied and collated with a view to ascertaining in what way and in what directions the Research Council can bring the resources of applied science to bear upon the solution of the problems presented in connection with the utilization of the iron ores of the Dominion for the purpose of building up on the basis of Canadian ores, Canadian fuel and Canadian power, a great iron industry in the Dominion of Canada.

A full report on this study of the iron ore situation of the Dominion will be presented to the Research Council for action in the immediate future.

Closely connected with the development of Canadian smelting is the question of the possibility of increasing the output of Canadian refractories. Of these the magnesite deposits of the Grenville district in the Province of Quebec are of special importance. In these deposits the magnesite occurs in white crystalline limestone, with which it is very intimately associated and mixed. The purest magnesite always contains a small percentage of carbonate of lime, which does not interfere with its utilization. Great bodies of the magnesite, however, occur mixed with so large a proportion of limestone that they cannot be employed industrially. If some satisfactory method of separating these two closely allied substances could be devised, this magnesite might be purified, and in this way an immense additional tonnage would be made available for use and the output of the deposits could thus be greatly increased. This problem of separation is one which could probably be successfully attacked by experimental investigation, and the Associate Committee has approached the Director of the Mines Branch of the Department of Mines, which department has an admirable experimental plant in the city of Ottawa, submitting this matter to them. The Director has undertaken to carry out some experiments on a large scale looking to the solution of this problem, which, if they are successful, will lead to a great development in this new Canadian industry.

The Committee has also made a study of the problem of the utilization of pulverized coal, but having ascertained that experimental work on this subject is now being carried out on a large scale by a number of different bodies, and that the various problems presented are now in a fair way to be solved, the Associate Committee did not consider it advisable for the Research Council to take further action in connection with this question at the present time, and therefore brought their studies to a close.

Mr. Arthur A. Cole, B.Sc., M.A., a member of the Associate Committee, who was also a member of the Peat Commission formed recently through representations made by the Research Council to the Government of the Dominion and the Provincial Government of Ontario, reported that the work of the Peat Commission in the development of the bog at Alfred, Ont., has met with a most gratifying success, and that in the summer of 1920 some 20,000 tons of peat from this bog will be produced and marketed in the cities of Montreal and Ottawa at a price of about $3.50 per ton f.o.b. on the cars at Alfred station. If this fuel meets with a satisfactory sale, the peat industry in Canada will have been placed on a thoroughly sound basis and the way opened up for the utilization of the great supplies of this fuel which are to be found in the many other bogs occurring in various parts of the Dominion.

With the desire to have the immense amount of information concerning the resources of Canada, which exists in the various Government departments at Ottawa, made more readily accessible to the public for the development of our natural resources, the Associate Committee was moved to pass again a motion carried at the Committee's meeting last year, to the following effect:—

> "That in view of the great urgency of this matter, the Advisory Council be requested to continue to press the Dominion Government for action on the proposed Bureau of Information, recommended in the resolution of the Committee last year."

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APPENDIX C.

REPORT ON THE WORK OF THE BRITISH COLUMBIA ADVISORY COMMITTEE FOR THE YEAR ENDING MARCH 31, 1920.

During the past year the readjustments in every kind of business made necessary by the demobilization of the army and the general unrest following the closing of the war, has made it impossible for members of the British Columbia Advisory Committee to devote time to questions of scientific research, except in so far as such questions came before them in their individual spheres of work.

It became clear that the Advisory Committee could accomplish little without the aid of a technically trained secretary who could devote a great part of his time to the work, and representations were made to this effect to the Chairman of the Research Council in August, 1919, with the result that in October last the Research Council authorized the appointment of a paid secretary who could devote half his time to the work, and made an appropriation requisite for this purpose.

In November the Chairman of the Research Council made a visit to Vancouver at the time of the convention of the Canadian Mining Institute held in this city, and he had a long discussion with the members of the British Columbia Advisory Committee, in which he outlined the work that had been done by the Research Council, and discussed the appointment of a secretary for the British Columbia Advisory Committee.

At a meeting of the British Columbia Advisory Committee held shortly thereafter, the general opinion was expressed that as nearly all questions and problems coming to the attention of the Committee were chemical or metallurgical in their nature, it would be advisable to appoint a trained chemist as secretary. A sub-committee was appointed to look into this matter and upon their recommendation Mr. Horace Freeman was appointed secretary as from February 1, 1920.

In the short time that has elapsed since this appointment, Mr. Freeman has pursued investigations along several lines with activity, and his reports on the progress of his work are attached hereto.

Of the questions that have been placed before the British Columbia Advisory Committee, two are of principal importance.

The first concerns a laboratory for testing structural materials. In 1918 an agreement was entered into between the Forestry Department and the University of British Columbia for the establishment of a laboratory to test the strength of British Columbia timber. This laboratory was established at the University.

There is, however, in Vancouver no testing establishment of any kind to which engineers or others can take metals or other structural materials to test their physical qualities, and in the opinion of the Committee it is of great importance that provision for such an establishment at the University of British Columbia should be made as soon as possible.

It is suggested that the Research Council might consider the question of an appropriation for the purchase of a 100-ton machine for testing the strength of materials, to be installed in a building provided by the University of British Columbia.

The second question is that of the production of alcohol from sawdust or waste forest products. This important question was referred to the British Columbia Advisory Committee by the Chairman of the Research Council, and Mr. Freeman's report shows the progress of investigation in respect to this matter.

APPENDIX D.

WOOD WASTE IN BRITISH COLUMBIA.

The waste produced in the lumber mills of British Columbia is at present disposed of in three ways:—

(1) The bulk of sawdust and shavings—over 90 per cent—is used for raising steam for use in the mill. A portion is sold to manufacturing plants outside the mills for the same purpose. The high price of coal at the coast tends to promote the sale of the material outside the mills.

(2) Between 60 and 90 per cent of the larger waste is sold for domestic fuel and power purposes in and around the cities.

(3) The remainder, which contains probably 5 per cent by weight, of bark, and is too small to sell for fuel, is consumed in the incinerators.

It may be noted that large quantities of hemlock sawdust are accumulating at various points owing to the difficulty in burning this material, due to high moisture content.

Considering the three classes of waste enumerated above, only unconsumed sawdust and the material sent to the incinerators can be considered as actual waste. Attempts have been made by the writer to arrive at some estimate of the amount of wood actually burnt in incinerators, but there is no direct method of arriving at this, except by the opinions of mill managers, who themselves are frank to confess that estimates are only approximate.

The mills in the city of Vancouver, when running at full capacity, consume between 400 and 1,000 tons of wood daily in the incinerators. The present cost of an incinerator is between $10,000 and $60,000. The latter sum would almost suffice to finance the processing of 50 tons of wood per day for the production of molasses cattle-food, and turn loss into profit.

The upkeep of an incinerator is by no means a negligible item in the cost sheet of a large mill, and in addition, the smoke produced from the incinerators, especially in the city of Vancouver, is so great as to constitute a public nuisance.

Reverting again to the amount of waste consumed in incinerators the writer considers that estimates of 15,000 tons daily are far in excess of the truth, and that with all mills busy, a total of 5,000 tons for all British Columbia is the maximum. A conservative estimate would be 2,500 tons and should be the basis for consideration of any processes for the disposal of this material. At the present time, the waste passing on conveyors to the incinerators is very carefully picked for material that is suitable for fuel purposes. This is due to the high price of coal. The demand for wood fuel falls off in the warm season, and consequently somewhat more is consumed in the burners.

Some method is desired to eliminate (1) the waste of wood, which now goes to the incinerators; (2) the direct expense entailed in creating this waste; (3) the smoke nuisance which results.

A number of methods have been proposed to turn this waste to profit. Those which may seriously be considered as offering commercial possibility are:—

(1) Distillation—producing charcoal and volatile by-products.

(2) Chemical processing to produce—

  (*a*) Molasses for use as cattle-food.
  (*b*) Ethyl alcohol as a motor fuel to take the place of gasoline.

(3) Production of sulphate pulp for the manufacture of paper.

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THE DISTILLATION OF WOOD.

In considering first the destructive distillation of wood, we find that the Pacific Coast woods are universally low in volatile constituents other than water.

The following data, culled from experimental work carried out at the University of Washington, gives some idea of what may be expected from mill waste:—

Wood Tested.	Wt. of one Cord.	Turpentine and Light Oils.	Tar.	Wood Alcohol.	Acetate of Lime.	Charcoal.	Yield Charcoal.
	lbs.	Gal. (U.S.)	Gal.	Gal.	lbs.	lbs.	%
Douglas fir—							
Average mill waste.....	3,330	3·4	27·8	3·9	75·0	977	29·3
Selected waste.....	4,250	10·8	46·4	3·7	74·0	900	23·5
Western pine—							
Average mill waste.....	3,260	5·6	19·9	2·6	56·0	675	20·7
Western hemlock—							
Average mill waste.....	2,840	4·9	24·8	3·2	73·0	478	16·8

Attempts made to commercialize the dry distillation process in British Columbia have not hitherto met with success, owing largely to the fact that reliance has been placed upon the volatile products to give the main returns, and the charcoal has been regarded as a by-product. Consequently, the plants designed for the purpose have been of such a type that they could not be considered suitable for economically disposing of the large quantities of waste.

If, however, attention had been concentrated upon the production of charcoal as the main product and the volatiles regarded as secondary products, or disregarded altogether, it is probable that the cost of producing charcoal would have been so low as to encourage the use of this material for fuel in competition with coal.

The suggestion is here made that cheap charcoal readily could be produced from mill waste, provided that the plant used for carbonizing were of simple construction, requiring low upkeep charges, and a minimum amount of labour.

Any plant for the purpose should be of such a nature that it could be placed under the present conveyers from the saw-mills, and not increase the fire hazard. It should be continuous in operation and should be able to take care of all varieties of waste and of all the waste as it is sent from the mill. It is possible that such a design would necessitate disregard of all the volatiles except perhaps tar and tar oils. It is probable also that a retort embracing these principles would be considerably smaller than the incinerator required for complete combustion of the wood. Average mill waste will yield 25 per cent of its weight of charcoal containing 12,000 B.T.U.'s per pound. The wet wood from which it is derived contains 4,000 B.T.U's per pound. The charcoal made from one pound of this wood will contain 12000/4, or 3,000 B.T.U.'s, or three-quarters of the heat contents of the wood.

It is for this reason that large incinerators are required, for they must dispose not only of the gases in the wood, but must burn up the fixed carbon. If it were possible to remove charcoal from the incinerator, instead of ashes, only one quarter of the total heat would be generated therein, and the expense of water jackets and periodical relining with firebrick would be avoided.

The writer holds the opinion that wood charcoal at the same price as coal would find a ready market as domestic fuel, and provide a very economical solution of the mill waste problem, bearing in mind the fact that weight for weight, charcoal contains more heat than soft coal, and also less of this heat is lost in the flues, etc., than is the case with coal. Soft coal now in use contains 11,000 B.T.U.'s per pound and from 10 to 25 per cent ash, while charcoal from mill waste contains 13,000 B.T.U.'s and less than 1 per cent ash.

MANUFACTURE OF WOOD MOLASSES AND ALCOHOL.

The production of ethyl alcohol from wood waste comprises the following steps:—

(*a*) Comminution of the wood.

(*b*) Digestion of this wood with dilute acid (sulphurous) under pressure. 0·25 per cent of the wood is converted by this means to fermentable sugars. This is done in digestors, such as are used in pulp manufacture. The solution of sugars is separated from the residue pulp and is fermented with special yeast cultures, producing a "beer."

(*c*) The "beer" is distilled and the distillate yields substantially pure alcohol.

The alcohol produced is of the potable variety, and should not be confused with wood alcohol, which is obtained by heating the wood in retorts at a red heat. For this reason the process now under consideration is under the same restrictions that govern the production of pure grain alcohol. Before it can be used as a motor fuel, this alcohol (from wood) must be denatured by admixture, preferably with other combustible liquids which render it non-potable.

The field is not yet clear for the production of motor spirit from wood, owing to the laws restricting the manufacture, the regulations governing the denaturing, which do not allow of this being done at the point of manufacture, and lastly, owing to the lack of a suitable denaturant which must fulfil several conditions, i.e., it must be cheap, combustible, of such a nature as to render the alcohol absolutely non-potable, not allow of illicit purification, and must readily mix wih alcohol.

It has been proposed, pending the removal of restrictions, to conduct the process to the point of production of wood molasses, using this product as a basis for stock food. At any time later the necessary equipment could be added for the production of motor spirit.

The following statement covering the production of molasses was submitted by Mr. G. H. Tomlinson, who has been instrumental in introducing the manufacture of alcohol from mill waste in the United States:—

"The waste at a saw-mill comprises all of the material destroyed either in the incinerator or for raising steam. All of this is available for alcohol (or molasses) production without disturbing the fuel supply for the reason that only 25 to 28 per cent of the actual wood is decomposed in the process. The balance of 75 per cent is still available for raising steam, and will furnish enough power for both saw-mill and alcohol plant.....The presence of the average amount of bark, or chlorides from sea water, does not affect the process.

"The comminution of the edgings, etc., is effected in two operations: They are first put through a hog and then through a shredder which beats them to the desired size. The cost of this operation is approximately 30 cents per ton.

"It is now an accepted fact that a certain portion of wood can be converted into sugar by treatment with dilute acids. By this means at least 25 per cent of the wood can easily be converted, and any technical or engineering difficulties in this connection have been entirely overcome. This process has already been applied on a large scale for the production of ethyl alcohol with satisfactory results.

"Since molasses has come into such generally accepted favour as a feeding material, it has frequently been suggested that this process of wood conversion offers an unlimited means of supplementing our food resources. The mixture of sugar, which is thus obtained, can be separated in solution from the residue and this solution can then be concentrated thus yielding a product substantially like molasses in sugar content and which is quite as acceptable to animals as either the cane or beet sugar product.

"A proper ration for feeding stock should consist, however, of a mixture of concentrated and coarse feeds. The ratio by weight of coarse fodder or bulky material to concentrated feed in the ordinary ration has been found to be 1:1.

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"Molasses which consists almost entirely of digestible carbohydrates and may be defined as a super-concentrated feed was used as early as 1830 for feeding horses and has recently come into very general use with extremely satisfactory results. When thus used, it is sometimes sprinkled on dry feed, being first diluted with water, or it is mixed with some material which absorbs it and renders it easy to handle such as peat dust, etc. It is also common practice to mix molasses with the drinking water in a trough allowing the animals to drink from this ad libitum. The best plan, however, is to thoroughly incorporate it with a coarse fodder so that the animals do not become smeared in eating.

"As a part of a mixed ration it has been proved that one quart of molasses will replace three to four quarts of oats; that molasses is a most nutritious food, easily digested and assimilated, and will in many cases correct faulty digestive processes; that molasses-fed horses will do fully as much work and remain in much better general condition than animals fed on dry food, while the cost is reduced. Much more can be said in favour of feeding molasses, but having these general facts in mind, the possibilities in connection with the production of a highly valuable feeding material from wood can be easily deduced, especially in view of the following facts. The product resulting from the hydrolysis of wood if properly conducted yields on the dry wood basis:—

Fermentable sugar (Dextrose)	22.6 %	
Unfermentable sugars (Pentosans) by diff.	1.58%	
Total reducing sugars		24.18%
Non-sugars		3.21%
Total water sol. extract		27.39%
Acid figured as H_2SO_4		2.10%
Insoluble residue (modified or partially digested cellulose,) by diff.		70.51%

"From this it will be seen that the sugars thus formed compare most favourably in nutritive value with the best grades of molasses. Protein and fats are of course negligible as one would expect. By employing a volatile hydrolysing acid such as SO_2 or HCl, using wood which is free from bark and properly distilling off all volatile residues after digestion, the percentage of free acid can be minimized and this when neutralized gives rise to no injurious salts. The insoluble residue resulting from this treatment is completely modified, rendering it an ideal coarse or bulky material to incorporate with the concentrated extract to form a proper ration. The digestibility of this residue has not been determined as far as I know, but it seems likely that it may be relatively high.

"In order to commercialize these possibilities, the following plan is indicated:—

"Hydrolyse the wood with either HCl or SO_2 and then divide the product into two parts. Extract the sugar from part one, render slightly alkaline and evaporate to a desirable concentration. Partially dry the material in part two and then thoroughly mix the product of part one and again dry to a suitable consistency. In this way a product containing any desired concentration would be produced in a form easily handled and ready to use. If desirable some waste product, high in nitrogenous content, such as blood, fish waste, etc., might be added, and in this way a complete or properly balanced ration would result."

Mr. Tomlinson makes an estimate of the cost of producing stock food from sawdust, based on a consumption of 50 tons sawdust daily. The following extract from his estimate is noteworthy:—

Fifty tons sawdust yields 15 tons stock food worth $35 per ton, or $525. The total cost of production is $194, including allowance for the purchase of sawdust at $1 per ton, at point of consumption.

It should be noted that an investment of $100,000 is required for a project of this size. If it be required to produce alcohol, the additional equipment would cost $50,000 and would produce 500 gallons from 50 tons sawdust daily, or 175,000 gallons per annum.

There is no individual mill in British Columbia with 50 tons actual waste sawdust per day, but there are several mills each producing more than this amount of general mill waste. In any case there are mills so grouped that 50 tons clean sawdust could be collected by conveyers and so ensure a constant supply and save the expense of comminuting the wood.

WOOD-PULP FROM MILL WASTE.

Turning now to the possibility of producing pulp and paper from mill waste, it may be said at the outset that this cannot at present be regarded as an economical means for the disposal of any very large portion of the waste that is now being sent to the burners.

Most of the western woods will make a good grade of sulphate pulp, this having been demonstrated in the U.S. Forest Products Laboratory, but to make a commercial grade of pulp the bark must be eliminated.

The cost of purchasing and collecting the wood waste would probably be more than the cost of lumbering selected wood, and the pulp being inferior could not compete for the larger uses of the better grade.

The supply of waste is subject to fluctuation, and this condition would hardly tie in with a pulp plant which requires a steady supply. The investment in a pulp plant is very large and a supply of material for at least twenty years would be a necessity.

Competition with existing pulp plants would require this manufacture to be carried out at tide water, and in conjunction with a reasonably large and cheap supply of power.

It is within the bounds of possibility that the foregoing conditions might be found in the case of one or two individual mills, but the variable amounts and quality of the waste and cost of concentration to a separate point for manufacture operate against the pulp manufacture as a possible outlet for the bulk of the waste.

CONCLUSION.

The writer is of the opinion that the production of charcoal particularly for use as a domestic fuel offers the best immediate means for obtaining revenue from mill waste, and at the same time disposing of the bulk of this material. To this end the charcoal must be produced cheaply and attention should be directed to this point in considering any means for carbonization. Any plant devised for this purpose should be of such a nature that it could take the place of the present incinerators under the conveyers from the mills.

As a means for economically disposing of waste sawdust at some points where mills are grouped together, the production of wood-molasses would appear to be a commercial proposition and might serve as a stepping stone to the manufacture of ethyl alcohol, when the field is clear for the use of this material for motive purposes. This latter manufacture is being carried on successfully in the United States, using mill waste, but the alcohol is not brought as yet into competition with gasoline. An increase in the yield of alcohol might be obtained as a result of research that would change the economic aspect of this process and lead to a very extensive development for wood cellulose.

APPENDIX E

SECOND SPECIAL GENERAL REPORT ON THE OPERATIONS OF THE LIGNITE UTILIZATION BOARD FROM OCTOBER 1, 1918 TO MAY 31, 1920.

The origin of the Lignite Utilization Board is found in the fact that the Honorary Advisory Council for Scientific and Industrial Research was seized, at its first meeting on December 4, 1916, with the gravity of the fuel situation in the West. In Saskatchewan coal for domestic heating reaches its highest price as it is roughly in this region that the increasing freight rates for American anthracite make it possible for the Alberta coal dealers to sell western bituminous coal for domestic consumption in spite of the increased trouble that such coal entails when used in anthracite furnaces during the severe weather. Yet throughout a large portion of Saskatchewan are to be found immense quantities of low grade lignites which unfortunately are not suitable in their raw state for handling in summer, nor have they proved satisfactory in winter for domestic heating, when used in equipment designed to burn anthracite.

A Committee of the Research Council was appointed to consider the whole matter, and as a result of their work, the Council brought to the attention of the Government, in June, 1917, a recommendation that a plant should be erected by the Government to demonstrate the fact that the low grade Saskatchewan lignites can be converted into an efficient domestic fuel by being carbonized and briquetted. When so treated, such briquettes possess practically the same heating value as anthracite. The details of this report to the Government may be seen in Report No. 1, entitled " The Briquetting of Lignites," issued by the Honorary Advisory Council for Scientific and Industrial Research.

In due course the Government in March, 1918, passed an Order in Council recommending an agreement between the Dominion Government and the Governments of the two provinces of Manitoba and Saskatchewan. This agreement was signed on the 20th of July, 1919, and by its terms the three mentioned Governments voted a sum of $400,000 for the carrying out of this project. The whole administration was entrusted to a Lignite Utilization Board, the personnel of which was named by Order in Council on the 2nd of August, 1918.

The Board commenced its actual operations on October 1, 1918, and after digesting all reports and correspondence then on file, sent Messrs. French and Stansfield, their engineer and chemical engineer, respectively, on a long tour of investigation throughout the United States and Canada. During this trip every coal treating plant of any importance was visited, studies were made of all apparatus used and results obtained. It had been hoped that, as a result of such a tour, the Board's representatives would merely have to recommend that for certain processes, certain specified apparatus would be found satisfactory. But in this hope, the Board was greatly disappointed, because it was discovered that in spite of many published reports, American lignites had never been carbonized commercially and the briquetting of carbonized lignite had never been undertaken at all except on the smallest laboratory scale.

It therefore became necessary for the Board to institute a complete experimental investigation in order to avoid the large costs of the almost inevitable mistakes that would be made with full scaled apparatus. To this end, through the courtesy of the Department of Mines, the Board erected in Ottawa a complete carbonizing and briquetting experimental plant, and the following experimental programme was decided upon during the third meeting of the Board held in Montreal, on February 10, 1919:—

1. The weathering and storing qualities of lignite.
2. The heat of carbonization.

3. Rate of carbonization.
4. Atmosphere in retort during carbonization.
5. Special retort of new type developed by the Board.
6. Briquetting investigations covering:
   (*a*) Material.
   (*b*) Degree of fineness.
   (*c*) Binders.
   (*d*) Mixers and presses.
7. Smokelessness.
8. Tests of finished briquettes.

Parts of this programme were instituted immediately in March, 1919, but the remaining portions were not prosecuted until later, owing to the extremely slow delivery of apparatus and equipment.

From the nature of the research, some of the items will take an immense amount of time before the work can be finished.

The Board felt, however, that the two main departments of research were those of carbonizing and briquetting. In the early part of the Research Council's work there had been some misconception as to the exact amount of investigation that had been accomplished regarding lignite carbonization. Much of the published material had led those interested to believe that commercial carbonization was "un fait accompli," and that it only remained to enlarge upon existing types of retorts in order to obtain any desired outputs. As mentioned, however, the Board's engineers did not find this to be the case. In fact no commercial carbonization of lignites had ever been accomplished successfully, that is to say, no apparatus existed that would carbonize lignite in commercial quantities at commercial costs. A large number of retorts were examined, but for one reason or other they were all deemed not suitable for the particular work in hand. The Board's staff, therefore, set itself to design a retort along new principles entirely, one in which there would be no moving parts, where high temperatures could be maintained, and where the benefits of so called low temperature carbonization could be obtained. In due course Mr. Stansfield produced a design that was satisfactory to the Board, and a small unit was erected in the Ottawa plant. Upon trial, the new carbonizer developed a certain number of inevitable faults. These were slowly corrected, and by the end of the season of 1919 the Board had reached a position when they were able to state that this problem had been solved.

It next became necessary to devote considerable attention to the question of briquetting. In this field the economical aspects are paramount. There was no doubt in the mind of any member of the Board or of the staff that briquettes could be made with carbonized lignite, but the whole point was, could they be made with a small enough amount of binder to make the product commercial? None of the binders that are satisfactory for lignite, is produced in the vicinity of southern Saskatchewan with the possible exception of petroleum pitch (hydrolene), which at Regina may be refined from crudes. In any event, the increasing cost of oil makes the utilization of hydrolene for a binder very improbable.

All kinds of binders and combinations of binders have been tried. As a matter of record, it may be of interest to know that coal tar pitches, oil pitches, asphalt pitches, lignite pitches, hardwood pitches, sulphite pitches, flour, starch, clay, water glass, cement and straw have all been used with varying amounts of water.

The general conclusion reached by the Board on the question of briquetting may be summed up as follows:—

1. A first-class saleable briquette can be manufactured from carbonized lignite.

2. The quantity of binder is much larger than many investigators have reported. The Board thinks that it is improbable that a good briquette can be produced with less than 11 per cent of those binders hitherto tried.

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3. The Board is not restricted to any one binder, but owing to the present excessive cost of other binders, coal tar pitch will be the main binder.

4. The quantity of binder necessary to produce a good briquette with carbonized lignite is roughly double that which is necessary to produce similar briquette from anthracite fines.

In the limits of such a report as this, it is not possible to make any full comment on investigations numbers 1, 2, 3, 4, 7, or 8, other than to say that smokelessness (No. 7) can be achieved by heat treatment after briquetting, but the Board does not feel at the moment that it is probable that such apparatus will be installed owing to the amount that it would add to the selling price of the briquettes.

On the finished briquettes, tests (No. 8) have been given for burning, brittleness, softness, and for the action of frost and water alternately. All the briquettes graded as "good" by the Board have successfully passed these tests.

The general progress of the Board may be outlined in a word or two. In the beginning of October, 1919, at the 4th meeting of the Board, held in Winnipeg, the Chairman announced that briquettes would be on the market by the autumn of 1920. To complete such a programme it was essential to have plans and specifications ready at the earliest date. Consequently the winter was spent in completing the experimental programme, and in preparing designs, plans, and specifications for buildings, plant, and general and special machinery. In addition the question of site was an extremely important one and the Board gave careful attention to it. After a long series of negotiations the Board selected a point about half way between the mines of the Manitoba and Saskatchewan Coal Company and the Western Dominion Collieries. Thus, the supply of raw material (lignite) and of water is absolutely assured independent of weather conditions. The Board have also let contracts for all plant buildings, briquetting machinery, power equipment, conveyers, and within a short time the remaining contracts will be awarded.

It may be not out of place to add a word or two of caution. It must be remembered that the Board's first objective is to erect a demonstration plant. It is far more important, from the point of view of the three governments which are financing the project, to insure that the process itself shall be demonstrated commercially, than it is to state that the actual costs incurred are the absolute minimum per ton of output. It is self evident that, once the process is demonstrated and all pertinent information gained, large commercial plans may be projected subsequently, the designs being laid on the sure foundation of exact operating and technical experience. The operating costs per ton of output of such commercial plants undoubtedly will be lower than those of the present 30,000 ton demonstration plant.

In addition to the foregoing word of caution on the question of operating cost per ton of output, it is desirable to guard against any undue optimism as to the selling price of the finished briquettes. The Board have noted with certain reluctance many extravagant published statements as to the cheapness with which the product would be manufactured and marketed. From its very inception the Board has studiously refrained from making any public statement as to the probable selling price of its product. The figure of $7 per ton at plant mentioned in Research Council's Report No. 1, is a figure that would have been possible in 1917, the date at which the report was written, but to-day is extremely unlikely.

In closing this brief statement the Board wishes to record its appreciation of the co-operation and assistance rendered by the Mines Branch, Department of Mines, Ottawa.

APPENDIX F

REPORT OF THE WORK ON THE PETAWAWA FOREST SURVEY FOR 1919.

The detailed forest survey of the Petawawa Military Reservation begun late in the season of 1917, was brought to completion in the past year by the Dominion Forestry Branch, Department of the Interior.

The appropriation for this work was provided at the request of the Honorary Advisory Council for Scientific and Industrial Research. Permission was granted the Forestry Branch by the Department of Militia and Defence to carry on this survey and also to make silvical and silvicultural experiments on different portions of the reserve.

The reserve proper is approximately one hundred square miles in area and is almost a natural unit, bounded on the north by Corry lake, on the east by the Canadian Pacific railway tracks, and the sand plains, on the south by the Barron river, the only artificial boundary being the west one. It is readily accessible from Ottawa and other large centres, being adjacent to the Canadian Pacific railway tracks and only a short distance from Chalk River, a divisional point on the said railroad where all trains stop. As a forest experimental station which will be of great practical value to forestry, scientists and the public, the reserve presents great attractions not the least of which is its permanency.

Two previous reports have been made for the work done, in 1917 by Mr. D. W. Lusk, in which season the work was begun, and the other report of Mr. R. A. Courtnage on the work done in 1918. These two foresters covered approximately 55 square miles.

The work of 1919 consisted of approximately forty-seven square miles and was divided into three areas as follows:—

(*a*) *First area.*—Work was begun in 1919 on an area of about fifteen square miles situated west of the plains and north of the Petawawa river. This area was of fairly level surface in the western part where it bordered on the plains, but elsewhere there were many variations of slope caused by rocky ridges.

Tucker lake, one of the largest lakes in the reserve, is in the northern part of this area and from the neighbourhood of this lake there is a chain of muskegs and beaver dams draining south into Lock Ian and from there into the Petawawa. The soil in the western part varies from pure sand to a fairly good sand loam with sand subsoil and is very seldom of a rocky nature. Elsewhere the soil is a good sand loam, but generally is shallow and rocky with a rock subsoil.

(*b*) *Second area.*—This consisted of about twelve square miles in the neighbourhood of Cartier lake in the northwestern corner of the reserve. This area is comparatively hilly and the soil is shallow and rocky with the exception of a stretch along the northeastern shore of Montgomery lake. Also southwest of this lake there is a large level area of pure jack pine on which the soil is of a good depth.

(*c*) *Third area.*—This covered about twenty square miles, comprising most of that territory lying between the Petawawa and Barron Rivers. On the whole the surface of this area is fairly regular and slopes are not very steep. The soil is quite shallow and rocky but is nowhere incapable of supporting good forest growth. There are two or three small lakes and a large amount of bog in this area.

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THE FOREST CROP.

A. *The Types.*

White and red pine are the most important species found on the reserve and young even-aged stands, pure or consisting of a mixture of these two species, are scattered over the whole area except the most easterly portion.

Poplar is next in importance and in company with white birch forms another forest type. These species are for a great part only a temporary type because they are short-lived and intolerant and have generally an under storey of pine which will become the permanent type. This type is at present, however, probably the most extensive of all and like most of the growth on the reserve, consists of even-aged stands seldom reaching an age of over sixty years.

Jack pine occurs extensively in large even-aged stands.

Balsam fir, white spruce and black spruce are found on small areas generally on moist soil.

Black spruce of the slow growing bog variety occurs in large areas in almost pure stands.

In swampy places there are often found mixtures of such species as black ash, northern white cedar, balsam fir, yellow birch, black and white spruce.

Red oak grows on the rocky ridges but is of such a stunted and scrubby description as to give little promise of ever becoming of value. Bur oak and white oak have also been noted growing with it.

In some places there are found stands consisting of mixtures of such species as hard maple, red oak, red maple, poplar and birch with small quantities of beech, basswood, ironwood and yellow birch.

The areas which are not at present producing a merchantable crop are open fields, burns not restocking, areas which have been recently clear cut, open muskeg, boggy areas supporting a growth of alders, stunted spruce or tamarack of little value and those areas on which the standing timber has been destroyed by flooding from beaver dams.

The types are then classified as follows:—

Productive areas—	Non-productive areas—
White and red pine	Fields
Poplar, birch	Burns
Jack pine	Cut-over areas
Balsam, spruce	Open muskeg
Spruce bog	Bog with growth of little value
Hardwoods	Flooded areas.
Mixed.	

B. *Types on the Area Surveyed in 1919*

(*a*) *First area.*—The western part of this area consists for a large part of open field as it borders on the military plains. Bordering on the fields and in the north-eastern section is a large area covered mostly with jack pine. Oak takes possession of rocky ridges; there is a large proportion of poplar, birch and a few good stands of red and white pine. On the southwestern part of this area, a few cuttings made by the military camp authorities were encountered. These cuttings were made for the purpose of getting fuel wood and the areas were clear cut, all species being taken (pine, poplar, spruce, birch, ash).

(*b*) *Second area.*—The greater part of this area is dry, rocky and hilly with shallow soil. Poplar and birch cover large areas as does also oak. There are a few good stands of pine, one in particular stretching along the northeastern shore of Montgomery lake and consisting of a mixture of white and red pine in about equal proportions growing in good soil. Southwest of the lake is a large level tract of pure jack pine, also on good soil.

(*c*) *Third area.*—The area immediately south of the Petawawa river between the Crooked and White Horse rapids was one of the most promising pieces of country encountered and it is for the most part covered with young white and red pine. Part of it is pure jack pine and in many places red and white pine is mixed with or is reproducing under jack pine. Immediately south of this area and about a mile from the river there is a good stand of black spruce. The rest of this area contains much poplar, birch, some good pine, some young hardwood and some red oaks, and is typical of the rest of the reserve.

C. *Injuries.*

The physical injuries consist of the effects of fire, lumbering, wind and beavers.

(*a*) *Fires.*—Small fires have been frequent in the history of the reserve. The present even-aged condition of the stands is the result of fires or logging operations, as few parts of the reserve have escaped fire or logging during the last sixty to eighty years. In the western part of the first area, there are a few recent burns, but practically no very recent burns in the second area. In the third area there is a large tract showing the effects of heavy logging and fires, the trees being scattered, of many age classes and of mixed species. Besides a few other recent burns, there is an area northeast of where the Squirrel Depot was situated on the Barron river, which is said to have been burned over in 1917 when the buildings at this place were burned. In some places this fire had the effect of killing the young pine by burning the bark and foliage and leaving the poplar, birch and oak unharmed; in other places it was more severe and burned everything, while on the other hand in some places it did practically no damage, being nothing more than a surface fire.

(*b*) *Logging Operations.*—The effects of lumbering were not particularly noticeable except in the third area where during the last sixty years there have been heavy cuttings. On part of this area reproduction has not been good but generally there has sprung up a good even-aged stand of pine or poplar.

(*c*) *Wind.*—A few individual cases of wind-thrown trees were noticed, particularly in places where the soil was shallow.

(*d*) *Beavers.*—Beavers are an active cause of the destruction of much good timber. A small beaver dam may flood a large area and it is not only bog lands which are flooded, but also the moist soil surrounding the bogs on which there is generally good timber. While causing the drowning out of growth on some areas these beaver dams have also the effect of keeping the reserve in a well-watered condition and of preventing the rapid drainage and erosion which might otherwise take place.

(*e*) *The Pine Weevil*—As regards biological injury, the reserve is in a very healthy condition, the only important example being the work of the pine weevil. This insect kills the terminal bud and prevents a rapid and straight growth of the young pine tree. Happily this enemy seems to flourish best near fields and open places and so does not affect the main forest.

D. *Reproduction.*

Natural reproduction after the effects of lumbering and fire has been very good and we have as a consequence vigorous young even-aged stands. There are a few tracts, generally of a dry and rocky soil, on which natural reproduction after fire and logging has not been good. Often it seems that poplar and birch are the first species to make their appearance, but merely form a temporary type, as young pine soon appears as an under storey and finally becomes the permanent type. In other places there is no pine reproducing under the poplar birch, but it is a common thing to have a poplar birch type with pine as young growth.

The final report of the forest survey is now in course of compilation and will be available in the next few weeks, complete with map and estimates. The object of this

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main survey is to delineate and describe the various forest conditions; to gather data in regard to topography, soil, distribution of age classes, growth, available supply of saw timber, etc., in short, to collect all such information as will be of help in planning the organization and management of the experimental area.

Besides the main survey, a very considerable amount of scientific investigative work was carried on under the direction of Mr. H. C. Wallin. This work took the form of permanently established sample plots for periodic measurements and observation. These plots have so far been of four kinds,—

(*a*) Plots to determine the result of thinning of different degrees and according to various methods. (White pine, red pine, spruce.)

(*b*) Plots established to determine yield of fully-stocked pure stands. Cleaning but no thinning undertaken. (White pine, red pine, jack pine.)

Plots under (*a*) and (*b*) are closely related to each other. Both will furnish us with information on which to base yield tables, plots (*a*) for stands which are thinned by man, plots (*b*) for stands where the thinning is left to nature.

Plots of the (*a*) and (*b*) classes so far laid out number ten. The plots which are thinned have been carefully mapped and described and all data recorded. The trees have been numbered and classified and the location, diameter and tree class of the removed trees, as well as of the remaining ones, are given on the map. On all trees a small cross has been painted at breast height to enable us to caliper the trees at exactly the same place when the plots are again measured. One of the (*b*) plots has also been mapped so that the development of each tree may be followed through later years. The trees are calipered two ways at right angles.

(*c*) Plots to study the development and behaviour of the various species in mixed stands under different conditions, especially with regard to the transformation of the character of the stand. Two plots laid out—mapped and described. (Hardwoods.)

(*d*) Plots to study natural reproduction from seed trees or surrounding stand and its development. These plots are fairly large so as to enable a study of the distance from the mother tree reached by the seed. Four plots of this class were laid out, on two of which the brush after logging has been burned.

Some six of these sixteen sample plots were laid out during the past year.

General diameter-volume and diameter-height curves have been plotted, based on 105 red pine, 86 white pine, 76 white birch and 90 aspen. These trees were felled and measured on the different sample plots. The area of these plots varies in extent from 0·3 to 1·6 acres.

In addition to the sample plot work, some 250 different herbaceous plants were collected, pressed and mounted with a view to building up a local herbarium for the use of the technical men attached to the Station.

It is, of course, absolutely necessary from the standpoint of efficiency that the officers engaged in silvical and silvicultural investigation should be acquainted with the ground flora, since the composition of the existing ground vegetation will often be of great assistance to the investigator in judging the suitability of the site in question for the growing of certain species.

Some work of an entomological nature was carried on in connection with the work at Petawawa and a collection of insects made.

The above is a short report of what has been accomplished at Petawawa. It is of course only a small beginning, but it is hoped that from now on we will have the chance and will see our way clear to carry on this work on a much larger scale.

APPENDIX G.

REPORT ON THE WORK OF THE ASSOCIATE COMMITTEE ON INDUSTRIAL FATIGUE.

In July of 1919 a circular letter was sent by the chairman to 72 representative manufacturers in Canada, explaining the purposes of the Committee, and requesting them to state whether they thought this would be of value to Canadian industry, and to offer any suggestions they might have as to particular problems. On the whole the replies were of considerable value, since those received indicated that the work of such a committee, if properly organized, would be of real value to industry and to the worker. It was insisted in several of the replies that it would be useless to undertake the work unless an adequate number of persons were employed by the Committee to devote their time to its various phases, under its guidance. It was decided in the meeting of the Committee in October that the position of Director should be created, to be filled by a person having experience in sociological and related work. The duties of the Director would be to consult with representatives of industry in Canada as to the conditions of industrial hygiene that exist, to recommend to the Committee what could be done to improve them and to carry out under the guidance of the Committee any work that it might approve.

By a canvass of available candidates in Canada, it was found that there is no one with the necessary qualifications at present available for the position.

It was decided at the meeting in December that work should be started in Toronto by the establishment of a local bureau in which all the available literature pertaining to problems of industrial hygiene might be collected, catalogued and abstracted, and that Miss Hutton, should be appointed as Secretary to the Committee, to undertake the supervision of these duties, and to advertise the work and purpose of the Committee by preparation of articles suitable for publication in various journals, and by correspondence. At the same time, the Committee authorized the chairman to employ Dr. Cunningham, Lecturer of Industrial Hygiene in the University of Toronto, to undertake certain investigations into the working conditions in Toronto and neighbourhood. The following is a review of the progress of the work by Miss Hutton and Dr. Cunningham:—

The purpose of the office of the secretary is broadly,—

(*a*) To secure publicity for the Committee;

(*b*) To set up an information bureau on industrial hygiene.

A. *Publicity.*

Manufacturers and others are being informed that the Committee are prepared to do the following:—

(1) To offer manufacturers the assistance of scientific laboratories in solving the health problems presented by the particular processes of their plants.

(2) To offer all interested the use of the Committee's intelligence bureau where the most up-to-date information on general and specific problems of industrial hygiene is kept.

(3) To co-operate in investigations into the health conditions in various industries.

At the present stage it is considered most important to attain publicity of the scope and nature of the work of the Committee. This is being done by contact with—

(*a*) various similar organizations in the United States and Great Britain;

(*b*) various plant physicians, employment managers in Canada, etc.

More directly, publicity has been attained by the following means:—

(1) Articles.

(*a*) *The Journal of Public Health* is publishing in May a 2,000-word article by us entitled "Industrial Hygiene: Need of Research in Canada." They are also publishing at the same time a 500-word editorial by us entitled "Canadian Recognition of the Scientific Basis of Industrial Hygiene."

(*b*) *Industrial Canada,* the organ of the Canadian Manufacturers' Association, is publishing in June an 1,800-word article by us entitled "Industrial Hygiene: Formation of a Committee to be of Practical Help to Canadian Industry."

The editor of this paper is ready to publish other similar articles.

(*c*) An article entitled "Canadian Research into Industrial Hygiene" has been offered to the *Canadian Medical Association Journal.*

(2) Representation at the annual meeting of the Ontario Safety League.

Dr. Macleod and Miss Hutton recently both spoke at this meeting. Dr. Macleod explained the formation and objects of the Committee and invited industry to make use of the facilities offered.

Although the meeting was small the contact established is valuable since persons directly interested in industrial hygiene such as plant physicians, chemists, service and safety men were there and appeared interested in the Committee. Two requests for information have since been received from firms who were represented at the meeting.

(3) Meeting with Dr. Riddell of the Trades and Labour Board, Ontario Government.

Early in the year Dr. Riddell met with the local representatives of the Committee. Dr. Riddell expressed appreciation of the existence of the Committee and showed himself most willing to co-operate with it. He mentioned two problems in which he thought the assistance of the Committee might be useful.

B. *The Information Bureau.*

The Committee is now in regular receipt of the most valuable periodic publications on industrial hygiene of the various Governments, English, Canadian and American. In addition to these "free" publications two periodicals are taken: "The Journal of Industrial Hygiene," and "Industrial Management." So far only a few of the standard books have been bought as it was felt that these could easily be purchased as soon as a demand for them arose. The pamphlet library consisting of the occasional publications of Government Departments, reports of scientific research and trade surveys, etc., amounts to nearly 400 in number and covers the field of industrial hygiene fairly comprehensively. All the material actually in the library, and also references collected from a variety of sources, has been indexed, in some cases in considerable detail, and this index gives a full bibliography of the current literature on the different branches of industrial hygiene.

The problems suggested for Dr. Cunningham's work were:—

(*a*) Investigation of present situation in regard to industrial hygiene and social welfare work in selected representative industries.

(*b*) To ascertain in certain selected but representative industries the amount of lost time due to sickness, and the amount of labour turnover.

(*c*) The incidence of occupational diseases in the industrial survey.

The Committee considered that (*b*) was the most suitable for the first work of the Committee. (*a*) and (*c*) are however, being borne in mind and some data has been collected.

Lost Time from Sickness.—The survey early showed that records of lost time from sickness were the exception. Nine firms with company or mutual benefit insurance schemes had records showing lost time from sickness among those employees who were members. As, however, the visiting was done after absence of varying number of days, the figures are not comparable, and lost time from sickness per member per year ranges from 3 to 13½ days.

Accordingly a record card was drafted based on one proposed for American industry by the United States Public Health Service and adapted by us to Canadian needs.

Twenty-one firms have indicated their willingness to consider its adoption for accident and sickness record.

The majority of managers show considerable interest in the proposal. Some, however, feel that labour unrest makes the present time inopportune for collecting statistics and some are not ready to establish the necessary follow-up system to distinguish between absence due to sickness or accident and absence due to other causes.

Labour Turnover.—Information as to the amount of labour turnover is not available for the following reasons:—

In some firms it is so high that the firms have ceased to keep any record.

In other firms records have never been kept.

APPENDIX H.

REPORT OF ASSOCIATE AIR RESEARCH COMMITTEE.

This Committee was appointed by the Research Council on January 30, 1920, and held its first meeting on February 7th, since which date three other meetings have taken place.

It is understood that its principal function is to make recommendations to the Research Council from time to time regarding the methods to be adopted to organize, assist, and co-ordinate research work in Canada in connection with aeronautics and the aircraft industry. The Committee was established with the full knowledge and approval of the Air Board, and, from the beginning, has worked in co-operation with the Board's officers.

One of the first actions of the Committee was to appoint as Associates a number of gentlemen from various parts of the Dominion who are interested in aeronautical work and are familiar with some phase of it on the experimental side. These Associates are not only available in an advisory capacity, but will, it is hoped, be able to give active assistance in connection with the arrangements for researches to be carried out in different parts of the country. The present list of Associates is as follows:—

Dr. C. Batho, McGill University, Montreal;
Dr. R. W. Boyle, University of Alberta, Edmonton;
Dr. E. Deville, Department of the Interior, Ottawa;
Commander C. P. Edwards, Department of Naval Service, Ottawa;
Capt. R. J. Grant, Willys-Overland, Ltd., Toronto;
Dr. Louis V. King, McGill University, Montreal;
Mr. C. M. McKergow, McGill University, Montreal;
Mr. J. Patterson, Meteorological Office, Toronto;
Dr. J. B. Porter, McGill University, Montreal;
Sir Frederick Stupart, Meteorological Office, Toronto;
Mr. Stanley Smith, University of Alberta, Edmonton;
Mr. W. R. Turnbull, Rothesay, N.B.;

The Associate Air Research Committee has collected data as to the existing facilities for aircraft research in Canada, and regrets to find that these facilities are somewhat meagre, almost the only equipment available for the work being that in the possession of two or three of the larger universities. Further, it appears that research work at these institutions is greatly limited by the absorption of those qualified to carry it out in teaching and routine work.

Communications have been addressed to the Air Board pointing out the necessity of provision for carrying out experimental work on machines in free flight, and it is understood that arrangements to this end will be made when the Board's Air Stations are organized.

Inquiry shows that little, if any, actual construction work, either as regards aeroplanes or aero engines, is now being done in Canada, the factories and equipment so successfully engaged in this industry during the war having been disposed of, and the staff disbanded or turned over to other forms of activity. This regrettable circumstance explains why a request from the Air Research Committee for suggestions from persons engaged, or formerly engaged, in the aircraft industry in Canada, has met with very little response.

The Committee has communicated with the Air Board, pointing out that as an indispensible preliminary to any aeronautical research, information as to what has already been accomplished must be available, and arrangements are being made for the utilization of the valuable information and data now in possession of the Air Board for this purpose. The Committee is also in communication with the authorities in England and with the National Advisory Council for Aeronautics, Washington, and it is hoped to keep in touch with these bodies so as to avoid unnecessary duplication of effort or overlapping as regards researches now in progress in England and the United States.

Considerable discussion has taken place with officers of the Air Board in connection with possible assistance to be given to that Board by the Committee as regards the solution of technical problems involving research. It is expected that the Committee and its Associates will be able to advise the officers of the Air Board, when necessary, firstly, as regards inventions which may be submitted and upon which judgment cannot be passed without investigations to determine the possible usefulness of the invention to the Board, and, secondly, as regards research investigation or advice necessary in connection with the examination by the Air Board Officers of the designs for new or altered machines.

Several suggestions have been received by the Committee as to problems now calling for investigation, of which the most promising appear to be those in connection with:—

Lubrication of aero engines;
Construction of aneroids and barographs with the view of avoiding hysteresis, lag, and other difficulties inseparable from the present methods of construction;
Air speed indicators and other instruments;
Problems in connection with photography as applied to topographical survey work;
Problems in connection with navigation, especially as regards the employment of directional wireless;
Flow of air around aerofoils.

It is hoped that arrangements will shortly be completed for the commencement of work on several of the points named.

From the replies to its inquiries, the Committee has been impressed with the fact that the chief difficulties in organizing aeronautical research work in Canada are,—

(*a*) The lack of trained experimenters with the necessary time for the work in question, and

(*b*) The difficulty in obtaining for these experimenters adequate mechanical assistance for the construction of their apparatus, instruments, and equipment. Both these matters are receiving the close attention of the Associate Air Research Committee.

APPENDIX I.

LIST OF ASSISTED RESEARCHES, 1919-20.

Grantee.	Where carried on.	Subject of Research.	Amount awarded.
			$ cts.
Forestry Branch, Dept. of the Interior, Ottawa.	Petawawa Forest Reserve....	Forestry studies.....	6,282 32
Prof. L. V. King.....	Physics Dept., McGill University.	Research on fog signalling.....	800 00
Dr. A. Stansfield.....	Dept. of Metallurgy, McGill University.	Reduction of iron ores by gases at low temperature and the electric furnace.	1,200 00
E. S. Hopkins.....	Dept. of Agriculture, Olds, Alta.	Investigation of the water requirements of crops in certain soils.	500 00
Dr. A. N. Shaw, Prof. N. E. Wheeler.....	Macdonald Physics Bldg., McGill University.	Investigation on the variations in the conductivity and vapour pressure in thin films of solutions containing highly deliquescent salts as the temperature and concentration change.	200 00
Prof. W. Sadler.....	Dept. of Dairying, University of B.C.	Investigation to determine the grading of cream and butter in relation to the bacterial contents of the cream or milk used in the preparation of these products.	1,000 00
Associate Committee on Industrial Fatigue.	.....	Investigation on industrial fatigue problems.	3,000 00
Prof. J. C. McLennan.....	Dept. of Physics, University of Toronto.	1. Research on the properties of helium.	5,000 00
		2. The measurement of explosive pressures which require a high voltage current apparatus.	1,000 00
		3. Research on molecular physics.	500 00
Dr. J. A. Gray.....	Macdonald Physics Bldg., McGill University.	Investigation to determine the character of the most penetrating type of röntgen rays and their application as compared with the penetrating rays from radium.	1,850 00
Assoc. Committee on Fox-breeding Industry	.....	Investigation of problems affecting the fox-breeding industry.	5,000 00
Capt. F. M. Dawson.....	McGill University.....	Research on the microscopic character of cement in relation to its hydration and its physical properties.	1,000 00
Prof. C. W. Drury.....	Dept. of Mining and Metallurgy, Queen's University.	Investigation to determine the most suitable slag for smelting vanadium ores.	1,500 00

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APPENDIX J.

LIST OF FELLOWSHIPS, STUDENTSHIPS AND BURSARIES, 1919-20.

FELLOWSHIPS.

Name.	Where held.	Subject of Research.
K. H. Kingdon.....	Physics Dept., University of Toronto.	Investigation of the ionisation potentials of gases and metallic vapours.
J. A. McRae (Special Fellowship).	Manchester University, Manchester, Eng.	(*a*) An investigation into the formation of substituted succinic acids by the action of potassium cyanide on the alkylidine cyano-acetic acids. (*b*) A study of the reactions of substituted succinic acids with a view to prepare compounds analogous to the rhodamine dyes produced from succinic acid.
W. F. Seyer.....	Chemistry Dept., McGill University.	Investigation of the tar sands; the separation of its constituents.
O. J. Walker.....	Chemistry Dept., McGill University.	Rubber resins: their constitution and relation to the vulcanization process.
F. H. S. Warneford.....	.....	Deferred until 1920-21.
E. G. Young (Ramsay Memorial Fellowship).	Biochemical Laboratory, Cambridge, Eng.	"The preparation and properties of pure proteins."

STUDENTSHIPS.

H. P. Bell.....	Dept. of Botany, University of Toronto.	Study of the diseases of the balsam.
Miss E. L. Bishop.....	Dept. of Physics, University of Toronto.	(*a*) A new form of nephelometer using the plane of polarisation of the scattered light. (*b*) Work on the motion of particles in an electric field.
J. W. Burns.....	Dept. of Chemistry Queen's University.	Measurement of the hydrogen ion concentration and hydroxyl ion concentration of rare earth salts.
H. R. Foreman.....	Dept. of Physics, University of Toronto.	Liquefaction of gases with a study of their applications to the production of explosives.
Miss C. W. Fritz.....	Dept. of Botany, University of Toronto.	Cultural criteria for the distinction of wood destroying fungi.
B. E. Gilbert.....	Department of Chemistry, McMaster University.	The effect of concentration on the precipitation of pigments in determining the shade of the colour obtained.
Eric Hearle.....	Dominion Government, Entomological Laboratory, Agassiz, B.C.	Investigation into the mosquito pest of the lower Fraser valley.
O. W. Herzberg.....	.....	Resigned.
W. A. Lawrence.....	Dept. of Chemistry, University of Toronto.	Friedel-Crafts reaction on derivatives of phthalic acid.
A. H. Leim.....	Dept. of Biology, University of Toronto.	The life history of the shad (*Alosa sapidissima*).
A. W. McCallum.....	Botanical Laboratories, University of Toronto.	Investigation on the biology of *Armillaria*—a wood destroying fungus.
J. W. McKinney.....	Dept. of Chemistry, McGill University.	The character of the organic matter in oil-shales.
Stuart McLean.....	Dept. of Physics, University of Toronto.	Investigating the heat of absorption of various gases by charcoals and carbonized lignites.
T. C. McMullen.....	.....	Resigned.
Miss B. K. E. Mossop.....	Dept. of Anatomy, Faculty of Medicine, Western University.	The growth of the sea mussel (*Mytilue edulis L*).
Miss M. Newton.....	Dept. of Biology, University of Saskatchewan.	Resistance of various varities of wheat to the form or forms of *Puccinia graminis* found attacking wheat in the grain-growing regions of Canada.
P. V. Rosewarne.....	Dept. of Chemistry, McMaster University.	The preparation of toluene derivatives.
Miss E. Shanly.....	Dept. of Pathology, McGill University.	Bacteriology of canned haddock, also the growth of bacteria in chilled fish (blackening in canned clams).
J. C. Thompson.....	.....	Resigned.

BURSARIES.

Name.	Where Held.
F. M. Archibald	Department of Chemistry, McGill University.
Miss Lucile Corbett	Dept. of Chemistry, Queen's University.
Miss Elsie Graham	Resigned.
W. F. James	Dept. of Geology, McGill University.
J. H. Mennie	Dept. of Chemistry, University of British Columbia.
H. R. McLarty	Dept. of Plant Pathology, McMaster University.
L. H. Nichols	Resigned.

APPENDIX K.

SUGGESTED DRAFT OF BILL TO AMEND THE PART OF THE INLAND REVENUE ACT DEALING WITH INDUSTRIAL ALCOHOL.

Recommended by the Research Council.

368. In this Part and in any regulation made hereunder, unless the context otherwise requires:—

(*a*) 'denatured alcohol' means alcohol in suitable admixture with such denaturants as to render it in the judgment of the Minister of Customs and Inland Revenue non-potable and to prevent recovery of the ethyl alcohol;

(*b*) 'specially denatured alcohol' means alcohol in suitable admixture with such special denaturants as have been approved by the Minister of Customs and Inland Revenue;

(*c*) 'Minister' means the Minister of Customs and Inland Revenue;

(*d*) 'regulation' means a regulation made under the provisions of this Act.

369. Alcohol without the admixture of any denaturants, and denatured alcohol and specially denatured alcohol as defined in section one of this Part, which is intended for use in the arts and industries or for fuel, light or power, or for any mechanical purpose, may be sold under conditions as hereinafter provided, free from excise duty.

370. Alcohol shall be manufactured, denatured or specially denatured in Canada only in premises thereto licensed.

371. (1) Denatured alcohol shall be sold, delivered and transported without restriction to dealers, manufacturers and other persons.

(2) Specially denatured alcohol shall only be sold or delivered under a special permit to dealers and manufacturers to be used in the arts and industries in cases where denatured alcohol would be unsuitable, and shall only be moved or transported under such conditions as the Minister may by regulations prescribe.

(3) Alcohol without any denaturant may be sold, free of excise duty, and delivered (*a*) for scientific purposes only in such limited quantities as may be prescribed by the Minister, to universities and to scientific and research laboratories approved by the Minister, and (*b*) in limited quantities for the purpose of medical treatment only to public hospitals chiefly maintained by public subscription or endowment, approved by the Minister. In any such cases the alcohol shall only be sold, delivered or transported under such conditions as the Minister, by regulation, may prescribe.

(4) Alcohol without any denaturant shall be sold or delivered, free of excise duty, under such conditions and in quantities as the Minister, by regulations, may prescribe, to specially licensed manufacturers of such products, in the preparation of which pure alcohol is essential as an agent, solvent or precipitant, but in which the finished product contains no alcohol.

(5) No alcohol shall be manufactured or sold under the provisions of this Act for beverage purposes.

372. The recovery of alcohol after it has been used for industrial purposes and its redistillation and purification shall only be done on the premises in which the alcohol was used or at a duly licensed distillery, and all alcohol recovered on the premises aforesaid must be used in the same manufacturing establishment in which it was originally used.

373. (1) All vessels, the capacity of which is one gallon or less, when containing wood alcohol or denatured alcohol, whether in the possession of the manufacturer or other person, shall have affixed thereto a label bearing the words 'Methyl-Hydrate—Poison' in black letters on white ground not less than one-fourth of an inch in height. If the capacity of the package exceeds one gallon, a label shall be affixed thereto bearing the inscription heretofore defined, in black letters on a white ground not less than one-half of an inch in height.

(2) Except as herein otherwise provided, any person who holds in possession, sells, exchanges or delivers any alcohol or specially denatured alcohol contrary to the provisions of this section shall be liable upon summary conviction to a penalty of not less than one hundred dollars and not exceeding five hundred dollars.

374. All the provisions of Part II of this Act respecting bonded manufacturers, licenses and the obligations of persons holding them, the keeping of books or accounts, and the making of returns, so far as applied by regulations, and all provisions respecting penalties, so far as applicable, shall have full force and effect with respect to the manufacture, denaturing, special denaturing and recovery of alcohol, and the persons licensed as herein provided, as if such provisions had been enacted with special reference to the manufacture, denaturing, special denaturing and recovery of alcohol and the issue of licenses for such manufacturers.

APPENDIX L.

CIRCULAR RELATING TO THE ADVISABILITY OF THE INCREASED USE OF FERTILIZERS IN CANADA. ISSUED BY THE HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

"The Honorary Advisory Council for Scientific and Industrial Research has, since its creation in 1916, kept in touch with matters relating to the manufacture of artificial nitrogenous fertilizers such as sodium and ammonium nitrate, cyanamide, ammonium sulphate, etc.

"The Council has, as a result, collected a large amount of information on these subjects and is in a position to gather and tabulate more if conditions in this country appear to warrant this being done.

"It would seem that there should be a considerable field in Canada for the use of fertilizers, and, as in other countries, the demand cannot be adequately filled from natural sources, such as manure, blood, etc., so it will, no doubt, be here, if fertilizers are to be made use of to the extent to which the benefits derivable from them warrant.

"The position regarding the use of nitrogenous fertilizers is not perhaps quite the same as in Europe where the desire to provide adequate supplies of foodstuffs

gives rise to intensive farming. There, most of the available land is already under cultivation and the only way in which greater actual production can be secured is to obtain larger yields per acre. In the Dominion, however, there are two ways of increasing production, viz., (*a*) by increasing the acreage under cultivation; (*b*) by increasing the yield per acre. Because of the comparative smallness of the population and the consequent difficulty of obtaining farm labour, however, the latter method is probably the more desirable as it tends directly to the conservation of labour as manifestly there must be less work involved at all stages from seeding to harvesting, in getting a given yield from one acre of land than in getting the same yield from a larger area.

"In view of the foregoing, the Council is very desirous of ascertaining what are the possibilities in this country for the use of nitrogenous fertilizers on an extended scale, and of learning whether your Department is undertaking, or is prepared to undertake, experiments with artificial nitrogenous fertilizers with the definite object of increasing their use by the farmers.

"There is an aspect of this question which should not be lost sight of as it is of great importance to the country at large.

"Several of the most successful methods of making artificial nitrogenous fertilizers use electric power in considerable quantity and Canada, with her great water-powers, is peculiarly well fitted to supply such power.

"The manufacture of such nitrogenous fertilizers on a large scale would, therefore achieve several results as follows:--

"(*a*) Tend to solve the farm labour problem.

"(*b*) Produce better foodstuffs with less waste.

"(*c*) Enable foreign markets to be supplied with fertilizers from Canada, thus bringing money into the country.

"(*d*) Enable existing large water-powers to be utilized to better advantage by employing off-peak power.

"(*e*) Enable water-powers to be developed in remote districts where otherwise it would not pay to develop them, thus opening up new districts and bringing in new industries, etc., and generally tending to the growth and economic benefit of the country.

"Though no thorough investigation of the subject has yet been made there is reason to believe that where large water-powers have been or are being, developed, there are, in many cases, large quantities of power running to waste through off-peak hours,—power which might well be employed in the manufacture of fertilizers.

"One process of making artificial fertilizers uses only materials which are to be found in very many localities, viz., air and lime; while another uses air, lime, and coke, so that if coke be obtainable in sufficient quantity this latter process could be employed.

"Still another process uses nitrogen obtained from the air and hydrogen which can readily be obtained electrically from water, though there are other means of getting it.

"The Council feels confident that it is in the best interests of the Dominion that the whole of the fundamental questions involved in this matter should be thoroughly investigated, and would be glad to learn that you are in sympathy with their view and that your Department would be willing to co-operate in any possible way in order that a subject of so great importance may be given the attention it deserves."

Available information regarding nitrogen fixation tends to show that it is possible, in Canada, to produce fixed nitrogen in the form of calcium cyanamide more cheaply, possibly, than in any other form.

It is therefore highly desirable to know at an early date whether calcium cyanamide can be used in the soils found in different parts of this country, particularly

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as reports of experiments made in England lead to the conclusion that this substance can be used to greater advantage on some soils than others.

It is understood from experiments recently made in England that the freeing of nitrogen from cyanamide is promoted by the action of certain bacteria and that these bacteria flourish in some soils better than in others. If the experiments in England be confirmed it is desirable that we in this country should ascertain whether our soils are suitable for the development of the requisite bacteria and whether soils which are partly suitable can be improved in this direction.

For this purpose tests should be carried out on Experimental Farms and in connection with the various Agricultural Colleges, as well as elsewhere, to furnish us with definite knowledge on these points and we shall be grateful for co-operation on your part to that end.

APPENDIX M.

LIST OF BRITISH TRADE ASSOCIATIONS FOR RESEARCH.

The following is a list of research associations which have been approved by the Department as complying with the conditions laid down in the government scheme for the encouragement of industrial research and have received licenses from the Board of Trade under section 20 of the Companies' (Consolidated) Act of 1908:—

British Boot, Shoe and Allied Trades Research Association, Technical School, Abington Square, Northampton.
Secretary—Mr. John Blakeman, M.A., M.Sc.

British Cotton Industry Research Association, 108 Deansgate, Manchester.
Secretary—Miss B. Thomas.

British Empire Sugar Research Association, Evelyn House, 62 Oxford Street, London, W. 1.
Secretary—Mr. W. H. Giffard.

British Iron Manufacturers' Research Association, Atlantic Chambers, Brazennose Street, Manchester.
Secretary—Mr. H. S. Knowles.

British Motor and Allied Manufacturers' Research Association, 39 St. James's Street, London, S.W. 1.
Secretary—Mr. Horace Wyatt.

British Photographic Research Association, Sicilian House, Southampton Row, London, W.C. 1.
Secretary—Mr. Arthur C. Brookes.

British Portland Cement Research Association, 6 Lloyd's Avenue, London, E.C. 3.
Secretary—Mr. S. G. S. Panisset, A.C.G.I., F.C.S.

British Research Association for the Woollen and Worsted Industries,
Bond Place Chambers, Leeds,
Secretary—Mr. Arnold Frobisher, B. Sc.

British Scientific Instrument Research Association, 26 Russell Square, London, W.C. 1.
Secretary—Mr. J. W. Williamson, B.Sc.

British Rubber and Tyre Manufacturers' Research Association, c/o Messrs. W. B. Peat & Co., 11 Ironmonger Lane, London, E.C. 2.

The Linen Industry Research Association, 3 Bedford Street, Belfast.
Secretary—Miss M. K. E. Allen.

Glass Research Association, 7 Seamore Place, London, W. 1.
Secretary—Mr. E. Quine, B.Sc.

British Cocoa, Chocolate, Sugar Confectionery, and Jam Trades Research Association, 9 Queen Street Place, London, E.C. 4.
Secretary—Mr. R. M. Leonard.

Schemes for the establishment of Research Associations in the following industries have reached an advanced state of development.

RESEARCH ASSOCIATIONS APPROVED BY THE DEPARTMENT BUT NOT YET LICENSED BY THE BOARD OF TRADE.

British Music Industries Research Association.
British Refractory Materials Research Association.
British Non-Ferrous Metals Research Association.
Scottish Shale Oil Research Association.

PROPOSED RESEARCH ASSOCIATIONS WHOSE MEMORANDUM AND ARTICLES OF ASSOCIATION ARE UNDER CONSIDERATION.

British Launderers' Research Association.
British Electrical and Allied Industries Research Association.
British Aircraft Research Association.

INDUSTRIAL ORGANIZATIONS ENGAGED IN PREPARING MEMORANDUM AND ARTICLES OF ASSOCIATION.

Silk Manufacturers.
Leather Trades.
Master Bakers and Confectioners.
Engineering and Shipbuilding.
Pottery.
Lighter Metal Trades (Manufacturing process).

In addition to the industries included above, certain others are engaged in the preliminary consideration for forming Research Associations.

APPENDIX N.

Research Association Circular I (Revised).

THE GOVERNMENT SCHEME FOR INDUSTRIAL RESEARCH.

A FUND OF A MILLION.

The Government, as already announced, have placed a fund of a million sterling at the disposal of the Research Department to enable it to encourage the industries to undertake research. Much will depend upon the way in which this money is spent. The independence and initiative of the British manufacturer have contributed largely

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in the past to his success. After the war he will need all possible assistance in undertaking and developing research work as a means of enlarging his output and improving its quality. But if the help is to be effective, it must increase his independence and initiative. It must avoid chaining him to the routine of Government administration, however efficient. It must be so given as to enlist his active support. To the initiative of the manufacturer, the improvement of old and the discovery of new industrial processes in this and other countries have largely been due. It has been the co-operation of progressive industry with science which has led to the practical application of the results obtained in the laboratories of scientific men. The Advisory Council for Scientific and Industrial Research have, therefore, recommended after consultation with manufacturers and others that the new fund should be expended on a co-operative basis in the form of liberal contributions by the Department towards the income raised by voluntary associations of manufacturers established for the purpose of research. By this method the systematic development of research and the co-operation of Science with Industry will be carried out under direct control of the industries themselves. It is also hoped that the co-operation of the firms concerned in any one industry may enable research work to be undertaken which could not have been dealt with by individual firms.

THE NEED OF COMBINATION FOR RESEARCH.

All considerations point to the necessity for combination to this end. If the firms in an industry which are engaged in the production of similar articles or alternatively if the firms in different industries which make use of the same or similar raw or semi-manufactured materials will combine to improve those articles or materials, to discover new processes or to increase the efficiency of existing processes, the Department will contribute liberally to a joint fund for this purpose. The fund for each industry will be expended by a Committee or Board appointed by the contributing firms in that industry, and the results obtained will be available for the benefit of the contributing firms.

The Department realizes that there will be many difficulties in the way. Some industries are large and well organized or their dependence on Science is obvious, while others are either small, badly organized, or are not obviously based on the application of scientific principles. Again, some industries are from their nature mainly interested in research because they are users of certain materials which are susceptible of improvement, and these materials are also used by other industries. Experience has shown that in some cases a Research Association may be established for the whole of a complex industry, whereas in others it is most convenient for only the firms engaged in a single section to combine to form an Association. Generally speaking, it is difficult to combine in a single Association both the makers and the users of any commodity, though there is one instance where the attempt to do so has been successful. It appears to be certain, however, from these considerations that some firms will wish to belong to more than one combination for research purposes, and that if wasteful effort is to be avoided, every possible means must be used to encourage co-operation between different research organizations as well as between the several firms within the same organization.

THE BENEFITS WHICH FIRMS WILL RECEIVE.

But this will not exhaust the problems ahead. Some firms in an industry will be in a better position to make profitable use of the results of research than others. All firms in an industry are not equally alive to the possibility of improvement, and each individual firm has its own views as regards the measure of the advantage to be obtained from research work in its particular branch of industry.

All firms invited to join such an organization as is contemplated are likely to ask themselves what they are going to get out of it. They would not be efficient businesses if they did not. The answer to this question ought to give an outline sketch of the way in which such an industrial research organization would work. The means and method of its establishment will be described in later paragraphs.

It is anticipated that each firm subscribing to a research organization will have the following privileges:—

(1) It will have the right to put technical questions and to have them answered as fully as possible within the scope of the research organization and its allied associations.

(2) It will have the right to recommend specific subjects for research, and if the Committee or Board of the research organization of that industry consider the recommendation of sufficient general interest and importance, the research will be carried out without further cost to the firm making the recommendation, and the results will be available to all the firms in the organization.

(3) It will have the right to the use of any patents or secret processes resulting from all researches undertaken either without payment for licenses, or at any rate on only nominal payment as compared with firms outside the organization.

(4) It will have the right to ask for a specific piece of research to be undertaken for its sole benefit at cost price, and, if the governing Committee or Board approve, the research will be undertaken.

It will be realized that no firm outside the organization will have any of these rights. The documents and bulletins available for members of the organization will not be published unless the controlling committee of the organization decide that they shall be.

BUREAU OF INFORMATION.

There are other privileges to which each firm subscribing to a Research Association will be entitled if the Association decides, as several Associations have already done, to establish a Bureau of Information. Every one who has had experience in research is fully aware of the fact that useful discoveries usually take time to reach the stage at which they are available for commercial use. If for no other reason than this it will often be desirable for a Research Association to set up a Bureau of Information which will give to each of its members technical information relating to the industry. If this is done each firm will have the following privileges:—

(1) It will receive a regular service of summarized technical information which will keep it abreast of the technical developments in the industry at home and abroad. To do as much for itself any firm would have to employ more than one man on its staff reading and translating the technical press.

(2) It will be able to obtain a translated copy of any foreign article in which it may be specially interested and to which its attention will have been drawn by the periodical bulletin.

SUBSCRIPTION FROM THE INDUSTRY.

The method of assessing the subscription of each firm will have to be determined in negotiation with each industry or section of an industry which may agree to combine for the purposes of research, but the intention is that firms should contribute on a basis proportionate to their size. Thus the small firm will contribute less than the large firm, yet it will have the same privileges, though as a rule it will not in the

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nature of the case have the same facilities for exploiting the results of research. On the other hand the small firm will be more likely to use the benefits offered under heads (1) and (4) than the large firm.*

APPROVED RESEARCH ASSOCIATIONS.

The Department is advised that the best machinery for the purpose in view is the establishment of Research companies limited by guarantee of a nominal sum (*e.g.* £1) and working without profit, *i.e.*, without the division of profits among the members in the form of dividends. In order to assist industries in the formation of limited companies or associations of this kind, the Research Department has drafted a specimen Memorandum and Articles of Association† based upon the skeleton prepared by the Board of Trade for use in such cases. It is not intended to impose this specimen Memorandum and Articles of Association on industries desiring to establish Research Associations. The order in which the objects of the Association are set out may need modification to suit varying circumstances, and the "objects" themselves may have to be varied by either excision or enlargement, but the intention of the draft has been to include, as far as could be foreseen, all those powers and activities which an Association founded for the purposes of research might need to possess. At the same time, the nearer any draft Memorandum and Articles of Association can be brought to the specimen, the quicker will be the departmental procedure and the smaller the legal costs.

REMISSION OF INCOME TAX.

Such Associations, being limited liability companies working without profits, will be able to distribute beneficial information to their members without infringing Section 20 of the Companies' Acts; and if they are established in accordance with the provisions referred to, the subscriptions paid to them by contributing firms will, under a recent decision of the Board of Inland Revenue, be recognized by the surveyors of taxes as business costs of the firms and will not be subject to income or excess profits taxes. The income of the Associations will similarly be free of income tax.

GOVERNMENT GRANTS.

Any such Association will also be qualified to apply for grants towards its income from the Research Department under stated conditions,‡ though experience has shown that not all industries will wish to do so. In those cases where aid is necessary a Government grant will be given for a period of years to be agreed upon, not exceeding five, though it may be extended if funds are available and the condition of the industry calls for further aid. The contribution will be made in the anticipation that when the new organizations are once fairly launched on their career the need for direct State assistance will disappear and British industry will be as self-sufficing in the field of industrial research as it has proved itself to be in other spheres of work.

OWNERSHIP OF THE RESULTS OF INVESTIGATION.

The whole of the results of researches conducted by any Research Association will belong to the Association itself, which will hold them in trust for the benefit of its members. The Government is, however, specially bound to safeguard the national interests where new discoveries are made with the assistance of Parliamentary funds,

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* The "Method of Subscription to Research Associations" is described in "*Research Association Circular* 4".

† Draft Memorandum and Articles of Association for Trade Associations for Research ("*Research Association* 2").

‡ See "*Research Association* 3."

and accordingly, besides the powers it already possesses under the Patents and Designs Act, 1907, it will keep in its own hands two additional powers, which may be said to limit the absolute ownership otherwise reserved to the Association—the right of veto in case any proposal is made by a Research Association to communicate any results of research to a foreign person or to a foreign corporation, and the right, after consultation with the Association concerned, of communicating the results of discoveries to other industries for their use on suitable terms. The Department will not, however, make any results obtained by a Research Association available to firms or individuals who are eligible for membership of that Association but have not joined it.

DELEGATION OF RESPONSIBILITY TO ASSOCIATIONS.

It will be seen from this short description and from a detailed study of these documents that the policy of the Research Department is to delegate the prosecution of industrial research on a co-operative basis to the industries themselves, working through voluntary associations of firms engaged in producing similar articles, or using the same materials. It is hoped and anticipated that these Associations will co-operate with each other in the solution of problems of common interest, and the Department intends to do its utmost to encourage such alliances. It is also anticipated that the Associations will make every possible use of existing facilities for scientific research whether at the Universities and Technical Colleges, or at such central institutions as the National Physical Laboratory. There will be ample scope for all these agencies as well as for any special research institutes which the Research Associations may establish in future for their own purposes.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH,
GREAT GEORGE STREET, WESTMINSTER, S.W.1.
December, 1918.

Research Association Circular 2. (Revised.)

DRAFT MEMORANDUM AND ARTICLES OF ASSOCIATION.

The following draft memorandum and Articles of Association are suggested for adoption by the promoters of Research Associations to be established under the Government Scheme for Industrial Research described in " Research Association 1," issued by the Department of Scientific and Industrial Research, with such modifications as the circumstances of each industry may require.

When the draft Memorandum and Articles of the proposed Research Association have been approved by the Department, they must be forwarded in duplicate to the Board of Trade with an application for a license under Section 20 of the Companies (Consolidation) Act of 1908, to enable the promoters to register the Association without the addition of the word "Limited." The application should also state the names of the persons who will sign the Memorandum and of the persons who will form the first Council of the Association, and should enclose a cheque for £5 10s. for Counsel's fees.

The Companies Acts 1908 to 1917.

COMPANY LIMITED BY GUARANTEE AND NOT HAVING A CAPITAL DIVIDED INTO SHARES.

MEMORANDUM OF ASSOCIATION OF THE BRITISH RESEARCH ASSOCIATION.

1. The name of the Association is the "The British Research Association."

2. The registered office of the Association will be situate in England.

3. The objects for which the Association is established are:—

(*a*) To promote research and other scientific work in connection with the trade or industry and other trades and industries allied therewith or accessory thereto, and for that purpose to establish, form, equip and maintain laboratories, workshops or factories, and conduct and carry on experiments, and to provide funds for such work, and for payment to any person or persons engaged in research work, whether in such laboratories or elsewhere, and to encourage and improve the education of persons who are engaged or are likely to be engaged in the industry.

(*b*) To prepare, edit, print, publish, issue, acquire and circulate books, papers, periodicals, gazettes, circulars and other literary undertakings treating of or bearing upon the said trades or industries or any of them and to establish, form and maintain museums, collections, libraries and collections of literature, statistics, scientific data and other information relating to the said trades or industries or any of them or to matters of interest to the members thereof, and to translate, compile, collect, publish, lend and sell, and endeavour to secure, or contribute to, the translation, compilation, collection and publication, by Parliament, Government Departments and other bodies or persons, of any such literature, statistics and information, and to disseminate the same by means of the reading of papers, delivery of lectures, giving of advice, the appointment of advisory officers or otherwise.

(c) To retain or employ skilled, professional or technical advisers or workers in connection with the objects of the Association, and to pay therefor such fees or remuneration as may be thought expedient, also to found, aid, maintain and endow scholarships and bursaries for the remuneration, instruction and support of students in research work, or persons engaged in studying the principles involved in any of the said trades or industries or connected therewith, whether in the laboratories of the Association or elsewhere, and to employ and remunerate as may be expedient, instructors and supervisors for such students and also for persons engaged in studying the principles involved in any of the said trades or industries or connected therewith, paying due regard to the provision of instruction by existing institutions.

(*d*) To encourage the discovery of, and investigate and make known the nature and merits of inventions, improvements, processes, materials and designs which may seem capable of being used by Members of the Association for any of the purposes of the said trades or industries or any of them and to acquire any patents or licenses relating to any such inventions, improvements or processes, and to acquire and register any designs or standardization marks, whether for general or special purposes, with a view to the use thereof by Members of the Association and others upon such terms as may seem expedient, and to develop, perfect and test the value of such inventions, improvements, processes and designs by manufacturing, exhibiting and placing on the market any article or substances to which the same may be capable of application.

(*e*) To apply to the Government, public bodies, Urban, Local, Municipal, County and other bodies, corporations, companies or persons for, and to accept grants of money and (subject to section 19 of the Companies (Consolidation) Act, 1908) of land, donations, gifts, subscriptions and other assistance with a view to promoting the objects of the Association, and to discuss and negotiate with the Committee of the Privy Council for Scientific and Industrial Research and other Government Departments, public and other bodies, corporations, companies or persons, schemes of research and other work and matters within the objects of the Association and to conform to any proper conditions upon which such grants and other payments may be made.

(*f*) To establish, promote, co-operate with, become a member of, act as, or appoint trustees, agents or delegates for, control, manage, superintend, afford financial assistance to, or otherwise assist the research work of any associations and institutions and other bodies incorporated or not incorporated, whose objects include scientific or industrial research.

(*g*) To establish, maintain, control and manage branches of the Association in the United Kingdom and elsewhere as may seem expedient, and from time to time to determine the constitution, rights, privileges, obligations and duties of such branches, and, when thought fit, to dissolve and modify the same.

(*h*) To undertake and execute any trusts which may be conducive to any of the objects of the Association.

(*i*) To carry out any of the above-mentioned research or other scientific work, and to do all or any of the above-mentioned things whether affecting the whole of the said trades or industries or merely one or more particular parts or sections of the said trades or industries or any of them or the business of any particular member or group of members of the Association, and, in the case of work not affecting the whole of the said trades or industries, to make such arrangements as to special payment by such particular sections or members or groups of members as may be expedient.

(*j*) To borrow or raise any money that may be required by the Association upon such terms as may be deemed advisable, and in particular by the issue of bonds, debentures, bills of exchange, promissory notes or other obligations or securities of the Association, or by mortgage or charge of all or any part of the property of the Association.

(*k*) To draw, make, accept, indorse, discount, execute and issue promissory notes, bills of exchange and other negotiable or transferable instruments.

(*l*) To invest the moneys of the Association not immediately required in any one or more of the modes of investment for the time being authorized by law for the investment of trust moneys and in such manner as may from time to time be determined.

(*m*) Subject to the provisions of the 19th Section of the Companies (Consolidation) Act, 1908, to purchase, take on lease or in exchange, hire or otherwise acquire any real and personal property, and in particular any land, buildings, workshops, factories, laboratories, machinery, plant, apparatus, appliances and any rights or privileges necessary or convenient for the purposes of the Association, and to construct, erect, alter, improve and maintain any buildings which may be from time to time required for the purposes of the Association, and to manage, develop, sell, demise, let, mortgage, dispose of, turn to account or otherwise deal with all or part of the same with a view to the promotion of the objects of the Association.

(*n*) To pay all expenses, preliminary or incidental to the formation of the Association and its registration.

(*o*) To use the funds of the Association in the employment of persons of learning or skill, and the provision and use of buildings, and of instruments, materials and appliances, and of any of the equipment of the Association for any form of scientific studies which may be considered to have some bearing, whether immediate or ultimate, on practical problems involved in the nature or use of

(*p*) To collect, arrange, index and publish information as to materials, patents, processes, machines, appliances and tools used or known in or in regard to or the said trades or industries or likely to be useful thereto, and to establish and maintain a Bureau of Information for the benefit of members of the Association.

(*q*) To establish and support or aid in the establishment and support of Associations, institutions, funds, trusts and conveniences calculated to benefit employees or ex-employees of the Association or the dependents or connections of such persons, and to grant pensions and allowances to and to make payments towards insurance of such persons.

(*r*) To procure the Association to be registered or recognized in any part of the British Empire or in any foreign country or place.

(*s*) To do all such other lawful things as may be incidental to or conducive to the attainment of the above objects.

Provided always that nothing herein contained shall empower the Association to carry on the business of life insurance, personal accident assurance, fire insurance or employers' liability insurance or the business of insurance within the meaning of the Assurance Companies Act, 1909, Section 1.

Provided also that the Association shall not support with its funds any object, or endeavour to impose on or procure to be observed by its Members or others any regulation, restriction, or condition, which, if an object of the Association, would make it a trade union.

Provided also that in case the Association shall take or hold any property subject to the jurisdiction of the Charity Commissioners or Board of Education for England and Wales, or any authority exercising corresponding jurisdiction outside England and Wales, the Association shall not sell, mortgage, charge or lease the same without such authority, approval or consent as may be required by law, and as regards any such property the Managers or Trustees of the Association shall be chargeable for such property as may come into their hands and shall be answerable and accountable for their own acts, receipts, neglects and defaults, and for the due administration of such property in the same manner and to the same extent as they would as such Managers or Trustees have been if no corporation had been effected, and the incorporation of the Association shall not diminish or impair any control or authority exerciseable by the Chancery Division, the Charity Commissioners, or the Board of Education or any such other authority as aforesaid over such Managers or Trustees, but they shall, as regards any such property, be subject jointly and separately to such control or authority as if the Association were not incorporated. In case the Association shall take or hold any property which may be subject to any trusts, the Association shall only deal with the same in such manner as allowed by law having regard to such trusts.

4. The income and property of the Association, whencesoever derived, shall be applied solely towards the promotion of the objects of the Association as set forth in this Memorandum of Association, and no portion thereof shall be paid or transferred directly or indirectly, by way of dividend, gift, division, bonus or otherwise howsoever by way of profit, to the Members of the Association.

Provided that nothing herein shall prevent the payment in good faith of reasonable and proper remuneration to any officer or servant of the Association or to any member of the Association, in return for any services actually rendered to the Association, or for any material, labour, plant or power supplied for experimental purposes, nor prevent the payment of interest at a rate not exceeding six per centum per annum on money lent, or payment of a reasonable and proper rent for premises demised or let by any Member of the Association, but so that no Member of the Council or Governing Body of the Association shall be appointed to any salaried office of the Association or any office of the Association paid by fees, and that no remuneration or other benefit in money or money's worth shall be given by the Association to any Member of such Council or Governing Body except by way of repayment of out-of-pocket expenses and interest at the rate aforesaid on money lent or the payment of a reasonable and proper rent for premises demised or let to the Association (or any remuneration to any member of the Council in accordance with any recommendation

by or with the approval of the Committee of the Privy Council for Scientific and Industrial Research), provided that nothing hereinbefore contained shall prevent any payment to any Railway, Gas, Electric Lighting, Water, Cable or Telephone Company of which a member of the Council may be a member, or to any corporate body of which a member of the Council may be a member or shareholder holding less than one-hundredth part of its capital or to any other corporate body or to any firm with the previous consent of the Committee of the Privy Council for Scientific and Industrial Research, and Members shall not be bound to account for any share of profits they may receive in respect of any such payment.

Provided also that nothing herein shall prevent any Member of the Association, whether a member of the Council or not, from exercising any processes and making, using, acquiring and vending any articles and things in the ordinary course of his business for profit or otherwise under any license or permission in respect of any discovery, invention and patents resulting from the work of the Association.

5. No addition, alteration or amendment shall be made to or in the regulations contained in the Articles of Association for the time being in force, unless the same shall have been previously submitted to and approved by the Board of Trade in consultation with the Committee of the Privy Council for Scientific and Industrial Research.

6. The fourth and fifth paragraphs of this Memorandum contain conditions on which a license is granted by the Board of Trade to the Association in pursuance of Section 20 of the Companies (Consolidation) Act, 1908.

7. The liability of the members is limited.

8. Every Member of the Association undertakes to contribute to the assets of the Association, in the event of the same being wound up during the time that he is a Member, or within one year afterwards, for payment of the debts and liabilities of the Association contracted before the time at which he ceases to be a Member, and of the costs, charges and expenses of winding up the same, and for the adjustment of the rights of the contributories amongst themselves, such amount as may be required not exceeding £5.

9. If upon the winding up or dissolution of the Association there remains, after the satisfaction of all its debts and liabilities, any property whatsoever, the same shall not be paid to or distributed among the Members of the Association, but shall be given or transferred to some other institution or institutions having objects similar to the objects of the Association, and which shall prohibit the distribution of its or their income and property amongst its or their Members to an extent at least as great as is imposed on the Association under or by virtue of Clause 4 hereof, such institution or institutions to be determined by the Members of the Association, subject to the approval of the Committee of the Privy Council for Scientific and Industrial Research at or before the time of dissolution, or in default thereof by such Judge of the High Court of Justice as may have or acquire jurisdiction in the matter, and if and so far as effect cannot be given to the aforesaid provision, then to some charitable object.

10. True accounts shall be kept of the sums of money received and expended by the Association, and the matters in respect of which such receipts and expenditure take place, and of the property credits and liabilities of the Association, and, subject to any reasonable restrictions as to the time and manner of inspecting the same that may be imposed in accordance with the regulations of the Association for the time being, shall be open to the inspection of the Members. Once at least in every year the accounts of the Association shall be examined, and the correctness of the balance sheet ascertained by one or more properly qualified auditor or auditors.

WE, the several persons whose names and addresses are subscribed, are desirous of being formed into an Association in pursuance of this Memorandum of Association.

Names, Addresses, and Descriptions of Subscribers.

Dated the day of , 19

The Companies Acts, 1908 to 1917.

COMPANY LIMITED BY GUARANTEE AND NOT HAVING A CAPITAL DIVIDED INTO SHARES.

ARTICLES OF ASSOCIATION OF THE BRITISH RESEARCH ASSOCIATION.

1. In the construction of these presents the following words and expressions shall have the following meanings respectively unless there be something in the subject matter or context repugnant thereto.

"The Companies Acts" means the Companies Acts 1908 to 1917 and every other Act incorporated therewith or any Act or Acts of Parliament amending the same.

"Month" means calendar month.

"The Association" means the British Research Association.

"The Office" means the registered office of the Association.

"The Council" until the election of the first Council means the Signatories, and thereafter means the Council of Management of the Association as a body or a quorum of the members thereof at a Council meeting.

"Secretary" includes any person appointed to perform the duties of Secretary temporarily.

"In Writing" and "Written" include printing, lithography, and typewriting and all other modes of representing or reproducing words in visible form.

Words which have a special meaning assigned to them in the Companies Acts have the same meaning in these presents.

Words importing the singular number include the plural, and the converse applies.

Words importing males include females.

Words importing persons include corporations.

"Notice" includes all written communications to members.

"These presents" means the Articles of Association for the time being of the Association.

"The Department" means the Committee of the Privy Council for Scientific and Industrial Research.

Members.

2. For the purpose of registration the number of Members of the Association is declared to be , but the Council may register an increase in the number of members whenever and as often as they think fit.

3. The Association is established for the purposes expressed in the Memorandum of Association.

4. The subscribers hereto shall be the first Ordinary Members, and subject as hereinafter mentioned it shall rest with the Council to determine the terms and conditions on which subsequent Members shall from time to time be admitted.

5. The membership of the Association shall consist of persons and corporate bodies with the following status:—

(*a*) Ordinary members who shall be the signatories of the Memorandum of Association and those British subjects carrying on business in the production or marketing of or in the production of machinery, appliances,

accessories or materials to be employed in the production or marketing of and those British Corporations carrying on business as aforesaid who shall be elected as Members of the Association in manner hereinafter provided.

(*b*) Associate Members who must be scientific workers, pressmen and others connected with the said trades or industries or any of them, or likely to assist in the development of the said trades or industries or any of them, or persons or incorporated companies dealing in requisites used in the said trades or industries or any of them in any part of the world, or superintendents, directors, secretaries or other officers of limited liability companies carrying on any of such businesses.

(*c*) Delegate Members, being delegates of other associations established for kindred purposes.

(*d*) Honorary Members, being persons whether entitled or not to become Members under the above provisions and nominated for membership by the Council for special services or for special cause, and elected at a General Meeting.

No Member, other than an Ordinary Member or the representative for the time being of an Ordinary Member under Articles 7-10 inclusive, or any of them, shall be entitled to vote at General Meetings. Members other than Ordinary Members shall be entitled to such of the privileges and benefits of the Association as the Council may from time to time determine, but without power to vote at any General Meeting.

Provided always that an Ordinary or Associate Member must be a British subject or a corporate body registered in Great Britain or Ireland or obtaining its Charter from the Government of these countries and in all cases where capital is divided into shares having three-fourths of the issued capital owned by British subjects in their own right entitling the holders thereof to not less than three-quarters of the voting power of the Company provided also that any member ceasing to fulfil the requisite conditions of membership shall *ipso facto* cease to be a member.

6. The following provisions shall have effect with respect to the Association, and in case of any conflict between the provisions of this Article and those of any other Article the provisions of this Article shall prevail:—

A. Every application for membership of the Association shall be accompanied by:—

(1) In the case of an application made by an individual, a declaration by the applicant stating whether he is or is not a British subject, and whether he has or has not ever taken an oath of allegiance or otherwise become a citizen or subject of any, and if so, what, enemy or foreign sovereign or State; and, if a British subject, whether he is a natural-born British subject, or a British subject by naturalization or otherwise, and, if naturalized, whether he remains for any purpose in the allegiance of any, and if so, what, enemy or foreign sovereign or State.

(2) In the case of an application made by a corporation, a declaration made on behalf of the corporation by the secretary or other officer authorized in that behalf stating whether the corporation is an enemy or foreign corporation or a corporation under foreign control.

And in either case the Council may, before electing any Member, require such further evidence as it shall in its absolute discretion think necessary in support of any such declaration.

B. In the event of its being proved to the satisfaction of the Council that the declaration to be made under Clause A. is untrue, the Council shall by resolution (which shall be final and conclusive and not subject to question by any person on any ground whatever) exclude such Member from membership, and upon such resolution being

passed such Member shall cease to have any interest in the Association and shall have no claim against the Association or the Council or any of its members in respect thereof.

C. The Council shall not without the consent of the Board of Trade elect to membership any foreigner or foreign corporation or corporation under foreign control.

D. If at any time a Member shall cease to be a British subject or shall come in any way directly or indirectly under the control or directions of, or become in the opinion of the Board of Trade subject to the influence of any foreign State, body, person or corporation, or corporation under foreign control, the Council may at any time and shall at the request of the Board of Trade serve on the Member in question a notice in writing requiring such Member to retire from the Company, and upon such notice being given, such Member shall *ipso facto* cease to be a Member of the Association, and shall not be eligible for re-election as a Member.

E. In the event of any Member ceasing to be a British subject or coming in any way directly or indirectly under the control or directions of any foreign State, body, person or corporation, or corporation under foreign control, he shall within thirty days disclose the fact to the Council, and failure to make such a disclosure within such period shall render the Member liable to exclusion in the manner provided by Clause B hereof. Provided that no such right of exclusion under this Article shall be exercised by the Council without the consent of the Board of Trade.

F. No person other than a British subject resident in the United Kingdom shall be qualified to be a member of the Council, and the office of a Member of the Council shall be vacated:—

(*a*) If he cease to be a British subject, or cease to reside in the United Kingdom.

(*b*) If he be called upon in writing by at least three-fourths of all the other Members of the Council for the time being to resign office on the ground that he is, in their opinion, subject to the influence of a foreign State, body, person, or corporation, or a corporation under foreign control, and for that reason is not a desirable person to be a Member of the Council, and so that the opinion of a three-fourths majority of the other Members of the Council so expressed shall not be subject to question by any person or corporation on any ground whatsoever.

G. In these provisions:—

The expression "foreigner" means every person who is not a British subject.

The expression "foreign corporation" means any corporation which is not incorporated in and under the laws of and has not its principal place of business in some part of the British Empire.

The expression "corporation under foreign control" means:—

(*a*) A corporation of which the majority of Directors or persons occupying the position of Directors, by whatever name called, are foreigners.

(*b*) A corporation members of which holding shares or stock conferring a majority of the votes are foreigners or foreign corporations or persons who hold such shares or stock directly or indirectly on behalf or under the control or directions of foreigners, a foreign State or foreign corporations.

(*c*) A corporation which is by any other means, whether of a like or of a different character, in fact under the control of foreigners, a foreign State or foreign corporations.

(*d*) A corporation whereof the executive is a corporation within (*a*), (*b*) or (*c*).

The expression "shares" shall include any securities which carry any power of voting with respect to the management of a company, and the expression "shareholder" shall have a corresponding meaning.

H. For the purposes of the foregoing provisions, service of a notice shall be deemed to be effected by sending by registered post a prepaid letter containing the notice and addressed to the Member at his registered address, and service shall be deemed to have been effected at the time at which the letter would have been delivered in the ordinary course of post.

7. No firm or other unincorporated association may as such become a member of the Association, but if any such firm or association should desire to obtain the advantages of membership it shall nominate one of its members to act as its representative, apply in its name for membership and sign the application as its representative and exercise the rights of membership on its behalf. Every person so applying for membership shall be subject to the same rules and regulations concerning elections and otherwise as any person not so nominated, and shall, if elected, have the same rights and be subject to the same liabilities and incidents as any person not so nominated, subject, however, to the provisions of Article 8. The firm or other unincorporated association shall deposit with the Council the nomination of such applicant for membership and shall give all information that may be reasonably required by the Council regarding such applicant.

8. A firm or other unincorporated association which has nominated as its representative one of its members as aforesaid may from time to time revoke the nomination of such member, and subject to the consent of the Council of the Association, nominate another representative in his place. Upon receipt by the Council of any such revocation such member shall *ipso facto* cease to act or be entitled or recognized as a representative of such firm or association, and any person nominated in his place shall, if duly approved by the Council, be and become the representative of such firm or association in the place of the representative whose nomination has been revoked as aforesaid.

9. All revocations and nominations mentioned in Articles 7 and 8 shall be in writing signed by all the members of the firm or other unincorporated association. Each such firm or other unincorporated association shall at the date of each nomination give to the Council in writing full particulars of the nature of the firm or association and its places of business, and of the names, nationality and private address of each partner or member thereof and all such further particulars as the Council shall require, and thereafter shall give such particulars when and as often as may be required by the Council. Any change in the constitution or nature of such firm or association or in the status of any of its members shall be immediately notified in writing to the Council, who if they do not approve such change shall be entitled (without prejudice to Article 16) to give notice in writing to the member representing such firm or association to terminate his membership and to withdraw from the association, and shall at the same time return a due proportion of such member's subscription having regard to the unexpired period for which it is paid, and thereupon such representative shall cease to act or be entitled or recognized as a member and such firm or other unincorporated association as aforesaid shall have no further right to nominate a member to act as its representative.

10. A corporation being a Member shall nominate a person to act as its representative subject to the approval of the Council, and for the purpose of such approval shall give all information that may be reasonably required by the Council. Such representative when so approved shall have the right on behalf of the corporation (and to the extent only to which the corporation would if a person be entitled to do so) to attend meetings of the Association and to vote thereat, and generally exercise all rights of membership on behalf of the corporation. A corporation may from time to time revoke the nomination of such representative, and (subject to the previous consent of the Council of the Association) nominate another representative in his place. All such nominations and revocations shall be in writing under the seal of the corporation. The Council may in its absolute discretion withdraw at any time

its approval of the nominee of a corporation and shall notify the corporation of such withdrawal, whereupon the corporation shall nominate another representative. Provided always that any director or secretary of a corporation which is a Member or any partner in a firm which shall have nominated a representative as hereinbefore provided may attend any meeting of the Association without any right of voting thereat, but the Members present at any meeting may exclude persons who are not Members from such meeting by a resolution passed by a majority of the Members present and entitled to vote and no special notice shall be required before the consideration of such resolution.

11. No person or corporation shall be admitted to Membership of the Association unless an application for membership shall have been signed by him or it or on his or its behalf setting out the particulars required by Article 6.

12. Subject and without prejudice to Article 6 the Council shall in all cases have absolute discretion in deciding whether any person or corporation shall or shall not be admitted to membership of the Association.

13. Any ordinary Member may withdraw from the Association by giving notice in writing duly signed to the Secretary at least six calendar months before the expiration of any financial year, and on paying with such notice any unpaid subscription for the current year, and also for each and any subsequent year which such Member shall have guaranteed to subscribe on election, and thereupon such Member shall be deemed to have ceased to be a Member from the date of the expiration of such financial year. In default of such notice being so given, an ordinary Member shall be liable to pay the subscription for the ensuing year and in cases where any undertaking or guarantee has been given for subscriptions or donations for any given number of years the Member shall continue to be liable thereunder.

14. Any Member other than an ordinary Member may withdraw from the Association by giving notice in writing to the Secretary at any time and paying with such notice any unpaid subscriptions that may be due, and also subscriptions for subsequent years and donations agreed upon or guaranteed by such Member on election (if any) and thereupon shall cease to be a Member.

15. Upon the retirement of any Member by notice as stated in Articles 13 and 14, the Member shall not be entitled under any conditions to any repayment of any subscription or any part thereof whether paid for the current year or for a year or years in advance.

16. Any Member may be moved from the Association by a resolution of the Council passed by a majority of at least three-fourths of the Members present and voting at a special Council meeting of which not less than twenty-one days' previous notice specifying the intention to propose such resolution shall have been sent to the Member whose removal is in question and to all the Members of the Council. Notice of the general nature of the grounds on which such resolution is proposed shall be sent to the Member whose removal is in question at least fourteen days before the meeting, and he shall be entitled to be heard by the Council at the meeting. On a Member being removed, the Council shall return the due proportion of such Member's current subscription having regard to the unexpired period for which it is paid. Provided that in the case of a Member who has been appointed by the Department to be a Member of the Council, the Council shall not take action under this Article without previous consultation with the Department.

17. The rights of any Member shall be personal and shall not be transferable and shall cease upon the Member failing to pay the annual subscription within three months of its becoming due, or in the case of a person on his becoming lunatic or of unsound mind or in any case on the Member ceasing to retain the qualifications on the ground of which the Member was admitted to membership. Nothing herein contained shall prejudice the rights of the Association to claim payment of the full

amount of the subscriptions which the Member shall have undertaken to pay or (subject to Article 6D) prevent the Member from again becoming eligible for membership.

18. Any Member of the Association who shall consider that his or its personal interests may be prejudicially affected by any research proposed to be undertaken by the Association may appeal to the Department against the particular work objected to and shall set forth in the appeal the grounds of the objection and shall at the same time forward a copy of the appeal respectively to the Secretary of the Association and the Director of Research or other responsible technical officer of the Association. The Department shall determine all questions raised on such appeal and its decision shall be final. Provided always that the Department may at any time give special permission or directions to the Director of Research through the Council to proceed with the research notwithstanding any appeal either during the time the appeal is pending or subsequently.

Duties of Members.

19. Every Member of the Association shall be bound:

(*a*) To pay to the Association such entrance fee (if any) and such annual subscription as shall from time to time be fixed by the Association in General Meeting.* Provided always that subscribers shall as a condition attached to membership agree in writing to continue to pay the said subscriptions whether Members or not and in a manner to bind their estates and assets for a period of years from the date of their election. Honorary and Delegate Members shall not be called upon to pay any subscriptions. All payments shall be made at the times in the manner and subject to the conditions set out in the By-laws of the Association in force at the date of such payments.

(*b*) To observe the provisions of these presents and of the Memorandum of Association and all the by-laws, rules and regulations of the Association for the time being in force.

(*c*) To pay and make good to the Association any loss or damage which the Association may sustain through any wilful act or default of such Member or any representative of such Member, but only if such act or default shall be a breach of any provisions of these presents or of the Memorandum of Association or of any by-law, rule or regulation of the Association.

Council of the Association.

20. The business of the Association shall be managed by a Council.

21. The Council shall consist of not more than and not less than Members, unless and until otherwise determined by the Association in General Meeting.

22. All Members of the Council shall save as herein otherwise provided be Ordinary Members of the Association elected by the Association. The Council may co-opt not more than Members of Council who need not be Members of the Association, and need not qualify for membership of the Council by subscription, donation or otherwise. Provided always that the number of such co-opted Members shall never be more than of the whole body of the Members of Council exclusive of those nominated and appointed by the Department.

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*NOTE.—The amount of the subscription may be entered here or in separate Articles under a fresh heading if need be. If desired a differentiated basis can be adopted, such as an assessment based on capital, output, wages paid, etc., as discussed in "Research Association No. 4," issued by the Department, with or without proportionate voting rights in accordance with such assessment, and with corresponding provisions for the ascertainment of the capital, output, etc., and other suitable clauses. The power to fix the subscription to be paid by Associate Members is given by this Article, but such subscription will usually be different from that assessed on Ordinary Members and will not be assessed for a period of years.

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23. The first Council shall consist of the following persons:—
The persons appointed Members of the Council by this Article and any person appointed under Article 30 to fill casual vacancies among them are for the purpose of these presents to be deemed to be elected Members of the Council.

24. The Association in General Meeting may appoint one President and such number of Vice-Presidents of the Association as they may deem advisable. Such President and Vice-Presidents shall be entitled to attend meetings of the Council and of the Association, but shall have no right to vote as such at any such meetings. The President and Vice-Presidents for the time being shall retire at each Ordinary General Meeting of the Association but shall be eligible for re-election. It shall not be necessary for any President or Vice-President to have any special qualification for office, either by way of subscription, donation or otherwise.

25. Subject to Articles 22, 23, and 26, Members of the Council shall be elected by the Association in General Meeting and shall retire as provided by Article 28.

26. The Department may, on the invitation of the Council, and if the Association is in receipt of a grant from the Department shall have the right to, nominate and appoint not more than persons (whether Members of the Association or not) as additional Members of the Council whatever the number of the Council may be, and may remove from time to time one or more of such additional Members and in that event or in the event of any casual vacancy among such additional members of the Council may appoint others in their place. Provided always that the Department shall not be bound to exercise the said right. All nominations, appointments and revocations under this Article shall be made in writing addressed to the Secretary of the Association and every Member of the Council so nominated and appointed shall continue to act as a Member of the Council until withdrawn by the Department.

27. Notwithstanding the provisions aforesaid a nominated Member shall cease to be a Member of the Council in any of the events mentioned in Article 29.

28. At the Annual General Meeting in the year 1919 and at the Annual General Meeting in each subsequent year one-third of the elected Members of the Council shall retire or if their number is not a multiple of three then the number nearest to one-third shall retire. The Members of Council to retire in every year shall be those who have been longest in office since their last election but as between persons who become Members of Council on the same day those to retire shall (unless they otherwise agree amongst themselves) be determined by lot. All elected Members so retiring shall be deemed to be eligible for re-election.

29. The office of a Member of the Council shall *ipso facto* be vacated:—
(*a*) If he becomes bankrupt or suspends payment or compounds with his creditors.
(*b*) If he is found lunatic or becomes of unsound mind.
(*c*) If by notice in writing to the Council he resigns his office.

30. Subject as aforesaid the Council shall be entitled to appoint a person as a Member of the Council to fill a casual vacancy, howsoever caused. The person so appointed shall hold office until the Annual General Meeting next after his appointment, but he shall then be eligible for re-election.

31. No act or resolution of the Council shall be invalidated by reason of the existence of any vacancy or vacancies among Members of the Council, but if the number of the Members of the Council shall be reduced to less than the continuing Members may act for the purpose only of filling vacancies in the elected Members or summoning a General Meeting of the Association.

Powers of the Council of the Association.

32. The Council shall have sole control in regard to all matters relating to the management and organization of the Association. In addition to the powers and

authorities by these presents or otherwise expressly conferred upon them, they may exercise all such powers and do all such acts and things as may be exercised or done by the Association and are not hereby or by statute expressly directed or required to be exercised or done by the Association in General Meeting, but subject nevertheless to the provisions of any Acts of Parliament for the time being in force and of these presents.

33. Without prejudice to the general powers conferred by the last preceding clause and the other powers conferred by these presents, it is hereby expressly declared that the Council shall have the following powers, that is to say:—

(*a*) To make and impose, vary and repeal by-laws, rules and regulations for the administration and government of the Association and for carrying its objects into effect. Provided always that the same shall not in any way affect, vary or alter the provisions contained in these Articles of Association.

(*b*) To agree and pay the costs, charges and expenses preliminary and incidental to the promotion, formation, establishment and registration of the Association and the preparation, adoption and registration of the Association's Memorandum of Association and of these presents.

(*c*) To pay all expenses incurred in carrying out the objects of the Association.

(*d*) To purchase or otherwise acquire for the Association any property, rights or privileges which the Association is authorized to acquire at such price, and generally on such terms and conditions as they think fit.

(*e*) To secure the fulfilment of any contracts or engagements entered into by the Association by mortgage or charge of all or any of the property of the Association, or in such manner as they may think fit.

(*f*) To take offices or acquire premises for the use of the Association, and to appoint and at their discretion remove or suspend such managers, secretaries, officers, clerks, agents and servants, whether engaged for permanent, temporary or special services, and to determine their powers and duties and fix their salaries or emoluments and to require security in such instances and to such amount as they think fit.

(*g*) To engage professional or other assistance in connection with the business of the Association and subject to the provisions of the Memorandum of Association to pay reasonable fees or remuneration for the same as they may think fit.

(*h*) To appoint any person or persons whether incorporated or not to act as trustee or trustees to accept and hold in trust for the Association any property belonging to the Association or in which it is interested, or for any other purposes, and to execute and do all such deeds and things as may be requisite in relation to any such trust and to provide for the remuneration of such trustee or trustees.

(*i*) To institute, conduct, defend, compound or abandon any legal proceedings by or against the Association or its officers, or otherwise concerning the affairs of the Association and also to compound and allow time for payment or satisfaction of any debts due and of any claims or demands by or against the Association.

(*j*) To refer any claims or demands by or against the Association to arbitration and observe and perform the awards.

(*k*) To make and give receipts, releases and other discharges for money payable to the Association and for the claims and demands of the Association.

(*l*) To affix the seal of the Association to all deeds and documents requiring the same.

(*m*) To determine who shall be entitled to sign on the Association's behalf bills, notes, receipts, acceptances, endorsements, cheques, releases, contracts and other documents.

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(*n*) To invest and deal with any of the moneys of the Association not immediately required for the purposes thereof, upon such securities for the time being authorized by law for the investment of trust funds and in such manner as they may think fit, and from time to time to vary or realize such investments, subject nevertheless to the provisions contained in the Memorandum of Association.

(*o*) To enter into all such negotiations and contracts and rescind and vary all such contracts and execute and do all such acts, deeds and things in the name and on behalf of the Association as they may consider expedient for or in relation to any of the matters aforesaid or otherwise for the purposes of the Association.

(*p*) To delegate any of their powers (other than their powers under Article 16 hereof) to Committees consisting of two or more Members of their body and to make and impose upon such Committees such rules and regulations and to vary the same from time to time as they shall think fit.

(*q*) To set up, constitute and organize local branches of the Association, consisting of Members of the Association in such places as they may think fit, and to appoint, or authorize the Members of such local branches to appoint persons as additional members of any local branch and Councils consisting of Members of the Association to control and manage such local branches and to define the powers and duties of such local branches and Councils, and to make and impose by-laws, rules and regulations for the administration and government of such local branches and of such Councils and to delegate any of their powers to such local branches and to such Councils as they may deem fit.

(*r*) To apply for, or oppose the application by others for patents, concessions, rights, charters and legislative acts and authorizations from any government or authority.

(*s*) To appoint at any time and from time to time by power of attorney under the seal of the Association any persons to be the attorneys of the Association for such purposes, with such powers, and for such period and subject to such conditions as the Council may from time to time think fit, but so that the Council shall not be at liberty to delegate to any such attorneys any of the discretions vested in the Council by these presents. Any such appointment may (if the Council think fit) be made in favour of the Members or any of the Members of any local branch established as aforesaid or in favour of any company or of the members, directors, nominees, or managers of any company or firm, and any such power of attorney may contain such provisions for the protection or convenience of persons dealing with such attorneys as the Council think fit, and may authorize any such delegates or attorneys as aforesaid to sub-delegate all or any of the powers, for the time being vested in them.

(*t*) To exercise the powers conferred by Section 79 of the Companies (Consolidation) Act, 1908, and such powers shall accordingly be vested in the Council. And the Association may cause to be kept in any part of the British Empire in which it transacts business a branch register of Members resident in such part of the Empire; and the Council may from time to time make such provisions as they may think fit respecting the keeping of any such branch register.

(*u*) To make provision for compliance with any regulations which may be attached by the Department to the payment of grant.

Proceedings of the Council.

34. The Council may meet together for the dispatch of business, adjourn and otherwise regulate their meetings and proceedings as they think fit, and may determine the quorum necessary for the transaction of business. Until the Council otherwise determine, five Members of the Council shall be a quorum.

35. The Council may elect a Chairman of their meetings and determine the period for which he is to hold office, but if no such Chairman is elected, or if he should not be present at the commencement of any meeting of the Council, the Members of the Council shall select a Chairman from those present for that meeting.

36. The Council may at any time, and the Secretary upon the request of three Members of the Council shall, convene a meeting of the Council. In the case of a meeting convened at the request of three Members the notice of meeting shall state the character of the business to be discussed, and only business of which notice shall be so given shall be discussed at that meeting. Each Member of the Council shall name an address in the United Kingdom at which all notices shall be served upon him, and all notices served at such address shall be deemed to be well served. Questions arising at any meeting of the Council shall be decided by a resolution of the majority of Members present at such meeting. In the event of the votes being equally divided the Chairman shall have a casting vote in addition to the vote to which he is entitled as a Member of the Council.

37. A meeting of the Council for the time being at which a quorum is present shall be competent to exercise all or any of the authorities, powers and discretions by or under the Articles of Association for the time being vested in or exerciseable by the Council generally.

38. The meetings and proceedings of any committee appointed by the Council under Article 33 (*p*) shall be governed by the provisions herein contained for regulating the meetings and proceedings of the Council, so far as the same are applicable thereto, and are not superseded by any regulations made by the Council under Article 33 (*p*).

39. All acts done by any meeting of the Council or by a Committee of the Council or by any person acting as a Member of the Council shall notwithstanding that it shall be afterwards discovered that there was some defect in the appointment of the Council, or such Committee or person acting as aforesaid, or that they or any of them were disqualified, be as valid as if every such person had been duly appointed and was qualified to be a Member of the Council.

Minutes.

40. The Council shall cause minutes to be duly entered in books provided for the purpose:—

(*a*) Of all appointments of officers;
(*b*) Of the names of the Members of the Council present at each meeting of the Council, and of any Committee of the Council;
(*c*) Of all orders made by the Council and Committees of the Council;
(*d*) Of all resolutions and proceedings of General Meetings and of meetings of the Council and Committees.

41. Any such minutes of any meeting of the Council or of the Committee, or of the Association, if purporting to be signed by the Chairman of such meeting, or by the Chairman of the next succeeding meeting, shall be receivable as *prima facie* evidence of the matters stated in such minutes.

Research.

42. There shall be at all times a Director of Research or other responsible technical officer who shall be appointed by the Council and entrusted with the general direction and supervision of the research work undertaken by the Association.

43. No Member of the Association shall be entitled to require discovery of or any information respecting any such research work, or make use of any such information except in strict accordance with the rules and regulations made by the Council of the Association.

44. Every Member of the Council, Director of Research, officer, or other responsible person employed in the business of the Association shall, before entering upon his duties, sign an undertaking to observe a strict secrecy respecting the progress and results of all researches of which he shall obtain knowledge in exercise of his duties or while occupying such office or in the course of such employment as aforesaid, and not to use or otherwise take advantage in his private capacity of special knowledge so obtained, or put into operation any invention or process of which he shall have obtained knowledge as aforesaid, except, as regards a Member of the Association, to the extent to which, and as and when he shall be entitled so to do in common with other Members of the Association in strict accordance with the rules and regulations made by the Council as provided by these Articles.

45. Nothing in Articles 43 and 44 shall prevent discussion, disclosure or publication as between Members of the Council and of the Association or its officers relating to researches undertaken or proposed to be undertaken by the Association or prevent the use of any information obtained by any Member of the Council or of the Association in the ordinary course of his own business or the continued user of any process already employed in such business though research may subsequently bring such process to the knowledge of the Association subject to any rules and regulations which may be from time to time made by the Council with regard thereto.

46. Every employee of the Association engaged on research or other scientific work shall contract in writing that he will in consideration of his employment hold exclusively for the benefit of and assign to the Association [and the Department or their nominees]* at the cost of the Association all rights and ownership in any discoveries, inventions, designs or other results arising in the course of such employment upon such research or other scientific work.

47. The Director of Research shall not, where a Member of the Association has appealed to the Department under Article 18 proceed with the research referred to in the appeal until the special permission or directions of the Department provided for in Article 18 have been received.

Seal.

48. The Council shall provide for the safe custody of the seal, and the seal shall never be used except by the authority of the Council or a Committee thereof previously given, and in the presence of two Members of the Council at the least, who shall sign every instrument to which the seal is affixed, and every such instrument shall be countersigned by the Secretary or some other person appointed by the Council.

General Meetings.

49. The first General Meeting of the Association shall be held at such time within not less than one month nor more than three months after the incorporation of the Association and at such place as the Council shall determine. Subsequent General Meetings shall be held once in every year at such time (not being more than fifteen months after the last preceding meeting) and place as may be prescribed by the Association in General Meeting, and if no other time or place is prescribed at such time and place as may be determined by the Council.

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* NOTE.— The words within brackets will only be added when the Department is making to the Association a grant calculated at a rate higher than pound per pound of the contributions made by the Members of the Association.

50. The General Meetings referred to in the last preceding clause shall be called Ordinary Meetings. All other meetings of the Association shall be called Extraordinary Meetings.

51. The Council may, whenever they think fit, and they shall, on the requisition of not less than Ordinary Members of the Association, forthwith proceed to convene an Extraordinary General Meeting of the Association, and in the case of such requisition the following provisions shall have effect:—

(1) The requisition must state the objects of the meeting and must be signed by the requisitionists and deposited at the office, and may consist of several documents in like form each signed by one or more requisitionists.
(2) If the Council do not proceed to cause a meeting to be held within 21 days from the date of the requisition being so deposited, the requisitionists or a majority of them may themselves convene the meeting, but any meeting so convened shall not be held after three months from the date of the deposit.
(3) If at any such meeting a resolution requiring confirmation at another meeting is passed, the Council shall forthwith convene a further Extraordinary General Meeting for the purpose of considering the resolution; and, if thought fit, of confirming it as a special resolution; and if the Council do not convene the meeting within seven days from the date of the passing of the first resolution, the requisitionists, or a majority of them, may themselves convene the meeting.
(4) Any meeting convened under this clause by the requisitionists shall be convened in the same manner as nearly as possible as that in which the meetings are to be convened by the Council.

52. Seven days' notice to the Members, exclusive of the day when the notice is served or deemed to be served, but inclusive of the day for which notice is given. specifying the place, day and hour of meeting, and in case of special business the general nature of such business shall be given and the notice sent by post or otherwise served as hereinafter provided.

53. Where it is proposed to pass a special resolution the two meetings may be convened by one and the same notice, and it is to be no objection to such notice that it only convenes the second meeting contingently on the resolution being passed by the requisite majority at the first meeting.

54. The accidental omission to give any such notice to or the non-receipt of any such notice by any of the Members shall not invalidate any resolution passed at any such meeting.

Proceedings at General Meetings.

55. The business of an Ordinary Meeting shall be:—

(*a*) To receive and consider the accounts, the balance sheet and the reports of the Council and the Auditors.
(*b*) To elect Members of the Council and other officers in the place of those retiring by rotation.
(*c*) To appoint an Auditor or Auditors and fix his or their remuneration.
(*d*) To transact any other business which under these presents ought to be transacted at an Ordinary Meeting.

All other business transacted at an Ordinary Meeting and all business transacted at an Extraordinary Meeting shall be deemed special. If any Member has any proposal or any matter which he wishes to make or bring before an Ordinary Meeting he shall give 14 days' written notice thereof to the Secretary.

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56. Every meeting of the Association shall be presided over by the Chairman of the Council, and in his absence the meeting shall elect a Chairman from the Members of the Council then present or if none be present from the Members of the Association.

57. For all purposes the quorum of a General Meeting shall be five Ordinary Members personally present.

58. No business shall be transacted at any General Meeting unless the quorum requisite shall be present at the commencement of the business.

59. If within half an hour from the time appointed for the meeting a quorum is not present, the meeting if convened upon such requisition as aforesaid, shall be dissolved, but in any other case it shall stand adjourned to the same day in the next week at the same time and place, and if at such adjourned meeting a quorum is not present, those Ordinary Members who are present shall be a quorum and may transact the business for which the meeting was called.

60. Every question submitted to a meeting shall be decided in the first instance by a show of hands, and in the case of an equality of votes the Chairman shall both on a show of hands and at a poll have a casting vote in addition to the vote to which he may be entitled as an Ordinary Member. Every Ordinary Member shall have one vote and no more, and no other Member shall be entitled to vote. The person nominated by a corporation under the provisions of Article 10 shall alone be entitled to vote for the corporation on a show of hands.

61. No Ordinary Member shall be entitled to vote if his subscription is in arrear for the space of one month.

62. At any General Meeting, unless a poll is demanded by the Chairman or by five Members entitled to vote, a declaration by the Chairman that a resolution has been carried or carried by a particular majority or lost, or not carried by a particular majority, and an entry to that effect in the book of proceedings of the Association shall be conclusive evidence of the fact without proof of the number or proportion of the votes recorded in favour of or against such resolution.

63. If a poll is demanded as aforesaid, it shall be taken in such manner and at such time within fourteen days and at such place as the Chairman of the meeting directs, and either at once or after an interval or adjournment or otherwise, and the result of the poll shall be deemed to be the resolution of the meeting at which the poll was demanded. The demand for a poll may be withdrawn.

64. On a poll votes may be given either personally or by proxy. A proxy shall be appointed in writing under the hand of the appointor, or of his attorney, or, if such appointor is a corporation, under the signature of a Director. Any instrument appointing a proxy may be printed, or in writing, or partly printed and partly in writing, and duly stamped, and shall be as nearly as may be in the following form:—

THE BRITISH RESEARCH ASSOCIATION

I of being a Member of the above Association hereby appoint of whom failing of , as my proxy to vote for me and on my behalf at the Ordinary or Extraordinary General Meeting of the Association to be held on the day of General Meeting of the Association to be held on the day of 19 , and at any adjournment thereof.

Signed by the said this day of 19 , in the presence of

65. No person shall act as proxy unless he is an Ordinary Member of the Association, or unless he is appointed to act at the meeting for a corporation, and the instrument appointing him shall be deposited at the office not less than twenty-four hours before the time of holding the meeting at which he proposes to vote.

66. The Chairman of a General Meeting may with the consent of the meeting adjourn the same from time to time and from place to place, but no business shall be transacted at any adjourned meeting other than the business left unfinished at the meeting from which the adjournment took place.

67. Any poll demanded on the election of a Chairman of a meeting or on any question of adjournment shall be taken at the meeting and without adjournment.

68. The demand for a poll shall not prevent the continuance of a meeting for the transaction of any business other than the question on which a poll has been demanded.

69. The Council shall cause true accounts to be kept of the sums of money received and expended by the Association, and the matters in respect of which such receipts and expenditure take place, and of the assets, credits and liabilities of the Association.

70. The books of account shall be kept at the office or at such other place or places as the Council think fit.

71. The Council may from time to time determine at what times and places, and under what conditions or regulations, the accounts and books of the Association or any of them shall be open to the inspection of the Members.

72. At the Annual General Meeting in every year the Council shall lay before the Association a statement of account showing the receipts and expenditure of the Association for the period since the preceding account (or in the case of the first account since the incorporation of the Association) made up to a date not more than six months before such meeting.

73. A balance sheet shall be made out and laid before the Association at the Annual General Meeting in every year, made up to a date not more than six months before such meeting. The balance sheet shall be accompanied by a report of the Council upon the general state of the Association.

74. A printed copy of the accounts, balance sheet, and report shall ten clear days previously to such meeting, be served on every member of the Association entitled to receive notices of General Meetings in the manner in which notices are hereinafter directed to be served, and a copy shall also be sent to the Department.

Audit.

75. Once at least in every year the accounts of the Association shall be examined and the correctness of the balance sheet ascertained by one or more properly qualified Auditor or Auditors.

76. The Association at each Ordinary General Meeting shall appoint Auditors to hold office until the next Ordinary General Meeting, and the following provisions shall have effect, that is to say:—

(1) If an appointment of Auditors is not made at an Ordinary General Meeting the Board of Trade may on the application of any Member of the Association appoint Auditors for the current year and fix the remuneration to be paid to them by the Association for their services.

(2) A Member of the Council or officer of the Association shall not be capable of being appointed Auditor of the Association.

(3) The Members of the Council may fill any casual vacancy in the office of Auditor, but while any such vacancy continues the surviving or continuing Auditor or Auditors (if any) may act.

77. The remuneration of the Auditors shall be fixed by the Association in General Meeting.

78. (1) Every Auditor of the Association shall have a right of access at all times to the books and accounts, and vouchers of the Association, and shall be entitled to require from the Members of the Council and officers of the Association such information and explanation as may be necessary for the performance of the duties of the Auditors.

(2) The Auditors shall make a report to the Members on every balance sheet laid before the Association in General Meeting during their tenure of office and the report shall state:—

(*a*) Whether or not they have obtained all the information and explanations they have required; and

(*b*) Whether in their opinion the balance sheet referred to in the report is properly drawn up so as to exhibit a true and correct view of the state of the Association's affairs according to the best of their information and explanations given to them and as shewn by the books of the Association.

79. The balance sheet shall be signed on behalf of the Council by two Members of the Council of the Association, and the Auditor's report shall be attached to the balance sheet or there shall be inserted at the foot of the balance sheet a reference to the report, and the report shall be read before the Association in General Meeting, and shall be open to inspection by any Member.

80. Every account of the Council, when audited and approved by a General Meeting, shall be conclusive except as regards any error discovered therein within six months next after the approval thereof. Whenever any such error is discovered within that period, the account shall forthwith be corrected and thenceforth shall be conclusive.

Notices.

81. A notice may be served by the Association upon any Member either personally or by sending it through the post in a prepaid envelope or wrapper addressed to such Member at his registered place of address.

82. Each Member shall from time to time notify in writing to the Association an address in the United Kingdom which shall be deemed his registered place of address within the meaning of the last preceding clause. If he shall not have named such an address he shall not be entitled to any notices.

83. Any notice required to be given by the Association to the Members or any of them and not expressly provided for by these presents shall be sufficiently given, if given by advertisement in one London morning newspaper.

84. Any notice required to be, or which may be given by advertisement shall be advertised once in one London newspaper.

85. Any notice sent by post shall be deemed to have been served on the day following that on which the envelope or wrapper containing the same is posted, and in proving such service it shall be sufficient to prove that the envelope or wrapper containing the notice was properly addressed and posted. A certificate in writing signed by any Manager, Secretary or other officer of the Association that the envelope or wrapper containing the notice was so addressed and posted, shall be sufficient evidence thereof.

86. The signature to any notice to be given by the Association may be written or printed.

87. Every notice or application to the Council or the Secretary or the Association, except where otherwise specifically provided, shall be sufficient if the same be signed by the person or persons giving or making the same, and be given to the Secretary or be left at the office addressed to him between the hours of ten in the forenoon and four in the afternoon of any working day, excepting Saturday, or be forwarded to him at

such office by post prepaid, and every person giving or making such notice or application shall be entitled to require an acknowledgment by the Secretary of the receipt of such notice or application.

Indemnity.

88. Every Member of the Council, Manager, Secretary and other officer or servant of the Association shall be indemnified by the Association against, and it shall be the duty of the Members of the Council, out of the funds of thee Association, to pay all costs, losses and expenses, including travelling expenses, which any such officer or servant may incur or become liable to by reason of any contract entered into or act or thing done by him as such officer or servant or in any way in the dischärge of his duties.

89. No Member of the Council or other officer of the Association shall be liable for the acts, receipts, neglects or defaults of any other Member or officer, or for joining in any receipt or other act of conformity, or for any loss or expenses happening to the Association through the insufficiency or deficiency of title to any property acquired by order of the Council for or on behalf of the Association or of the insufficiency or deficiency of any security in or upon which any of the moneys of the Association shall be invested or for any loss or damage arising from the bankruptcy, insolvency, or tortious act of any person with whom any moneys, securities or effects shall be deposited, or for any loss occasioned by any error of judgment or oversight, omission or default on his part or for any other loss, damage or misfortune whatever which shall happen in the execution of the duties of his office or in relation thereto unless the same happen through his own dishonesty.

Arbitration.

90. Subject to the provisions of Article 18, if and whenever any difference shall arise between the Association and any of the Members or their respective representatives touching the construction of any of the Articles herein contained, or any act, matter, or thing made or done or to be made or done or omitted or in regard to the rights and liabilities arising hereunder or arising out of the relation existing between the parties by reason of these presents or of the Statutes or any of them, such difference shall be forthwith referred to two Arbitrators—one to be appointed by each party in difference—or to an Umpire to be chosen by the Arbitrators before entering on the consideration of the matters referred to them, and every such reference shall be conducted in accordance with the provisions of the Arbitration Act, 1889.

Names, Addresses and Description of Subscribers—

DATED the day of 1918

Research Association Circular 3. (Revised.)

CONDITIONS AS TO THE PAYMENT TO RESEARCH ASSOCIATIONS BY THE COMMITTEE OF COUNCIL.

Draft Letter.

THE SECRETARY TO THE BRITISH RESEARCH ASSOCIATION.

SIR,—I am directed by the Committee of the Privy Council for Scientific and Industrial Research to address you on the subject of the grant which they are prepared to make to the British Research Association for the promotion of research in connection with the Industry.

The conditions attached to the grant to be made by the Committee of Council are set out below. They are based upon the assumption that the Association will raise from its members in each year of the period for which the grant is made, a sum of not less than and not more than . Should the Association raise additional sums, the Committee of Council will be prepared to consider the question of paying to the Association such further sums as may be hereafter agreed between the Committee of Council and the Council of the Association. Should, however, the sum received by the Association in respect of any one or more years of the period be less than , the Committee of Council reserves to itself full discretion to reduce the total amount of the grant to be paid to the Association under the conditions specified in this letter and also to modify those conditions, provided that the Association will not be held liable to refund on this account any payment which may have actually been made to it out of the grant.

So far as the conduct of the affairs of the Association is concerned, it is the intention of Government that this shall be in the hands of the Association itself, subject to the Statutory and other duties imposed upon the Association by the conditions and by the Memorandum and Articles of Association.

The conditions to be attached to the grant are as follows:—

(1) There shall be payable a sum of in respect of a period of five years dating from provided that the Association raises a sum of at least in respect of and in each year of the period in question. The proportion of the said which will be payable in respect of any one year of the above-mentioned period shall not exceed one-fifth of that sum unless otherwise determined by the Committee of Council after consultation with the Council of the Association. This sum will be paid to the Association in equal quarterly instalments as soon as possible after the 30th June, the 30th September, the 31st December and 31st March in the year in question.

(2) A further sum of for each additional pound over and above the sum of raised in respect of any one year of the period will be payable provided that the additional payment so made in respect of that year shall not exceed . This further sum, if any, will be paid to the Association as soon as possible after the close of the year upon the receipt of a statement duly certified by the authorized Officer of the Association and showing the amounts actually received by the Association in respect of that year.

(3) The general scheme of research for each year will be submitted in advance to the Committee of Council, together with an estimate of the expenditure to be incurred thereon during the year.

(4) If any research is undertaken for the benefit of an individual firm or for a group of firms, the Association will enter into an agreement with the firm or firms concerned, in a form to be approved by the Committee of Council.

(5) Any expenditure by the Association on buildings or permanent equipment beyond a sum of in any single year must be approved by the Committee of Council before it is incurred. Plans and estimates, as well as copies of the tenders submitted, will be referred to the Committee of Council for approval in advance.

(6) The Committee of Council shall have access to any laboratories, workshops, or other premises owned, leased, or loaned to, or controlled by the Association, and have power to inspect the work in progress therein and all documents or records connected therewith.

(7) All rights and ownerships in any discoveries and inventions arising from the work of the Association shall be the property of the Association and shall be held by the Association for the benefit of members, always provided that the Department, acting in the national interest may,

(*a*) after consultation with the Council of the Association secure that the results of investigations shall be communicated to other industries on such terms of payment and such other conditions as the Department, after consultation with the Council of the Association concerned, and with other co-operating bodies and persons, deem fair and reasonable.

(*b*) prohibit the communication of any results to any foreign person or body or to any person or body under foreign control as defined in the Model Articles of Association (*see* "Research Association 2.")

In order that the Department may determine whether any action is required by the national interest the Council of the Association shall make arrangements by which the results of investigation as obtained from time to time shall not become available until after communication to the Department.

(8) The Association shall enter into an agreement in writing with each employee engaged on research or other scientific work that he will in consideration of his employment hold exclusively for the benefit of and assign to the Association (and the Committee of Council or their nominees,*) at the cost of the Association, all rights and ownership in any discoveries, inventions, designs or other results arising in the course of such employment upon such research or other scientific work.

(9) The Association will keep accounts in such form as the Committee of Council may direct, and the accounts will be open to inspection by the Committee of Council.

(10) The Association will submit to the Committee of Council an annual report of its proceedings and of the progress of all research and scientific work being undertaken by or on behalf of the Association, together with copies of duly audited acccounts.

(11) Payment of the grant shall be conditional upon the due performance of the Association of these conditions and upon the due prosecution of research. In the event of any default the Committee of Council may, in their discretion, reduce or withhold the grant.

I am, sir, your most obedient servant,

Research Association Circular 4.

THE METHOD OF SUBSCRIPTIONS TO RESEARCH ASSOCIATIONS.

1. *The Basis of Subscriptions.*

In the leaflet describing the Government scheme for industrial Research (Research Association I.) it is stated that "the method of assessing the subscription of each firm will have to be negotiated with each Industry or section of an Industry which agree to combine for the purposes of research, but the intention is that firms should contribute on a basis proportionate to their size. Thus the small firm will contribute less than the large firm, yet it will have the same privileges, though as a rule it will not in the nature of the case have the same facilities for exploiting the results of research."

It is certain that most British industries are conducted on so large a scale that if a majority of the firms engaged in each of them join the appropriate Research

*NOTE.—The words within brackets will only be added in those exceptional cases in which the Department is making to an Association a grant calculated at a rate higher than pound for pound of the Contribution made by the Members of the Association.

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Association and contribute in proportion to their size, the burden on any single firm will in many cases be comparatively small—less, indeed, than the premiums for Fire, Employers' Liability or National Health Insurance.

For this reason, it will normally be sufficient if a Research Association levies subscriptions on such a basis that a near approximation to the correct amount is raised from each firm. There is no need, even if it were possible, to make careful calculations in order to ensure that the burden is distributed quite equitably and in exact proportion to the size of each of the contributing firms.

It may be noted that experience has shown that, in some cases in which the industry is not a very large one or the initial expenditure on research is not expected to be on any considerable scale, it has been found sufficient to arrange for the levy of uniform subscriptions from the firms or individuals joining the association. Such cases are, however, somewhat exceptional, and the following paragraphs deal with the more numerous associations for which proportionate subscriptions are likely to prove more suitable.

2. *Estimation of the Size of Businesses.*

As soon as an attempt is made to determine the relative sizes of the firms constituting a Research Association, the difficulty arises that it is necessary to select a standard by which the size of each can be measured. A number of different standards suggest themselves:—

(*a*) The total capital employed.
(*b*) The average annual profits over a definite period.
(*c*) The annual wage bill.
(*d*) The number of persons employed.
(*e*) The volume of the output.
(*f*) The value of the output.
(*g*) The amount of plant.

3. *Homogeneous Firms.*

If all the firms in the Association carry on businesses of similar character, there will be little difficulty in selecting the most suitable basis of subscription. Almost any one of the standards mentioned above, except (*b*), may be chosen, the particular one adopted depending on the nature of the business. If a Federation of Employers exists in the industry, it will be most convenient to adopt the basis they employ for the assessment of their ordinary subscriptions.

4. *Businesses differing in Character.*

It will very often happen that a Research Association will include firms carrying on businesses differing considerably from one another, but having very closely related interests. Thus, an Iron and Steel Association might include makers of Bessemer Steel and puddled iron; a Pottery Association would probably include makers of china, of earthenware and of sanitary ware; a Cotton Association would include cotton growers, spinners, manufacturers of cloth, of lace and of hosiery, dyers, bleachers and calico printers; and a Wool Association or a Non-ferrous Metals Association would be no less complex in structure.

It is evident that the method of deciding the basis of assessment must often be a difficult matter, since it is unlikely that any single standard can be employed for determining the relative sizes of diverse branches of a single great industry. The difficulty is increased by the fact that in some idustries there are Federations of Employers, each of which has selected a basis of assessment for its own purposes which is not universally suitable for all the industries co-operating with it in the Research Association.

To take an example, the Federation of Master Cotton Spinners' Associations bases its ordinary levy on the number of spindles owned by each of its constituent firms, the Federation of Calico Printers bases its subscription on the number of machines in each business, and the Federation of Dyers takes as its basis of subscription the annual Wage Bill. All these varying standards must, however, be reconciled so as to provide a convenient and reasonably equitable basis of subscription in the Cotton Research Association which includes all of them .

5. *Conditions Which Standards Must Fclfil.*

The standards selected for measuring the size of businesses in order to determine the basis of subscription must be:—

(*a*) easily accessible,

(*b*) fairly constant,

(*c*) readily comparable,

not only as between businesses of exactly the same kind, but also between dissimilar but closely linked businesses.

6. *Consideration of Each Standard.*

(*a*) CAPITAL.—(i) At once the difficulty appears of defining exactly what is meant by the capital of a firm. Does it include preference shares, debentures, bank overdrafts and loans repayable at short notice? The reply to this appears to be that it should include all the capital normally employed in the business, that is to say, ordinary and preference shares, debentures and loans of a semi-permanent character, the amount of these last being determined by calculating the average indebtedness as disclosed by the balance sheets of, say, the three years preceding the assessment.

(ii) It is advisable that all the firms in the Association should be divided for purposes of assessment into a small number of groups, each of which has within certain rather wide limits about the same capital. Thus all firms with a capital of £20,000 or less might form a single group, those with from £20,000 to £40,000 capital another group, and so on.

As the size of the firms increased, the range of capital in a single group would become greater and greater, until in the case of the very large firms, or combinations of firms, those whose capital did not differ by more than £500,000 or £1,000,000 might be included in the same group.

Such a plan as this has, of course, no claims to be exact, but it has the advantages that it is simple and convenient; further, it does not lead to inquisitorial inquiries from the Association. The responsibility for the statement of the capital of any firm should rest on the firm's own accountant, although the Association would necessarily reserve the right of employing its own accountant to check the statement in case of a serious dispute; it is improbable, however, that the need for such a check would ever arise.

(iii) Once the capital of each firm in the Association has been ascertained, no further difficulties arise, since the other conditions that it is fairly constant and readily comparable as between one firm and another are satisfied.

(*b*) ANNUAL PROFITS.—This standard is quite impracticable, as it fails to satisfy the conditions that the basis shall be easily accessible and fairly constant.

(*c*) ANNUAL WAGE BILL.—At first sight this method is attractive, since there are usually no strong reasons for concealing the total amount of wages paid, and the amount is fairly constant. It would not, however, afford a definite guide to the size of each firm engaged in different branches of the same great industry where those branches are dissimilar.

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Thus, a firm engaged in making very cheap woollen cloth may pay the same total amount of wages as one making the most expensive cloth, but the total capital involved would probably be much less. Again, a cotton weaving mill with a capital of £25,000 would probably have at least as large an annual wage bill as a cotton spinning mill with several times its capital.

(*d*) NUMBER OF PERSONS EMPLOYED.—There are precisely the same objections to taking this as the basis of assessment in certain cases as there are to adopting the annual wage bill, since the two are so closely related. There is, further, the difficulty that the proportion of men and women, and of adults and young persons, vary in different branches of the same industry.

(*e*) and (*f*) OUTPUT.—This basis might be adopted in some cases as in coal mining, but difficulties would arise where exact statistics of output are not kept. There would also be cases in which some firms might prefer not to disclose particulars relating to the value or volume of their output.

(*g*) THE AMOUNT OF PLANT.—Although this standard may be excellent for businesses of the same character, it is impracticable in cases where the separate businesses are of different kinds. For example, the number of spindles in a spinning mill cannot be compared with the vats, dyeing-machines, etc., in a dyeworks.

7. *Capital often the Most Suitable Standard.*

A consideration of all the different standards which have been mentioned suggests, therefore, that the most practical method of raising funds for a Research Association is , in many cases, to base the subscription of each firm on the amount of capital it employs in its business. There are objections to this, some of which have been dealt with above, but no other factor complies so fully with the necessary conditions where dissimilar branches of the same industry are concerned.

8. *The Compounding of Subscriptions by Federations of Employers.*

Serious difficulties arise in fixing suitable bases of assessment when Federations of Employers engaged in different branches of an industry join the same Research Association and agree to compound their subscriptions. These difficulties must, however, be faced, as the compounding of the subscriptions of members of an Employers' Association leads to simplicity of administration, to equitable assessments for firms engaged in similar businesses, and to economy of effort in the task of securing general co-operation.

Whether a Federation has adopted the amount of plant, wages, output or any other comparable quantity as a basis for the assessment of the ordinary subscriptions of its members, the proper course for the Research Association appears to be to accept the method employed by the Federation and to try to bring it into terms of capital. Thus, if the number of spindles or looms is the basis, calculations must be made as to the approximate capital represented by a spindle or a loom in a mill and the assessment based on that; if the wage bill is the basis, then a relation between the wage bill and the capital of several typical concerns must be determined. In any case it is essential that the Employers' Federation, when such exists, shall in each case be taken fully into consultation, in order that its members may have the opportunity of learning that the levy made upon them is equitable.

OTTAWA, February 20, 1922.

The Hon. J. A. ROBB,

Chairman of the Sub-Committee of the Privy Council for Scientific and Industrial Research, Ottawa, Ont.

SIR,—I have the honour of presenting to you herewith the report on the work of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1921.

This report has been prepared by Dr. A. B. Macallum, F.R.S., who served as Administrative Chairman for a portion of that year.

Your obedient servant,

R. A. ROSS,

Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research.

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1920-21
submitted Jan 22

REPORT

OF THE

ADMINISTRATIVE CHAIRMAN

OF THE

HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

I. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL

1. *Meetings of the Council—General Observations.*—There were nine meetings of the Council and all, with one exception, were held in Ottawa. Each of these involved a session of two days and the attendance of the members averaged seven, a high number in view of the long distances that several of the members had to travel in order to be present. As in each of the three preceding years the members through committees devoted a considerable amount of time between the meetings to the work of such committees, and this service facilitated very greatly the work of the Council in its sessions.

The members of the Council serve in a purely honorary capacity, receiving no remuneration for the work they do. The time which they have given to attendance at the meetings, including also that spent in going to and returning from Ottawa, amounted in the case of the majority of the members to nearly a month, in some considerably more than that, all taken from the time which, otherwise, would have been given to the pursuit of their own professional callings. This sacrifice has been prompted by the hope, a keen one, that the work which they have done, and are doing, has been, and is still further to be, of inestimable value in the institution in Canada of an organization which will be an all-important factor in promoting the development of the industries of the Dominion and in utilizing its natural resources in the creation of the wealth necessary to lighten the great burden of debt which Canada will have to carry for the next fifty years at least. Any measure that will, when carried out, achieve this object in the next ten years will relieve the anxieties of all who have at heart the interests of the country and all who assist in the promotion of this result will feel that they have, in some degree at any rate, been its benefactors. That explains the willingness of the members of the Council to make the sacrifice of their time and energies.

It must be confessed that the hope which stimulated the Council in its work from 1916 on, during the early part of last year seemed in danger of defeat. The organization which the Council aimed at promoting was a National Research Institute for Canada, in which would centre many of the activities in research concerned in the industrial and mineral development of the country. The recommendation that such an Institute be established had a general, practically a unanimous, approval throughout the Dominion. Boards of Trade, Clubs, Canadian and Rotarian, and scientific organizations, enthusiastically endorsed it and two committees of the House of Commons, one for each of the sessions of 1919 and 1920, composed of members of both sides of the House, appointed to enquire into and report on the

measures which should be taken to promote scientific research in application to the development of the resources of the Dominion, in two reports strongly urged the acceptance by Parliament and the Governor in Council of this recommendation, which reports were unanimously approved by the House on both occasions. Towards the end of the session of 1920, therefore, there seemed to be a fair prospect of this National Research Institute being established by legislation undertaken to this end. The Government, however, failed to take action before Parliament was prorogued in June, and, as might be supposed, the Council, after three years of effort to attain the cardinal object of its aim, felt that its achievement was in danger of being indefinitely delayed.

The supposed set-back, however, was only temporary for in September came assurances to the Council, which were welcomed, that the Government would at the next session undertake to provide legislation establishing the proposed National Research Institute. These assurances were made good by the action of the Government in introducing into the House of Commons a Bill along the lines of the draft Bill proposed by the Council, which if it received the assent of the Governor General would very soon result in the development of a Research Institute for Canada which would greatly enhance the industrial efficiency of the country.[1]

The Council, it may be freely confessed, is not infallible and it has never claimed to be, but its members are disinterested and, what is of special importance, their training along scientific lines and their experience in scientific work qualify them for the role of advisors as to the type of organization for research which the Dominion requires if it is to keep step with the advances made abroad to promote industrial research as an aid to national prosperity. They naturally expect, and the intelligent portion of the public will also expect that their recommendation will receive some measure of recognition as otherwise the Council would have no justification for its existence.

The Council still hopes that the National Research Institute will be founded, and it is of the opinion that the forward-looking section of the public of the Dominion hopes likewise. That hope supplies the incentive to the members of the Council to continue in a service which has involved a sacrifice not only of their time and energies but also, to no small degree, of their own interests.

2. *The Standing Associate Committees.*—Each of these Committees held meetings during the year.

The Associate Committee of Chemists which met in Toronto on May 29-30, 1920, under the chairmanship of Professor R. F. Ruttan, was attended by sixteen of its twenty members. It discussed a large number of subjects of special interest to those concerned in the development of chemical research and of the chemical industries in Canada and amongst these the following:—

1. Legislation regarding industrial alcohol.
2. The recovery of waste paper.
3. The alkali and salt deposits of the Northwest.
4. Studentships and Fellowships to assist those training for careers in research in Canada.
5. The education of the chemical engineer.
6. A Reference Scientific Library for Canada.

The Associate Committee on Mining and Metallurgy met in Montreal on February 4, 1921, under the chairmanship of Professor Frank D. Adams. Ten members were in attendance. The subjects dealt with in this meeting included the following:—

1. A Central Information Bureau at Ottawa.
2. The preparation of peat in Canada for domestic fuel.
3. The utilization of Canadian iron ores.

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[1] The subsequent history of this Bill will come within the scope of the Report of the Council's activities for 1921-22. It may, however, be very briefly set out here. This Bill was accepted almost unanimously by the House of Commons and was given its Third Reading on May 10th, but it failed later to pass the Senate.

The success which has so far attended the operations to produce peat for domestic fuel at the Alfred bog was reported by Wm. Cole, the chairman of the Ontario Peat Committee, who stated that about five thousand tons of manufactured peat which had been produced at the bog during the year had been sold in the city of Ottawa and in some twenty-five of the smaller towns in the various parts of Central Canada. The peat so prepared met with a ready sale and he stated that the market demand was such as to take, if it were available, ten times the output. The product sold readily in Peterborough at $13.50 per ton, in Ottawa for $9 a ton, and a shipment of it went as far east as New Brunswick. Indeed certain manufacturers offered to take the entire output at a higher price than had been fixed but this was not accepted as the object of the Peat Committee was to introduce peat for domestic purpose. The success so far achieved was encouraging but another year's operations were necessary in order to demonstrate finally that the production of peat for domestic fuel is a practical proposition. So far the work done had received the approval of Dr. Purcell, acknowledged as the leading British authority on peat, who, representing the Honorary Advisory Council for Scientific and Industrial Research of Great Britain, had investigated the work of the Committee at Alfred and reported that Canada was further advanced in the development of peat production than any other country in the world.

To continue this work for one more year it was necessary that a further appropriation be provided and a resolution strongly recommending that the Government make this additional grant received the unanimous approval of the Associate Committee.

On the subject of the utilization of Canadian iron ores the Committee had in 1920 appointed a sub-committee with the object of investigating this question and to demonstrate that such ores can be utilized and put on the market commercially. The sub-committee has confined its efforts for the time to practical problems and as 98 per cent of the ore mined is used by blast furnaces the sub-committee reported that they should confine their investigations to the use of Canadian iron ores in blast furnaces and that the question of the electric furnace in connection with such ores should be left for future investigation. A report on the results so far obtained by this sub-committee was forwarded to the Research Council.

A report of the work of the Committee in its investigation of the possibility of utilizing these ores is given in appendix " A."

The formation of an Associate Committee on Physics and Engineering Physics was approved by the Research Council at a meeting held on December 12, 1919, in order that such a body should act in a consultative capacity to the Council on problems in these two departments of science and, in consequence, such a Committee was subsequently appointed whose membership is indicated elsewhere in this report. Two meetings of this Committee under the chairmanship of Prof. J. C. McLennan, F.R.S, were held during the year, one on May 21, 1920, in Ottawa, the other on January 14 and 15, 1921, in the Physical Laboratory of the University of Toronto. Reports of the proceedings of the two meetings of this Committee are given in appendix " B."

3. *The Expenditures of the Council.*—The parliamentary vote for the year was $120,000 and the net expenditure was $109,577.48, leaving a credit balance of $10,522.52, which was returned to the Receiver General at the end of the year. This exceeded the expenditure of the preceding year by $9,705.06. This was due to a larger number of grants for assistance for special researches, which amounted to $48,779.05, and $9,000 was used to purchase, from the Imperial Munitions Board, apparatus (standard gauges, etc.), which originally cost nearly three times as much, and which will prove very serviceable in the Research Institute when it is established. There was a net expenditure of $16,925 for Fellowships, Studentships, Bursaries and Scholarships, the holders of which numbered 36 in all. Salaries amounted to $17,600.51, which was less than the total for salaries for the preceding year by $559.44.

4. *Assisted Researches.*—As stated in the preceding section, the amount expended by the Council to assist approved researches was $48,779.05, which exceeded the amount ($33,315.53) spent in the previous year by $15,463.52, due chiefly to new

researches undertaken, some of which required large grants to carry them on. The total number of grants was seventeen, or three more than the number assisted in the previous year. As in that year so for the year now under report no part of any one of the grants was expended in paying for the services of those responsible for the investigation thus assisted. The grants were used for the purchase of the material or apparatus needed and in several cases for salaries or honoraria for assistants employed either for whole or part time in attending to the details of the investigations. A list of all the researches assisted during the year is given in appendix "K."

It may be pointed out here that the comparatively small number of researches assisted is a fair indication of the availability for research work of those in the scientific staffs of the universities and of the technologists trained for research, in Canada. A very great majority of the scientific members of the staffs of the universities, are, unfortunately, in the conditions which now prevail in these institutions, overloaded with hours of instruction for their classes as well as, in some instances, with the supervisory work of their departments, and in consequence only a few have enough free time to devote to research. Further, a number of these carry on research on subjects in the "fundamental" sciences the results of which are not, or will not be immediately applicable in solving industrial technical problems, subjects which do not in many cases require financial aid from sources outside the universities themselves. The number of those qualified as well as free to undertake important researches of an urgent character for the achievement of which grants from the Council may be necessary is, accordingly, in Canada, very limited. This is one of the facts emphasizing the necessity of a National Research Institute for Canada in which a large research staff constituted for that purpose may carry on continuously investigations on problems the solution of which may be of the most pressing importance to the industrial and mineral development of the Dominion.

In the report for the year 1919-20 attention was directed to the cement problem of Western Canada, especially of the Provinces of Manitoba, Saskatchewan and Alberta. It was pointed out that the soil waters nearly everywhere in these Provinces are charged with alkaline salts which attack concrete structures and cause a decay which necessitates their renewal in the majority of cases in less than a decade and the loss so incurred amounts, it has been estimated, to a million dollars or more a year. The processes involved in this disintegration, it was stated, are unknown, although researches undertaken by the Reclamation Service at Washington, with the co-operation of the Bureau of Standards, and by cement companies and engineering associations on the causation of disintegration of cement structures of the Western States, where soil waters impregnated with alkalies also obtain, have not so far shed much light on the subject, and the subject, therefore, calls for more investigation. The Council, it was further stated, proposed to undertake an investigation of the problem as it concerns the Prairie Provinces very greatly if the proper expert organizations required could be constituted and if also, it could out of its modest parliamentary appropriation, meet the necessary expenditures which would be incurred.

The Council followed up this question by referring it to the Engineering Institute of Canada to report on how this investigation could be most effectively undertaken. This matter was considered during the Western Professional Meeting of the Institute held at Calgary in August, 1920, with the result that it recommended that $15,000 per annum for three years be secured to engage specialists to devote their entire time to this investigation and, further, that this investigation be carried on under the supervision of a committee of the Institute on the destructive effect of alkali soil waters, which committee would represent the provincial branches of the Institute in the three Prairie Provinces. The Council approved of these recommendations and granted $5,000 to assist in carrying on the investigation during the year, under the direction of Professor C. J. Mackenzie, of the University of Saskatchewan, chairman of the above named committee of the Engineering Institute, which has secured contributions amounting in all to $8,000 for this purpose from

the Canadian Pacific Railway Company, the Governments of Saskatchewan and Alberta, and the Canada Cement Company to assist in carrying on this work. The investigation, which is now in progress, is being participated in by both chemists and engineers, the problem for the former being to discover the exact reactions which lead to the disintegration, and, if possible, to provide a remedy, while the work of the engineering part of the investigating staff is to adapt all the findings so obtained to practice, to investigate thoroughly the relative part played by grading of adequate consistency, mix, permeability, and so on, and, further, providing the chemists can find no remedy the engineers must evolve standards of practice in the construction of concrete work which will neutralize in some measure the effect of alkali soil waters. It is hoped, in any event, that the results of this investigation will give results which will lessen very considerably, if not wholly prevent, the great loss incurred annually in the West through this disintegration of concrete.

A grant of $1,000 was given to Professor Wilfrid Sadler, of the Department of Dairying, of the University of British Columbia, to continue his investigation, begun in the preceding year, on the grading of dairy products (cream and butter) and to correlate this grading with the bacterial content of the milk or cream used in the preparation of these products. The object of this investigation is dealt with in the report for 1919-20. The results of the investigation at the end of that year were of such a character as to justify the Council in continuing its support of this investigation and those which have been obtained for 1920-21 constitute a distinct advance in our knowledge of the bacteria which are very important factors in affecting the production of standard quality butter in Canada. Professor Sadler has presented a lengthy interim report of his work so far, detailing what has been achieved and what he hopes will be accomplished during the coming year. The final results will, it is expected, be incorporated in a report which will appear as one of the bulletins which are published, as occasion warrants, by the Council.

A grant of $8,006 was made to the Foresty Branch of the Department of the Interior to continue the detailed forest survey conducted for the three previous years on the Petawawa Military Reservation with the object of inaugurating an investigation, more or less protracted, to determine the conditions which affect the growth of the more valuable forest trees in Eastern Canada, and to assist the establishment under the Forestry Branch on this reservation of a Forest Experimental Station which would continue this investigation for a number of years, from ten to twenty, with the object of obtaining the data necessary to the reforestation of the burnt or cut over areas in Eastern Canada. The Council now considers the results so far achieved as demonstrating the advisability of the establishment of this Forest Experimental Station and has recommended that the Department of the Interior should in its annual budget make provision for such a station at the earliest possible date.

The investigation on the nutritional problems affecting the fox-breeding industry, initiated during 1919-20, was continued during the year with the aid of a grant of $5,500 from the Council. This investigation was carried on in association with the Health of Animals Branch of the Department of Agriculture at the Research Laboratory of the branch at Hull, Quebec. Ranch accommodation on the grounds attached to the laboratory had been made for the foxes which were used in this investigation and also adequate space was accorded in the laboratory for the biochemist engaged in this investigation. The ranch attached to the laboratory affords accommodation for six pairs of foxes which have been generously donated for this purpose by a number of Prince Edward Island fox breeders. The biochemist engaged for this investigation is Mr. G. Ennis-Smith, a Canadian, who has had a very considerable experience as a biochemist in the nutrition of animals in the Agricultural Experimental Stations in Dakota and elsewhere, along lines which qualify him for this work. The experiments so far carried out have enabled him to fix, at least approximately, the maintenance ration for the fox. It is expected that the general nutrition, condition of fur, fertility and success in rearing of the

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young foxes may shortly yield definite information regarding the type of diet most likely to be practically successful. The preparation of a report of the results so far obtained is in progress and it will be published as a bulletin at an early date.

A grant of $1,200 was made to the Associate Food Research Board to enable it to meet the expenses of an investigation which had for its object the isolation in a pure form of one of the so-called "Vitamines," or "Accessory Food Factors," A knowledge of these compounds began to develop after 1904, but it was only after 1912 that their importance in nutrition was recognized generally, and during the last five years a great deal of work has been done with regard to their action on the growth and the maintenance of normal conditions in animals and in the human body. One of these is known to promote growth, a second to maintain a normal condition of nerve and other tissues, while the third in a diet prevents the development of the conditions which characterize the disease known as scurvy. They must all be more or less constantly present in the diet of an individual if growth and health are to be maintained and their importance in nutrition is, therefore, unmistakable. None of these three has been isolated in a state of purity and in consequence nothing is known regarding their chemical nature except that they are not of a protein, fatty or carbohydrate character. Attempts to isolate them have failed because they occur in almost infinitesimal quantities in the foodstuffs and because also they, and especially one of them, the absence of which causes the disease known as beri-beri in man and polyneuritis in animals, are more or less subject to decomposition as they undergo purification. If they were isolated in a pure and active form it would be possible to ascertain their chemical composition and this would lead very probably to a more thorough knowledge of their action in the body and to their synthesis for use in foodstuffs known to be deficient in vitamines, an event that might result in recasting much of our present knowledge of a normal diet. That they can be prepared in a pure form is the hope that encourages the Associate Food Research Board to try new methods with this object in view confining its efforts first to the isolation of the vitamine the absence of which from a diet for a prolonged period causes beri-beri in man. When isolated the properties of this substance will be carefully investigated. Afterwards the isolation of one of the two others may be attempted.

A grant of $10,000 was made to Mr. Horace Freeman, Secretary of the British Columbia Advisory Committee of the Council, to meet the expenses of an investigation to devise an economic method for the reduction of the complex silver-lead-zinc-iron-sulphide ores of the Slocan district of British Columbia. The mines at present are required to separate the zinc as far as possible from the ore before shipment to the smelter and this can only be accomplished very imperfectly at some considerable expense. The smelter does not pay for the zinc remaining in the concentrates and makes large deductions from the lead and silver values according to the amount of zinc present, owing to its interference with the smelting process. On the other hand, when the ore is treated for zinc for the electrolytic process the lead must be eliminated as far as possible, and, moreover, in the roasting process the iron sulphides present are oxidized and give rise to zinc ferrates which are not dissolved by the acid used in the leaching process. As a result upwards of twenty per cent of the zinc is lost in this insoluble form. The loss, therefore, in either case, is great and the methods that will obviate this loss would make these ores more valuable. Mr. Freeman proposes to try electric smelting of these ores with metallic iron as a reducer and in an electric furnace of special construction, and the object would be the separation in one operation of the valuable metals and only the argentiferous lead would need further treatment. The research will be carried on under the supervision of a sub-committee of the British Columbia Advisory Committee in Vancouver, and it is estimated that it will take more than a year to obtain definite results and to bring it to a conclusion.

For a research on Ultra-Sonics under the conduct of Professor R. W. Boyle, of the University of Alberta, a grant of $2,500 was made. When acoustic (sound)

vibrations of pitch are higher than the audible, that is when they exceed 20,000 per second, they are known as "ultra-sonic." The wave lengths of such vibrations are, consequently, very short, only a few centimeters or less, and it is possible to reflect, refract and diffract them by objects of ordinary size and with appropriate detecting apparatus they may be used for signalling under water. Further, submerged objects and icebergs act as reflectors to these waves and, consequently, their presence can be disclosed by the "echo" produced by the ultra-sonic waves reflected from their surfaces. Such an "echo" is imperceptible under ordinary conditions but it can be made readily perceptible by a device to the ear and as it is carried at least one-half, probably three-quarters, of a mile it may be made the means of detecting icebergs and submerged obstructions on the paths of ships. A thorough investigation of the properties of ultra-sonics and of their utilization may yield results of great practical value in navigation and submarine operations, which constitute one of the objects Professor Boyle has in view in undertaking this investigation. The grant of $2,500 made by the Council will cover only part of the expense involved, the remainder it is understood, to be met by a grant of $2,000 from the University of Alberta.

Professor Frank Allen, of the Department of Physics, of the University of Manitoba, was allowed a grant of $1,000, to cover the cost of an optical instrument of special design for his researches in colour vision on which he has been engaged for several years. The instrument is a colour mixing spectrophotometer with a special prism designed to give three spectra in close juxtaposition or superposed as desired.

A grant of $1,000 was made to Prof. J. C. McLennan, F.R.S., to assist a research undertaken by him on Infra-Red Radiations. These waves are not detectable by sight but with the aid of certain devices they can be used for secret signalling to distances of 8-10 miles even through fogs and clouds, which they penetrate more readily than rays of visual range. Further, when these rays fall on certain substances they produce modifications therein which render them easily detectable. The aim of Professor McLennan is to investigate these rays more fully and to explore their usefulness in the direction of revealing hitherto unknown physical properties of elemental substances. The grant is to be used for buying apparatus specially adapted for this research.

To Professor McLennan another grant of $3,000 was made to continue his work on the liquefaction of helium. Professor McLennan had previously received from the British Admiralty $5,000 for this work, also $5,000 during 1919-20, and the University of Toronto had assisted to the extent of $12,000 which sum was spent in installing for this purpose a liquid air machine. The $5,000 grant by the Council in 1919-20 was for additional apparatus necessary for this work. At present experiments are in progress in the direction of liquefying helium which as liquid has a temperature within two degrees of absolute zero, and it is hoped to gain valuable information regarding the thermal, electric and magnetic as well as other physical properties of substances at very low temperatures, information which will have a direct bearing on the problem of determining the nature of the ultimate structure and constitution of matter.

A research on the utilization of the Milkweed, which is very common throughout Eastern Canada, was undertaken by Professor A. C. Neish, of the Chemical Department of Queen's University, with a view to determining its availability as a source of textile material, of its oil as a paint oil and of its coma as a filling for mattresses, pillows, etc. A grant of $250 was given to meet the expenses involved. Professor Neish had as a collaborator in this work Mr. J. W. Burns, a holder of one of the Studentships awarded by the Council.

A grant of $850 was made to assist a research on the surface energy of solids conducted by Professors F. M. G. Johnson and O. Maass, of McGill University. The surface energy of ordinary liquids has been accurately ascertained but it has been determined in only the case of one solid and then only approximately. Professors

Johnson and Maass are applying a new method in this determination which will probably yield decisive results.

A sum of $3,000 was granted to the Associate Committee on Mining and Metallurgy to conduct a survey of the iron ore supplies of Canada with a view to their utilization in the production of pig iron and steel. As a very great part of the ore smelted in Canada, in some years since 1915 as much as 96 per cent, has been imported, it is a question of great economic importance to the Dominion whether native ores can be utilized under new methods of treatment and thus help in some degree in reducing the balance of trade which obtains against Canada. A sub-committee of the Associate Committee has this survey in charge and is also engaged in ascertaining how these ores may be rendered suitable for treatment and the appropriate methods of smelting them.

5. *Fellowships, Studentships and Bursaries:*—The total number of these awarded for the year was: Fellowships, eight; Studentships, thirteen; Bursaries, fifteen. Three of those awarded Fellowships, two of those awarded Studentships and six of those awarded Bursaries, resigned them, while one Studentship and one Bursary awarded were deferred to 1921-22. Thus only twenty-three students were actually in receipt for the year of this assistance to them in their training to qualify for a career in research. The number finally holding all these did not exceed the number held in the previous year although it was expected that there would be a considerable increase. The low number awarded and the considerably lower number accepted of these awards may be explained as due in part to the modest sums which they have involved hitherto and in part to the small number of young graduates of Canadian universities qualified to receive such assistance. The amount allotted to a Bursary is $500, to a Studentship $750, and to a Fellowship $1,000. Urgent representations have been made to the Council, chiefly from members of the scientific staffs in the various universities, all to the effect that these amounts, especially those for the Bursaries and Studentships, are insufficient to maintain students while training themselves for research and that an increase in each is necessary. The cost of living in the larger university centres is high and it is a factor which should determine whether the amounts given are adequate or not for the object in view. That some of the students appear to find them adequate is indicated by the number who have accepted these Bursaries, Studentships and Fellowships, but in answer to this it is stated that not a few of these students are relying not wholly for their maintenance on what they receive from these but draw also on their own or other private resources to supplement the sums they so receive. The Council finally, after careful consideration of the subject, decided to increase the amounts given to $750 for a Bursary, $1,000 for a Studentship and $1,200 for a Fellowship, and that this scale should prevail for a couple of years or until the cost of living decreased sufficiently to permit of reducing the sums allotted to each class to the amounts hitherto fixed. This new scale will obtain for the year 1921-22 and it is expected that it will add to the number of holders of the Bursaries, Studentships and Fellowships.[1]

In the selection of students for the Bursaries, Studentships and Fellowships it must not be forgotten that the Researcher is born, not made. Further, only a small proportion, not more, and according to some experienced university teachers, much less, than five per cent of the students who graduate in science from the universities have the fundamental qualifications, initiative, imagination, and the special scientific knowledge that go to make a researcher of even mediocre capacity. This is the view of the writer of this report. When he began his university teaching career he held that almost every student who graduated in a science course could be trained to follow a career in research. The experience of the years since then has proved otherwise. Many

[1] At the time of the preparation of this Report the number awarded for 1921-22 is forty-five, nearly double the number actually held for 1920-21. The increase may not be the result of the increase in the scale of the amounts of each class for the grants to student-in-training made by the British Research Council for the current year is one hundred and thirty-two while it was only fifty-six for 1920-21, although there was no change in the scale of the grants in the two years.

may be called, but few chosen. It is a truth that must be recognized by the younger generation of professors in the scientific departments of our universities as, otherwise, their efforts may be wasted in attempting the impossible. On the other hand, the quest for those who have an inborn capacity for research should be assiduously and earnestly followed *for such when found and trained may be counted amongst the greatest of the natural resources of a country.* Not all of these are included in the final class lists of the universities. Just as in "the dim common population" there are "mute, inglorious Miltons", so there may be mute, inglorious Faradays, and even Faraday himself had he not been so fortunate as to serve as a laboratory attendant under Sir Humphrey Davy in the Royal Institution, might have spent his life as a bookbinder, to which trade, when he attracted Sir Humphrey Davy's notice, he was apprenticed. To find a few of such, wherever they may be, and to train them, is an achievement for a teacher of science of not less distinction than that which may come from his own contributions to knowledge, however important they may be.

The Council, to assist in the discovery of such potentialities and to permit of training them adequately, established the system of Bursaries, Studentships and Fellowships. These are not eleemosynary in any respect, nor are they to be considered as stipends or salaries, and care must be taken to prevent them from being regarded as such. They are but aids to assist students of the right type to develop as capable researchers. Such will be greatly needed in the next decade if the natural resources of the Dominion are to be effectively utilized and if also Canadian industries are to hold their own in competition with their rivals abroad. If such researchers were not now being trained in our universities a large number trained abroad would have to be imported eventually. *There are many too few in the Dominion to meet even its present needs, a fact that is not generally appreciated.*

6. *Associate Committee on Industrial Fatigue.*—This Committee, which was constituted at the close of 1918, has been, after two years of activity, reconstituted to carry on work in a more limited field than that in which it then functioned. As pointed out in the last report of the Administrative Chairman, that for 1919-20, the committee "found that all the factors of industrial fatigue are associated very intimately with health and diet of the worker and hygienic conditions or otherwise of his environment, not only during his working hours, but also of his life outside the factory or workshop." In consequence, the Committee asked that its name be changed to that of Associate Committee on Industrial Hygiene. As, however, public hygiene is one of the functions of the Dominion Department of Health, then recently established, to have "investigations on subjects in certain lines in industrial hygiene carried on by a Committee outside of and not responsible to that department is contrary to the policy of the Research Council, which has scrupulously avoided any duplication of the work or of the functions of a Department in the public service." When it appeared that the work of the Committee would inevitably include investigations in public hygiene the Administrative Chairman was instructed by the Council to recommend to the Deputy Minister of Health that the Department take over and carry on the work of the committee which legitimately belongs to it. This recommendation was not accepted by the Department because its limited budget did not permit of a larger programme than that already provided for.

Early in 1920-21 the Council put itself on record according to the following Minute:—

> "The Council had under consideration a communication from the Associate Committee on Industrial Fatigue asking that the Committee be authorized to change its name to Associate Committee on Industrial Hygiene. It was moved by Sir George Garneau, and seconded by Dr. Ruttan and resolved: That whereas the Associate Committee on Industrial Fatigue was constituted before the creation of the Federal Department of Public Health, and whereas the problems engaging the attention of this committee lie within the purview of the said

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Department, it is resolved that the Research Council deems it inadvisable to make any change in the name of the Committee under the present conditions; that the Council is of the opinion that after the expiration of the present fiscal year the investigations in connection with industrial fatigue should be carried out by and under the Department of Public Health and that the Department be advised to that effect."

Thus the matter stands. Meanwhile the Committee continued its work to the end of the year along the line on which it began, namely, a survey of the present situation in regard to industrial hygiene and social welfare in certain representative industries, with a view to obtaining enough data to enable it to concentrate its energies on a line of investigation distinct from any of those undertaken in the United States, Great Britain and France, and of special importance in Canada. It proceeded to investigate the general conditions of industrial hygiene in Toronto and Montreal, more particularly in the former, where seventy-six plants were kept under observation for this purpose and a large number of facts, with deductions therefrom, were collected which will undoubtedly prove to be of value in future effort along this line. These results were summarized in a report published by the Council in April, 1921.[1]

Because of the inability of the Federal Department to undertake the investigation, Professor J. J. R. Macleod brought the question of continuing this survey to its completion before the Provincial Board of Health of the Province of Ontario, and the latter eventually decided to establish an Industrial Hygiene Division, which is now in full acitivity. The functions of the Committee and two of its staff have been taken over by the Division which will in all probability justify its existence. The large collection of reports and publications on industrial hygiene collected from abroad has been placed temporarily at the service of the Division. The Committee, reconstituted with a smaller membership, is now confining itself to collecting publications and reports from similar organizations elsewhere which are engaged in studying industrial fatigue, and may, when a problem presents itself in this line which is not in the scope of any of the Departments or Boards of Health, Dominion or Provincial, undertake to investigate it.

Meanwhile, there remain problems in industrial hygiene to be solved which are of the very first importance to industrial life in Canada. Similar problems are under investigation abroad and already the results obtained are telling on conditions in many industrial centres. These results are applicable only partially to industrial conditions in the Dominion.

7. *The British Columbia Advisory Committee.*—The report of this Committee for the year 1920-21 appears as appendix "C".

Early in 1920 a number of members of this Committee had resigned or left the Province, and in consequence it became necessary to review the situation there with the object of reorganizing the Committee and enhancing its activities. One of the members most keenly interested in the work of the Committee, the chairman, Mr. R. F. Hayward, urged that a Secretary be appointed who would conduct the correspondence, prepare the list of agenda for the meetings of the Committee and attend to technical and other matters brought to its attention and also make preliminary surveys of problems in British Columbia for the consideration and action thereon of the Research Council. The Council made provision for the office expenses and the salary of a steno-typist for a Secretary, and in February, 1920, Mr. Horace Freeman was appointed in that capacity, a position which he has held and still holds. Soon after this appointment Mr. Hayward resigned his chairmanship because of his removal to Santiago, Chili, to assume there the managership of a mining company and

[1] Report No. 7. Survey of General Conditions of Industrial Hygiene in Toronto by the Associate Committee on Industrial Fatigue of the Research Council. Published by the authority of the subcommittee of the Privy Council for Scientific and Industrial Research. Ottawa, 1921.

this necessitated further changes. It was found difficult to get a representative attendance of the members at the meetings of the Committee owing to the fact that some of them live at points in the Province more or less distant from Vancouver, while the calls of their professions entailed the absence of others on the occasions of such meetings. To get speedier action on many matters which should receive the attention of the Committee but which do not involve questions of policy or principle, the Administrative Chairman recommended the appointment of a sub-committee with executive powers to act on all matters except those which should be dealt with by the Committee as a whole. This recommendation was accepted by the Council and the Committee, and the sub-committee appointed consists of the three members—Professor J. M. Turnbull, of the Department of Mining and Metallurgy of the University of British Columbia, Dr. C. McLean Fraser, of the Biological Department of that University, and Mr. H. R. MacMillan, President of the H. R. MacMillan Timber Export Company, of Vancouver.

The report of the Committee, prepared by the Secretary, given in appendix "C," deals with the results of a survey of the more outstanding industrial problems of British Columbia.

8. *The Utilization of the Flax Straw of the Prairie Provinces.*—The flax grown in Manitoba, Saskatchewan and Alberta is almost wholly that for seed, and the straw, which is cut, not pulled, when the crop is harvested, has not, except in one line and then to a negligible extent, been used as raw material to make any commercial product. The exact amount of the straw yield, annually, is not known but as it is on the average about one ton per acre and as the acreage devoted to it in 1920 and 1921 was about 1,391,076 and 516,972 respectively, the tonnage of each of these years could not have been less and may have been more. This straw, because of the character of the soil and possibly the climatic conditions under which it is grown, and because also it is cut and not pulled, is not suitable for producing high grade textiles and even if it were the dryness of the climate renders "retting" impossible, or nearly so, except in irrigated areas. The straw is almost wholly disposed of by burning it.

Early in 1920 the question of utilizing the straw for some commercial purpose was brought to the attention of the Council by the Board of Trade of Regina, by Dr. W. D. Cowan of that city, and by Mr. T. M. Malloy, Commissioner of Labour and Industries for the Province of Saskatchewan, and the Council, after consideration of the matter, decided that some investigation of an experimental character, if it could be provided for, should be undertaken with the object of determining the use to which this material could be profitably put. It was ascertained that at least one manufacturing firm operating in Duluth was using straw of a similar character produced in the Western States south of the international boundary, in combination with cotton to produce crash towelling, rugs and some other textiles. It was also known that the Arthur D. Little Company, in association with the Canadian Pacific Railway Company, had endeavoured to find some economic use to which this straw could be put, and succeeded in the production of a high grade pulp from which was made a writing paper of high quality, almost equal to a bond paper, which because of its price had only a limited market. Two lines of utilization of the straw, therefore, seemed to be possible in Canada. That in which the straw was made into fibre employed for the production of textiles of a certain character did not need demonstration as a commercial proposition. The success of the manufacture of crash towelling, rugs, etc., from it achieved by the Duluth firm was decisive on this point. The other line, involving the production of paper, had not been fully investigated and there remained the question whether the straw could be used to make other grades of paper, especially those which would command a large market, as, for example, news print. The Council decided to have an attempt made to solve this problem.

In the Industrial Institute associated with the Bureau of Standards at Washington there is a pulp and paper making outfit constructed on a semi-commercial scale which is being used to determine whether a large number of lines of raw material

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from different countries can be economically used in the manufacture of paper of various kinds. Aware of the fact that such experimental work was being carried on, the Administrative Chairman asked Dr. Stratton, the Director of the Bureau, to have flax straw from Western Canada tested in the plant of the Institute to determine its value as a raw material for the manufacture of paper of all kinds on a commercial scale. To this request Dr. Stratton at once responded and agreed to receive a shipment of the straw for this purpose. Through the assistance of Major G. G. Ommanney, of the Department of Colonization and Development of the Canadian Pacific Railway Company, a quantity of this straw was shipped at the expense of the Company from Coaldale, Alberta, to the Bureau of Standards in January of 1921, where it is now being tested for its value as raw material for making paper. It will take some time before the experimental work is finished and it is possible that another shipment may be necessary, but it is hoped that in the end the results will be such as to indicate definitely whether the straw can be so utilized on a commercial basis.

If it can be so used, it will mean, possibly, the development of a new industry in the Prairie Provinces for the amount of straw available at railway shipping points, about one half of the total yield, was, it is estimated, in the neighbourhood of 250,000 tons in 1921 and 700,000 tons in 1920. Whether by special treatment news print can be made from this raw material remains to be seen.

Flax for pulling has been successfully cultivated in the irrigated areas in southern Alberta. A flax-pulling machine which has been invented and which may be so improved as to render it very serviceable, may result in an increase in the yield of pulled flax straw, for if it is profitable under certain conditions in the West to grow flax for the seed alone it will be more so in districts near shipping points if the straw is a marketable raw material.

9. *The Utilization of Low Grade Lignites of Western Canada for Domestic Fuel.*—The history of the formation of the Lignite Utilization Board, its relation to the Research Council, and a resumé of its work up to May 31, 1920, are to be found in previous annual reports of the Administrative Chairman.

At present the situation with regard to the Board is that it has completed the construction of its main demonstration plant near the town of Bienfait, Saskatchewan, and has made tests on the various portions of the plant and found everything to be satisfactory, with the exception of the carbonizers, upon which experiments are still being conducted.

The carbonization of lignite is the very heart and kernel of the whole problem, and until these retorts are altered in such a manner that they may be operated commercially, the rest of the project must necessarily mark time. In regard to the carbonizers, it may be said that the principle has proved sound, and the mechanical operation has been demonstrated, but owing to subsidiary and minor troubles they cannot be operated for some months yet. Every effort is being expended to bring about these minor alterations at the earliest moment, and a successful trial of the carbonizers is looked for during the coming summer. In spite, however, of the difficulties with the carbonizers the Board has been successful in turning out briquettes at its plant.

It may be noted also that carbonized lignite briquettes possess fine burning qualities, and have proved a successful substitute for anthracite.

For further details regarding the operations of the Lignite Utilization Board, the reader is referred to appendix "I" accompanying this report.

10. *Industrial Alcohol.*—The Research Council, as may be gathered from a perusal of the previous reports of the Administrative Chairman, has given attention since its inception to the promotion of measures which should be taken to remove the restrictions imposed on the use of alcohol for industrial purposes, in Canada. On the recommendation of its Associate Committee of Chemists, a special committee was appointed in 1917 to investigate the question and to report its findings to the

Council. This Committee had numerous conferences with representatives of the manufacturers in various lines and of those industries using alcohol in large quantities as a solvent or precipitant, or as raw material from which chemicals could be made, and it found that a number of handicaps were imposed on its use for these purposes which limited its consumption and the development of such industries as depend for their success on cheap alcohol, whether pure or denatured. Those imposed on the use of denatured alcohol arose from the manner in which it was prepared and put on the market and the very limited number of kinds of denatured alcohol allowed. There were pratically only two kinds available and these were prepared at Ottawa and under the control of the Department of Inland Revenue. The distribution of the product to places distant from Ottawa, for example to Halifax or Vancouver, imposed a considerable charge for transportation which increased its cost and thus discouraged its use except in very limited quantities. Further, as only one kind, namely "Methylated Spirits," of a fixed composition was in the main of general use, this restricted its consumption greatly. It was ascertained also that no provision was made for the use of pure tax-free ethyl alcohol in industry except under conditions which of themselves exacted a heavy toll on its use and consequently it was impossible to manufacture in Canada tinctures, essences, extracts, etc., and a considerable line of chemicals to compete successfully with manufacturers of like products in Great Britain and the United States.

The Council on the report of the findings of this Committee made recommendations as to amendments in the Act governing the production of denatured alcohol in Canada and the use of pure ethyl alcohol, tax-free, in certain lines of chemical industry. Of these recommendations the leading ones may be summarized as follows:—

1. That alcohol for general industrial purposes be denatured in premises thereto licensed at various points throughout Canada.

2. That denatured alcohol, used for ordinary purposes, be sold, delivered and transported without restriction to dealers, manufacturers and other persons.

3. That specially denatured alcohol, i.e., alcohol denatured for special purposes for which the ordinary denatured alcohol would not serve, should only be sold or delivered under a special permit to dealers and manufacturers to be used in the arts and industries in cases where ordinary denatured alcohol would be unsuitable.

4. That pure ethyl alcohol (without any denaturant) may be sold free from excise duty and delivered

(*a*) for scientific purposes, in limited quantities, to Universities and scientific and research laboratories approved by the Minister of Customs and Inland Revenue, and

(*b*) In limited quantities for the purpose of medical treatment only to public hospitals chiefly maintained by public subscription or endowment, approved by the Minister.

As a result of this movement to free the use of alcohol for industrial purposes from unnecessary restrictions the Government introduced in the Session of 1920 a Bill, No. 178, to amend the Inland Revenue Act, which Bill passed both Houses of Parliament and received Vice Regal assent in June of that year. This Act, however, embodies only some of the recommendations listed above and some of these with qualifications. It allows alcohol to be denatured either for general purposes or with special denaturants for particular uses, not "in premises thereto licensed," *but only in distilleries thereto licensed.* It also provides (Section 267) that "the Governor in Council may from time to time make regulations respecting the sale of spirits to be used for any chemical or manufacturing process not herein otherwise provided for."

So far so much to the good. The Act permits the manufacture of denatured alcohol of any variety, approved by the Department, in any distillery which is

licensed for that purpose, and sold free of excise duty and delivered to the purchasers, the ordinary denatured varieties without any restrictions, the specially denatured varieties only under departmental permit to industries in which ordinary denatured alcohol will not serve. This is an improvement on the former regulations, as it provides extra facilities for obtaining completely denatured alcohol and it gives the Department the power to provide specially denatured alcohols for different industries such as these may require.

So far the Department of Customs and Inland Revenue have allowed two varieties of ordinary or completely denatured alcohol and three of specially denatured, but it is possible that these will be added to in the near future.

The result of the change in the regulations is not all that was desired and it is due to the fact that the denaturing of alcohol is confined to *distilleries thereto licensed instead of in premises thereto licensed.* In consequence the price of ordinary denatured alcohol in Canada at this writing is $1.30 per imperial gallon in barrel lots, while in the United States it is $0.55, also per imperial gallon. This involves a very serious discrimination against Canadian industries using such alcohol in competition with similar American industries.

The use of tax-free pure ethyl alcohol of Canadian origin is not allowed by the Act for use in the scientific and research laboratories of the universities and other public institutions. These can import duty-free such alcohol from abroad without the excise duty of the country of origin and thus they obtain it at a low figure per gallon. If they used Canadian alcohol it would cost them $10.50 per gallon 65 O.P., a prohibitory price. This high price prevents the use of pure ethyl alcohol for bathing purposes in public hospitals in the case of patients for whom such treatment may be prescribed and in consequence ordinary denatured alcohol has sometimes to be used, resulting not rarely in toxic effects on the patients from the vapour of methyl alcohol which may be inhaled during such treatment. It is, however, a matter for satisfaction that the Department is considering the question of allowing under certain conditions the use of tax-free pure ethyl alcohol in hospitals for such cases.

It is in the interest of Canadian industry that the number of varieties of denatured alcohol allowed by the Department of Customs and Inland Revenue should be increased. In this connection it may be pointed out that the Internal Revenue Department of the United States, with a National Prohibition Act that makes it criminal to use alcohol as a beverage, has very greatly increased the number of specially denatured alcohols available to the public, a number that is in utter contrast with the number that is allowed in Canada. It is, therefore, a matter for regret that the Department of Customs and Inland Revenue has not so far permitted the production of a greater number of specially denatured alcohols.

That there may be abuse of this permission does not seem to be indicated by the experience of the Internal Revenue Department of the United States. Mr. James F. Doran, Chief of the Industrial Alcohol and Chemical Division of the United States Internal Revenue Bureau, in a recent address before the National Convention of the Anti-Saloon League in Washington stated as follows: "Referring to the use of alcohol in industries since 1906, the amount of alcohol that was denatured increased each year, replacing a certain amount of pure alcohol in commerce, but did not replace an equal volume of alcohol for the reason that new industries were being developed under the stimulus of tax-free alcohol." It may be stated that the regulations governing the use of tax-free, pure ethyl alcohol in the United States and England are not so stringent and complicated as those in force in Canada.

Mr. Doran goes on to say: "The National Prohibition Act changed the outlook very materially and it became apparent that one of the best law-enforcing weapons was the provision of the National Prohibition Act providing for more extended denaturation than had hitherto seemed possible under excise laws."

The Inland Revenue Department at Washington has authorized six formulæ for completely denatured alcohol which can be sold under no further restriction than those governing the sale of milk or gasoline, and has authorized also fifty-eight formulæ for specially denatured alcohol for use in a great variety of general industries and hundreds of specific products. There is one formula used in the States more generally than any other, which the Research Council has, through its special committee, strongly recommended to the Department of Customs and Inland Revenue, viz., ethyl alcohol denatured with five per cent of methyl alcohol. This is used in the States as a solvent and as a vehicle for the extraction and preparation of upwards of two hundred pharmaceutical preparations. These cannot be made by Canadian drug manufacturers by the use of the alcohol available in Canada in competition with the American manufacturers. The use of a large number of specially denatured alcohols under Government surveillance should make the inspection of bonded warehouses very much simpler. Specially denatured alcohol is of no use as a beverage and the manufacturers, as well as the Government, are largely relieved of the responsibility incident to handling and storing pure alcohol.

11. *Associate Air Research Committee.*—This Committee, composed of representatives of the Air Board and the Research Council, with a large number of associate members, has been very active during the year, as may be gathered from a perusal of the report of its activities (appendix "H"). It has provided for a number of experimental investigations on problems of immediate interest in aeronautics. In all these it has arranged to avoid duplication of researches undertaken elsewhere, and it has striven to co-operate as far as possible with official research organizations in this line in the United States and Great Britain. The expenses incurred in such investigations have been met by grants from the Air Board which is specially interested in the solution of the problems undertaken, and whose co-operation in this work is appreciated by the Council and the Associate Committee. Attention may be called specially to the final paragraph in the report which refers to the need for further interest in air research work on the part of the public, to the scanty supply of researchers now available, and to the difficulties experienced in the conduct of such research work in Canada due to the lack of facilities for instrument making and precision mechanical work.

12. *The Associate Biological Committee.*—This Committee, which has concerned itself with problems in the chemistry and bacteriology of canned and cured fish and lobster, in 1920 commissioned Principal F. C. Harrison, of Macdonald College, to investigate the causation of the pink or red discoloration which of late years has frequently appeared in green-salted, cured and dried codfish of the Canadian catch of the Atlantic coast. This discoloration, when it occurs in the product, seriously affects its market value and the loss involved, though in instances it may be low, sometimes reaches as high as forty per cent of the producer's output, a figure that is of special significance when taken in conjunction with the fact that the value of these products, the greater part of which is usually exported, in the year ending March 31, 1921, exceeded in value $5,000,000.

This discoloration, although comparatively new to these Canadian products, has occurred at various times and in different countries for the last forty years, and during this period its causation has been investigated with more or less indecisive results. Further, the discoloration, when it did occur, was not such a serious factor in the trade as it is to-day. In the past the cod was smoked, dried and green-salted chiefly in the colder months of the year, the products were immediately thereafter exported and, in consequence, but small quantities of such were affected. Now these products are also prepared and marketed during the warm season of the year and the discoloration has become an important factor in the export trade because its development is promoted at the higher temperatures of that period. Formerly, there-

fore, the problem of the discoloration had little more than a scientific significance. Now it is one of such economic importance as to make it necessary to investigate its causation with the object of finding methods of preventing its occurrence.

Principal Harrison, with whom Miss M. E. Kennedy was associated in this work, gave careful and prolonged attention to the problem, and has reached results which constitute a very considerable advance in our knowledge of the causation of this discoloration. He has found it to be due to a micro-organism to which he has given the name "*Pseudomonas salinaria*," which grows readily in culture media rich in salt and also grows in the sea-water of the tropics and sub-tropics, for he isolated it from samples of brine obtained from Turks Islands (West Indies). It is capable, in different concentrations of solutions of salt, of altering its form, appearing in ordinary sea water as of very minute spherical shape, but when the salinity approaches saturation cylindrical rods are formed between which and the spherical forms all transition stages may be found. The change from the spherical to the cylindrical form of the organism may be brought about by increasing greatly the concentration of salt in the culture medium.

The organism is non-pathogenic, that is, it does not cause disease in animals inoculated with it, nor does it give any injurious effects when the discoloured fish, properly cooked, is eaten.

It occurs in the salt derived by evaporation of sea water of the Mediterranean and the Tropics, in which it draws on the seaweed and other marine vegetable forms of life for the materials necessary for its own growth. It does not occur in the salt derived from mines, such as Liverpool salt, the Windsor (Ontario) salt and the Malagash (Nova Scotia) salt. The occurrence of this organism in the cured codfish from the Atlantic coast of Canada is due to the use of Mediterranean and Tropical salt in place of mined salt. Codfish treated with mined salt does not develop the red discoloration.

Other organisms were isolated from the discoloured fish, and some of them were slightly chromogenic, but none of these played any part, or more than a very subordinate part, in the production of discolouration.

Principal Harrison recommends the resort to a number of measures which will, if constantly put into effect, result always in a product which will be completely free from the organism and the red discolouration it causes. These are:—

1. To use only mined salt in the curing.

If Tropical or Mediterranean salt must be used, it may be sterilized by heating it to 100° C. for half an hour.

2. To clean and disinfect thoroughly all fish curing establishments in which Mediterranean and Tropical salt has been used, this in order to get rid of the organism which otherwise might infect the mined salt used. The disinfection must be thorough and involve all the utensils used.

The findings obtained by Principal Harrison and Miss Kennedy in this investigation must be regarded as of outstanding value in the solution of the problem of the discolouration of fish in the curing of which salt is used.

The report, a comprehensive one, which Principal Harrison has prepared, of the results of this research will, it is very probable, be published by the Research Council for general distribution at an early date.

13. *Fish-curing in Canada.*—In the autumn of 1914 and 1915 the Biological Board of Canada instituted at St. Andrews, New Brunswick, and in connection with the Biological Station there, a series of experimental investigations on the method of curing haddock by salting and smoking to ensure a product which would keep for some time and preserve its flavour and other desirable qualities when marketed in Toronto, Winnipeg, and other centres distant from the Atlantic coast. The experiments concerned the optimum length of time for salting and also for smoking, the length of time in each case determining the keeping capacity of the

product for the market for which it was prepared. Samples of such products were distributed for consumption to a number of centres in order to ascertain their acceptability and reports from those testing them were collected from which data were obtained to indicate the treatment in each case which would give the best product. The results showed that a very decided improvement could be effected in the product destined for each market centre, an improvement that would greatly increase the consumption of cured haddock throughout Canada.

The investigation did not solve all the problems involved and there are still some which it would be advisable to investigate. Nor did the Board undertake at the time any propaganda with the object of inducing the public to call for an improved product, the reason at the time being the lack of funds to meet the expense which might be so incurred. That the investigations and the propaganda may be undertaken some time shortly is a possibility and in view of this any information on the methods used in such curing elsewhere would be of service for reference. In consequence, the Council commissioned Professor J. J. R. Macleod, of the University of Toronto, who was spending a month or so at and near Aberdeen, Scotland, in June and July of 1920, to examine and report on the methods employed in producing the "finnan haddie" which has such a very large market in Great Britain, a task which he performed, to satisfaction, and presented in October of that year a report to the Council which embodied a great deal of information on the subject. This report it was intended to publish in extenso but it was later decided to publish a summary of it in some journal devoted to the fishing interests and it, accordingly, was accepted for the "*Canadian Fisherman*" in which it appeared in the issue of that publication for January, 1921.

There is not the slightest doubt that the consumption of cured haddock in Canada, which is now considerable, could be trebled or quadrupled if standard methods were employed and the public were assured of a product that would be always acceptable. To this end, therefore, further experimental work should be undertaken, not of research, but rather of the empiric kind, to establish such standards in the product for different parts of Canada which would be followed by those engaged in the curing of haddock.

14. *The Administrative Chairmanship.*—When the Council was instituted at the close of 1916 it recommended the appointment by the Government of an administrative officer for the same, to be called the Administrative Chairman. This recommendation the Government accepted and Dr. A. B. Macallum was offered the appointment, which he accepted after some hesitation because he recognized that the position would involve work of the most wearying character but which would have to be undertaken by some one if the Council was to be of effective service in the development of scientific and industrial research in Canada. When he assumed the position it was stipulated by him that it should be for about a couple of years, long enough, he supposed, to organize all the possible lines of activity of the Council. The work proved to be very exacting and onerous, rendered especially so by the fact that a full time Secretary was not appointed to assist. There was for the first two years as Honorary Secretary, Mr. J. B. Challies, Director of the Water Power Branch of the Department of the Interior, who gave as much time to the secretaryship as the duties of his position as Director would permit, of which unselfish service the Administrative Chairman is appreciative

In 1918 Mr. Leslie R. Thomson was appointed Corresponding Secretary and Mr. Challies' services were retained as honorary Recording Secretary, but in a few months Mr. Thomson resigned to accept the secretaryship of the Lignite Utilization Board. As the position vacated had just then been classified under the Civil Service and with a low initial salary it was impossible to find a successor to him who would have, amongst other qualifications, the necessary scientific training for the position, and the Chairman had, in consequence, to carry on thenceforward, performing the duties of

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two positions, at times almost an intolerable burden. How exacting his task was may be indicated by the fact that in all the four years of his term of service his holidays did not total three weeks.

At the end of the two years which he originally contemplated as the limit of service as Administrative Chairman, Dr. Macallum found that one especially important aim of the Council, the foundation of a National Research Institute for Canada, was still unachieved. He decided, therefore, to carry on still further until that aim was accomplished, and when accordingly in September, 1920, the Council received assurances that legislation would be undertaken to establish the proposed National Research Institute he presented his resignation of the position to the Right Honourable Sir George E. Foster, Chairman of the Sub-Committee of the Privy Council for Scientific and Industrial Research, the resignation to take effect on Octobed 31, and followed this up by accepting the newly created Chair of Biochemistry in McGill University. After November 1 he carried on for over three months as Honorary Administrative Chairman and until Professor R. F. Ruttan was appointed to the position in an honorary capacity.

In June, 1920, in view of the contemplated resignation of Dr. Macallum the Council decided to recommend to the Sub-Committee of the Provy Council that to carry on the administrative work of the Council the position of Chairman should be an honorary one, to be occupied by a member of the Council, and that a very large part of this work should be performed by a Techical Executive Officer who has had a special technical training and also a very considerable experience in the executive line.* The Chairman under this scheme would call and preside at meetings of the Council, bring before it general matters involving measures to promote scientific and industrial work and to represent the Council officially on all occasions when its activities and policy may be concerned. Under this arrangement the work hitherto performed by the Administrative Chairman would be carried on by two officers each with functions which can be performed without too great a sacrifice of their time and energy and therefore with a certain degree of satisfaction to themselves and to the Council.

In this his last report as Administrative Chairman, Dr. Macallum desires to express his grateful appreciation of the courtesy he has experienced throughout the four years from his Colleagues in the Council, from the Members of the Government, a large number of Members of the House of Commons and Senate, and of the leading Government officials with whom he came in contact in his adminstrative capacity.

II. ON THE OVERLAPPING AND DUPLICATION OF EFFORT IN THE SCIENTIFIC AND TECHNICAL WORK IN CANADA

When the Council was constituted in 1916 by Order in Council its duties as laid down therein included the following:—

(*a*) To consult with all responsible bodies and persons in carrying on scientific and industrial research work in Canada with a view to bringing about united effort and mutual co-operation in solving the various problems in industrial research which from time to time present themselves.

(*b*) To co-ordinate as far as possible the work so carried on as to avoid overlapping of effort and to direct the various problems requiring solution into the hands of those whose equipment are best adapted therefor.

There is bound to be, as there is actually, a great deal of overlapping of effort in research in industry. A firm with a great deal of capital at its command, recognizing that the discovery of valuable new processes may result from research, may, in

* This recommendation was accepted by the Sub-Committee in August last and Dr. R. A. Ross was appointed as Honorary Chairman, Professor R. F. Ruttan having resigned the Administrative Chairmanship after six months of service, while Col. F. M. Gaudet was selected to fill the post of Technical Executive Officer.

its provision to this end, cover all the problems of that industry which another firm similarly circumstanced and engaged in the same line of production may undertake independently to solve. The firm that through research discovers and then utilizes new processes which cheapen production or improve its products, or which enable it to utilize cheaper raw material, gains an enormous advantage in the market and even at times can oust competition therefrom. Such a rivalry cannot, and except under special conditions, should not be abated. Industrial firms are, in a free country just as individuals are, entitled to do what they wish with their own funds and their wisdom in the use of such resources may be justified by the results. Rivalry is the law of life in industry, and it is through its operation that manufactured products ever tend to improve in character, increase in output and to become cheaper to the consumers. That much may be gathered from the experience of the past three decades, and it is illustrated to-day in the case of such large industrial organizations as the General Electric Company, the Western Electric Company, the Dupont Company and the Eastman Kodak Company, amongst those of the United States. It is only when the firms or the individual manufacturers have each a very small capital and consequently a small amount to be devoted to research that duplication and overlapping is unwise because it is wasteful. In nearly all the industries of to-day the easily solved problems have been disposed of, that is those which required only small expenditure for their solution. Those that remain or are to be faced if improvement in character and increase in yield of output are to be obtained require for their solution an equipment and a research staff on a larger scale than their resources would permit. For each to attempt on a small scale the solution of such problems may after years give no result justifying the expenditure which may be involved. If one firm or industrialist of limited means undertakes research while the others in the same line do not its or his expenditures may diminish the dividends or profits at the end of the year while there may be no improvement in the character or increase in the yield of the output. If more than one firm or all the firms or individual industrialists in the same line, each with limited resources, provide on a small scale for research, not one useful result may be obtained and consequently firms in that line of industry as a whole may be seriously handicapped in competition with their rivals abroad organized for co-operation in research or which individually engage in large expenditures for this purpose. In such a case the duplication and overlapping of effort in research is wasteful of resources and in the vast majority of instances wholly unjustifiable.

To enable such firms with limited means to engage in research and in the end to benefit from it, the British Research Council began five years ago to advocate the formation in each line of industry in Great Britain of a Trade Association for Research in which all the firms, or a majority of them, in each line would "pool" all their funds available for research on its problems, to be carried on in some large laboratory or plant organized for this purpose. In the case of a Trade Association in which the "pooling" of the funds of its members did not provide an amount sufficient to make certain that the results of the research to be undertaken would be of a character to justify the formation of the association, the Research Council, out of the Parliamentary grant of £1,000,000 voted in 1916, made an annual grant to supplement the amount which resulted from the "pooling." Twenty-four such Trade Associations for Research have been so far established and a number of others are in the process of formation. These will certainly be a factor in determining the success of the industries concerned in the international struggle for trade supremancy. The National Research Council of the United States has followed the lead of the British Research Council and is promoting the establishment in the industries of the United States of similar Associations for Research and a certain amount of success has attended its efforts in this line. The Research Council of Canada has advocated the formation amongst the industries of the Dominion of similar associations

under the name of Guilds for Research. This would provide for effective co-operation in research which would soon put the Canadian industries abreast with, if not in advance of, those abroad which, employing research to the utmost of their resources, aim at conquering the world's market. These Guilds for Research, aided, as occasion and necessity may demand, by close association with the National Research Institute until they can exist alone, would in a few years be a powerful factor in promoting Canadian industrial prosperity, but until the Institute is established not much headway can be made in their formation, for, unassisted by such an organization of highly trained and able scientific experts, they might, except in a few instances, result in failure. The National Research Institute will, therefore, be the keystone of the Guild System and the urgency of its establishment at an early date is not open to question.

The Research Council held that in the rescript of the Order in Council quoted above it was instructed to give attention to the question of duplication and overlapping of effort in the scientific and technical branches of the Government service and its opinion on this point was corroborated by the instructions given to the Council when it was constituted by the Chairman of the Sub-committee of the Privy Council, in which the following were included:—

(*a*) To ascertain and schedule the various agencies in Canada which are now carrying on scientific and industrial research, in the universities and colleges, in the various laboratories of the Government, in business organizations and industries, in scientific associations, or by private or associated investigators.

(*b*) To note and schedule the lines of research or investigation that are being pursued by each such agency, their facilities and equipment therefor, the possibilities of extension, and, particularly, to ascertain the scientific manpower for research available for research and the necessity for adding thereto.

(*c*) To co-ordinate these agencies so as to prevent overlapping of effort, to induce co-operation and team work, and to bring up a community of interest, knowledge and helpfulness between each other.

In the years 1916-1919, two of which were the last of the war period, and the remaining covered the time of readjustment after peace was declared, conditions in the Departments of the Government were more or less unusual as they were for the same reason in the Imperial service and during 1917-1919 in the Federal service at Washington. There were created at Ottawa a number of Boards and Commissions to deal with special problems, not a few of which were technical, relating to the conduct of the war, and unusual duties were imposed on some branches of the Departments which also involved technical work. There was undoubtedly duplication and overlapping in all these activities, yet it was inevitable under the strain of the war; but it was expected that once peace was declared the medley of unusual duplication and overlapping would cease, as in fact it did. There remained the technical and scientific services on the civilian side of the Departments in which, it was currently reported, there was duplication and overlapping but because of the resignation or the detailing of the members of their staffs for military service these services were then more or less in abeyance as it were. In consequence the Council believed that any investigation of the question whether duplication and overlapping in these services might give results which would not obtain during normal conditions and it therefore delayed action on this matter till 1920.

In the meantime the Council regarded it as imperative that it should do nothing that would give even a colour to any accusation of indulging in duplication or overlapping in its own work. Such duplication or overlapping in the work of the Council is impossible because it has no power to carry on scientific or technical work under its own immediate control. As its name implies it is an advisory body—advisory to the Sub-committee of the Privy Council for Scientific and Industrial Research in Canada. It is indeed empowered to give grants for researches on special problems not already

undertaken either in the technical or scientific branches of the Government Departments or elsewhere in Canada, but even these grants have to obtain the approval of the Sub-committee before they are made. Further, it has been the policy of the Council, which it has rigidly observed, not to make a grant for assistance to any research which it considers should be undertaken in the scientific branch of the Department concerned. In one case the Council came to the assistance of a Department. Early in 1917 the Forestry Branch of the Department of the Interior, desiring to initiate investigations on the rate of growth of the more valuable forest trees in Eastern Canada, with the view of determining the conditions which would favour reforestation on a large scale, applied to the Council for a grant to enable it to undertake this research. The Council, knowing that the budget of the Department for that year could not provide the funds required, and recognizing the urgency of the information which such an investigation would give, gave the grant required and repeated it in each of the three succeeding years. At the end of this period, however, it recommend that the Department should make provision in its own budget for carrying on this investigation to its completion, a recommendation which was accepted, and the Forestry Branch is now carrying on the forestry studies on a scale which will, it is believed, be of the very greatest service in initiating a successful system of reforestation which Canada must undertake if one of her largest natural resources is to be maintained undiminished.

It should be noted that in two other instances the Council did recommend that the Government provide for investigations on problems of outstanding importance. One of these was the utilization of the low grade lignites of Western Canada for domestic fuel by the carbonizing-briquetting process. Early in 1917, the Council, after a very careful consideration of the factors involved in this process, and also of the need of some prepared fuel in the West which would take the place of the anthracite imported from Pennsylvania, urged that a grant of $400,000 be made by Parliament to undertake this investigation. This recommendation was not accepted by the Government, but because of the urgent necessity of providing for Manitoba and Saskatchewan an efficient substitute for anthracite, the price per ton of which was then rising there to an almost prohibitive figure, the Administrative Chairman, authorized to do so by the Council, approached the Governments of those two Provinces to induce them to make provision jointly for this experimental investigation. This led to negotiations with the Federal Government on this subject, the result of which was an agreement whereby these Governments undertook to make provision in common for the investigation under a Board known as the Lignite Utilization Board, composed of three members, one representing each of the three Governments, a Board which is now carrying on the experimental work of this investigation in a plant erected for that purpose, near Bienfait, in Saskatchewan. Had it not been for the Council there would have been no attempt made to determine the economic feasibility of the lignite carbonizing-briquetting process. Further, had the Government accepted the original recommendation of the Council it is likely that the experimental work of the investigation would have been carried out by a Board appointed wholly with the approval of the Department of Mines, which from the first desired that this investigation be undertaken and which approved of the Council's original recommendation. As the situation has so far developed the representative of the Dominion Government on the Lignite Utilization Board is a nominee of the Department of Mines.

In the other instance the Council acted in co-operation with the Mines Branch of the same department. In 1919 there was an insistent demand that the peat supply of Eastern Canada should in some measure be utilized as a source of fuel for domestic purposes. In co-operation with the Director of the Branch, Dr. Haanel, who had for several years previously given special attention to peat as a possible domestic fuel, it recommended that an attempt be made to develop commercially the methods for preparing peat for the market, a recommendation which was accepted by the Government and in consequence, and in co-operation with the Ontario Government a Peat

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Committee was constituted of representatives of the two Governments, which with the assistance of a technical staff some members of which are members of the staff of the Mines Branch, is now operating a plant at the Alfred bog, from where already a large output of prepared peat has been shipped to, sold and used in Ottawa, Montreal, Peterborough and other centres in Ontario and Quebec. The degree of success which has attended this work may be gathered from the report of Professor Purcell, the technical advisor of the British Peat Board, who examined the work of the plant at Alfred, in which he states that the methods for the exploitation of peat as fuel as employed there are far in advance of those in use elsewhere.

Thus the Council has acted throughout the last four years, avoiding everything that would give rise to even a suspicion of duplication of work or overlapping in research or scientific activities. It may, perhaps, have been over-scrupulous in this, but it is better to err thus than to encourage in the slightest degree any activity which might appear as a duplication of any research carried on in a Government service or in any institution outside it. The funds available anywhere to assist research are all too small and to apply any of them wastefully is, in the opinion of scientific men generally, a crime. Research to-day in many lines, and especially in those involving industrial application, involves long-continued patient efforts on the part of those engaged in it, and therefore, the funds devoted to it should be expended as economically as possible. That is the view which has determined the policy of the Council for the last four years, and it has rigidly observed that policy.

So much for the Council in respect to its own activities in promoting research. There remains the question of duplication and overlapping in the activities in the technical and scientific services of the Government.

As pointed out in the foregoing some of these services were understaffed during the last three years of the war period and in consequence their activities were very considerably curtailed. Duplication, if it had previously obtained, was reduced to a very considerable extent and an investigation of its extent during that time would not have given an indication representative of it as it obtained before 1915 or since 1918. In the two and a half years since the close of the war, however, the services resumed their former activities, inclusive of those which possibly involved duplication and overlapping of effort, and the situation was then such as to make it appear advisable in the public interest, as well as in the interest of the Government Departments concerned, to ascertain the extent and character of this waste of effort. In an attempt made in 1920 to determine the feasibility of the task involved, however, the Administrative Chairman found that any information which might be elicited on the subject through inquiry by the Council, because it would be unofficial, could not be used as the basis of a report thereon that would be authoritative. The Research Council has no inquisitive powers on this score and, accordingly, such information, to be decisive, must be obtained by some one specially appointed to that end by Order in Council, empowered to investigate the technical and scientific services in the various departments and to call before him for examination the chiefs and others of the staffs of those services in order to make an accurate survey of their work and thus to obtain the facts for a report which would be accepted as authoritative.

There the question rests so far as the Council is concerned.

That overlapping and duplication of effort in the scientific and technical services of the Government may, if unchecked, attain a formidable character, may be gathered from what has developed in Government Departments abroad. According to Mr. Adolph Lewisohn, Chairman, and Mr. J. Parke Channing, Vice-Chairman of the New York Committee of the National Public Works Department Association, *twenty-five Federal agencies do mapping work, twenty-seven have authority to build hydraulic works, thirty to make chemical investigations, twenty-two to make engineering researches,* and so on. This, it has been said, is "in miniature the Government system, an absolute want of system, continual overlapping and reduplication and interference, a might maze, and all without a plan!"

III.—THE NATIONAL RESEARCH INSTITUTE

In 1917 the Council, after a full consideration of all the measures which should be taken by the Government to promote scientific and industrial research in Canada, recommended as of the first order of importance the establishment of a National Research Institute for Canada. In the report of the Administrative Chairman for 1917-18 the situation in regard to the provision made for research as compared with that which obtains in the United States, Great Britain, Germany and France was discussed at length and the result was summed up as follows:—

> "In consideration of these facts which are advanced to show the general agreement as to the urgency for each State to provide for organized research by the establishment of Institutes or Bureaus for Research to assist the development of the industries of each, and also because of the special need in Canada of one such, the Research Council has approved of the proposal that a Central Research Institute be established at the earliest possible date, whose functions will be that of carrying on research, not only in pure science in relation to standards of measurement, quality and composition of material, but also in science applied to the industries of Canada."

The report then concludes:—

> "The work of the proposed Institute would powerfully aid the development of scientific research in Canada by stimulating the Canadian Universities to increase their resources and facilities for research, and thereby to direct into the ranks of science the ablest of their young graduates desirous of qualifying for a career, whether in pure science or in science applied to Canadian industry. It would place at the service of Canadian industry a factor which would ensure its success in the strenuous trade competition which is near at hand. It would, above all, enable the nation to direct its energies towards the economic and right utilization of its untouched stores of national wealth in order that it may bear, with some degree of ease, the almost Atlantean financial burden it is assuming as a result of its playing its part in the present world struggle."

In the report of the Administrative Chairman for 1918-19 the urgency of the establishment of the Institute was again pointed out and it was emphasized in the report for 1919-20, in which the following occurs:—

> "The establishment of a National Research Institute which primarily is necessary to promote a great increase in the developed wealth of Canada is, therefore, necessary to the development of the industries of the Dominion and to enable them to hold their own not only in the home markets but also abroad. The urgency of the establishment of this Institute is, therefore, of the first order of importance and every year lost in effecting this establishment will increase the difficulties which Canadian industry will face in competition with industry abroad, aided by all the resources that scientific research will place at its command."

In the session of Parliament for 1919, a special committee appointed to consider the development in Canada of scientific research which was under the chairmanship of Mr. Hume Cronyn, M.P., gave consideration to the measures which should be taken by the government to foster scientific research and it presented to the House on July 2, 1919, a report in which "the establishment of a Bureau of Standards was recommended but while a generous national support for scientific research was unanimously favoured for reasons then stated no decision was reached as to the precise method whereby that support could be most effectively applied."[1] The

[1] Quotation from the report of the Committee for 1920 presented to the House of Commons on April 27 of that year.

Committee recommended that it be reappointed at the next session of Parliament to consider still further and report on the measures which should be taken to promote scientific and industrial research. *The report was, after a debate in which a number of members participated, unanimously adopted by the House.*

The Committee was reappointed in the following session of Parliament with a membership very largely the same as that of the Committee of the preceding year and again under the same chairman. The Committee presented its final report to the House on April 27. *This, after a discussion on it in the House, was also unanimously adopted, the leading representatives of all the parties endorsing it. A copy of this report is given in appendix "G."*

This report urged the establishment of a National Research Institute of the same character as that recommended by the Research Council. To the functions which the Council proposed the Institute should perform the Committee added one: "researches undertaken to promote the utilization of the waste products of the industries." Besides outlining the work which the Institute should undertake the report goes on to recommend:—

> "1. That a National Research Institute for Canada endowed with the functions and of the character indicated in the foregoing, be established in the vicinity of Ottawa, on a site fifty acres in area of easy access and conveniently located for water, gas and electric power supply.
>
> "2. That the first building to be erected for the Institute should be of the best modern construction suitable for laboratory work and of such dimensions as to provide accommodation for some years to come.
>
> "3. That there be appropriated by Parliament $500,000 for the purchase of the site and the construction of the building, $100,000 for the scientific equipment of the Institute, and $50,000 for salaries and maintenance during the first year of its operation.
>
> "4. That legislation be enacted at this session to provide for the establishment of this National Research Institute and the government of the same."

In support of the establishment of a National Research Institute came the unanimous pronouncements thereon from the Canadian Manufacturers' Association, Boards of Trade all over Canada from the Atlantic to the Pacific, Canadian and Kiwanis clubs, and scientific and technical societies, including the Royal Canadian Institute, the Canadian Branch of the Society of Chemical Industry, and so on. The approval voiced by the press was equally unanimous.

The Council after more than three years of effort and hope in regard to the establishment of the Institute had reason, therefore, to believe that it would by legislation be provided for. Unfortunately the government did not take action before the close of the session of 1920, and it was with the Council a case of "hope deferred." In September, however, the Council was assured that the Government would undertake at the ensuing session of Parliament to provide the legislation required, a promise which it implemented by introducing in the session of 1921 a Bill for that purpose, a copy of which is rendered in appendix "I," which Bill with amendments introduced in its passage through the House of Commons received its third reading on May 3, only, however, to fail to receive the approval of the Senate at a later date in the same month.

This is not the place to discuss the action of the Senate on the Bill. Indeed it would be impossible to gather from the debate on it what the attitude of the Senate as a whole was on the principle involved. One thing, however, is clear. It is that the members had not given consideration to the history of the effort to bring about the establishment of the Institute or to reasons which led to that effort being made. The work of the Committee of the House of Commons appointed to consider the best means to promote scientific and industrial research in Canada which resulted after two years of careful consideration of the question in a report, adopted unani-

mously by the House, urging the establishment of the Institute as recommended by the Research Council for the last four years, had not engaged the attention of the members, and they consequently were not in a position to grasp the purport of the clauses of the Bill. Perhaps it would have been well if the Senate had a committee, like that of the House of Commons, which would have for two consecutive sessions given careful attention to the question, even if there might have resulted "duplication and overlapping" of effort.

The Council, despite this setback, hopes that the establishment of the National Research Institute will be accomplished by legislation at the coming parliamentary session. The Council is an advisory body to the Government and Parliament on all measures which should be taken to promote scientific and industrial research in Canada. Its members are qualified by their training and experience in science to determine what these measures should be. It has urged now for four years the establishment of this Institute.

In the large number of Committees associated with the Council there are one hundred and twenty-nine representative men of science of Canada. Without exception these and the committees which they constitute approve of the recommendation of the Council that a National Research Institute be established.

Elsewhere Research Institutes have been or are being founded. Of those already in operation there are the National Physical Laboratory of Great Britain, the Bureau of Standards, with its Industrial Research Institute, at Washington, the Commonwealth Institute of Science and Industry for Australia, the Cawthron Institute for New Zealand, the National Institute of Japan, the Physikalische-Technische Reichs Anstalt of Charlottenburg, and the Chemical Institute at Dahlem, Germany, and the Research Institute at Brussels for Belgium.

Besides the Central Research Institute at Dehra Dun, India, which is to be enlarged to cover industrial research on a semi-commercial scale, the Government of India has accepted the proposal to found another central Research Institute advanced by the Chemical Services Committee of the Government. Further, the establishment of a Research Institute for Burmah is now under consideration.

The National Physical Laboratory of Great Britain, as its name implies, concerns itself with research in physical, electrical and engineering problems of all kinds and with the standardization of technical instruments and apparatus, of measurements of length, volume, weight, capacity and energy in its different forms. It, however, also undertakes researches on metallurgical problems in co-operation with the Iron and Steel Institute, the Institution of Mechanical Engineers and other technical organizations. It performs a very great service in the development of many technical processes of the industries.

The function of the Bureau of Standards was until 1919 indicated by its name. Since then it has taken on industrial research work. A building of a very large capacity and of the most solid construction, erected in the immediate vicinity of the laboratories of the Bureau and designed for engineering problems for war service, but completed only in November, 1919, was given to the Bureau by President Wilson and is devoted to Industrial Research which will be carried on on a large scale. In it can be located a large number of industrial plants on a semi-commercial scale and some are installed therein already. All these will be engaged on problems of special importance to various lines of industry as the need for the investigation of these arises.

The functions of the Commonwealth Institute of Science and Industry of Australia are:—

(*a*) The initiation and carrying out of scientific researches in connection with, or for the promotion of, primary and secondary industries of the Commonwealth;

(*b*) The establishment and awarding of industrial research studentships and fellowships;

(*c*) The making of grants in aid of pure scientific research;

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(*d*) The recognition or establishment of associations of persons engaged in any industry or industries for the purpose of carrying out industrial scientific research and the co-operation with and the making of grants to such associations when recognized or established;

(*e*) The testing and standardization of scientific apparatus and instruments, and of apparatus, machinery, materials and instruments used in industry;

(*f*) The establishment of a Bureau of Information for the collection and dissemination of information relating to scientific and technical matters; and

(*g*) The collection and dissemination of information regarding industrial welfare and questions relating to the improvement of industrial conditions.

The Institute is constituted a body corporate, capable of suing and being sued, with power to hold lands, tenements, goods and any other property for the use of the Institute and to acquire by purchase, gift, grant, bequest or device, any such property for the same purpose. The object is to permit the Institute to acquire from private benefactions funds, and endowments to meet the expenses of the Institute. Further, the appointments to the staff of the Institute are not subject to the control of the Commonwealth Public Service Act (Civil Service Act). The Director is subject to the regulations and direction of the Minister of the Commonwealth Government under whose charge the Institute is placed. This gives a freedom of action for the Institute that could not be had if it were directly under a Government Department.

The National Research Institute of Japan, which is established in the suburbs of Tokyo, has already a large part of the endowment of 10,000,000 Yen which those promoting it aimed at the outset at obtaining, large sums having been given by the Emperor and the Diet. It will function, when complete, as a Bureau of Standards and an Industrial Research Institute for Japan. It is expected that it will be of immense service to the Japanese industries in the competition, which they are now facing, for a place in the markets of the Orient.

In the chief lines of German industry, especially the chemical and metallurgical, research has, during the last forty years, been promoted as it has been nowhere else and, in consequence, Germany had, before the war, won for herself a position in the markets of the world which might readily have become a dominant one had her rulers by their criminal folly not brought about that great catastrophe. Even with the aid of research, however, provided for generously from the capital and earnings of the companies concerned, German industry would not have won such a success had it not been for the service given it by the Physikalische-Technische Reichs Anstalt at Charlottenburg and the Chemical Institute at Dahlem. The former, before the Bureau of Standards and the National Physical Laboratory were established, was practically the Bureau of Standards for the world but it primarily performed for Germany an inestimable service. The latter, staffed with scientific men of pre-eminent research capacity and concerning itself with investigations of fundamental interest in Chemistry as applied to German industry was uutil ten years ago without a peer outside of Germany.

To repeat, there are in Great Britain, Germany, Belgium, the United States, Australia, New Zealand, India and Japan, National Research Institutes which have played or are certain to play a decisive part in the struggle not only for a place in the markets of the world but also for each nation to maintain a supremacy of its home trade. In Holland and the Dutch colonies there are, and in France, Italy, Finland, and Czecho-Slovakia there are projected, organizations which will provide for each one of these the service of a National Research Institute.

The lesson for Canada is an obvious one. Almost everywhere abroad there is a recognition of the value of scientific research as a factor in the promotion of national prosperity, scientific research, not casually pursued as was the case in the past, but organized and directed to the economic utilization of the natural resources of each

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country and to the promotion of human welfare. The day is past when organized society, Micawber-like, waited for something "to turn up" instead of persistently and strenuously directing its efforts to the acquisition of the knowledge that will lessen toil and make life a greater boon than it is to the "dim millions" of the masses.

There must be in Canada an organization, a National Research Institute, in which will centre many of the activities engaged in research with the object of increasing the developed wealth of the Dominion which has been estimated to be something over eighteen billions and less than twenty-five billions of dollars. Under the operation of this Institute properly supported and efficiently organized, there would result an increase in this wealth to perhaps ten times as much in two or three decades. The developed wealth of the United States is estimated to be as much as three hundred billions of dollars.[1]

Canada is less wealthy in natural resources than the United States only in tillable land, coal and water power. The leeway for the development of the wealth of Canada is so great that if this development is achieved in any considerable degree, the debt of the Dominion, $2,350,000,000, and, therefore, now a heavy burden, may become if not a negligible, at least a very light, one on the nation.

In the United States, research, especially in connection with industry, is now being carried on on an enormous scale. There are, it has been claimed, more than 2,000 firms which maintain laboratories specially equipped and staffed to carry on research each in its own line. The Dupont Company, the Western Electric, the General Electric, the Nela Company and a number of other firms spend annually huge amounts to this end. Further, it is estimated that about $30,000,000 will have been spent in 1921 for research of which amount one-third is voted by Federal and State Governments, the remainder being derived from private sources. Research is fostered there as it is nowhere else to-day.

The people, the Parliament, and the Government of Canada cannot be and ought not to be indifferent to this situation. The nation must not be forced in the matter of new knowledge to live on the crumbs that fall from a wealthy neighbour's table. The establishment of a National Research Institute is the first and the earliest measure that should be taken to put Canada in a position to hold her own, to develop her natural resources and thereby to permit a great increase in her population.

This Institute should, as advocated by the Research Council, be under its control, subject of course to the approval of the Sub-Committee of the Privy Council for Scientific and Industrial Research in such matters as the appointments to and the salaries of the staff of the Institute, and the acceptance of grants, donations or bequests given under conditions by private individuals or companies to support special lines of research. The Council should be made a body corporate to administer such and other funds and to acquire and hold property of all kinds necessary for the carrying on of the work of the Institute.

The membership of the Research Council, constituted as the governing body of the Institute, should always consist of representative men of science and some of the leading industrials of the Dominion who would by this membership in the Council be a guarantee to the business, industrial and other producing sections of the nation that the work of the Institute in the line of research would constantly aim at practical results. Without representatives of those sections the Council would indeed in the management of the Institute see to it that its work should be intensely practical, but it would contribute to the success of the Institute for its managing body to have the confidence of the business and industrial classes of the country. To have other interests officially represented in the Council, for instance, those of certain sections of the

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[1] The incomes on which taxes were levied in 1918 by the Federal Government at Washington amounted to about $13,400,000,000, but it is believed that if all incomes were included the total would exceed very considerably $20,000,000,000. From this one may infer approximately what is the total of the developed wealth of the United States.

Civil Service, would suggest in the popular mind a tendency to bureaucratic control of the Council or give it a "political complexion" which would impair its usefulness. The National Physical Laboratory of Great Britain is not directly under the control of any Government Department although it receives a large vote annually from Parliament, in some years in the past a sum often in excess of £150,000. It is under the management of a committee of the Royal Society of London. The Australian Institute of Science and Industry is an organization apart from the Commonwealth Civil Service and is subject in the exercise of certain of its functions only to the approval of one of the Commonwealth ministers. The Research Institute of Canada should be wholly free from political control except that exercised as indicated above by a Sub-Committee of the Privy Council. It should be free from even a suspicion of such a control.

Except in the determination of standards, the Institute should not, in the slightest, concern itself with routine work. Standards of the utmost accuracy are used in industrial research and provision must be made for the determination of such in the Institute. Further, not a few of these standards are based on the ultimate properties of matter which, therefore, to be of service must be determined with extreme precision and by methods and apparatus that are not used in ordinary standardization. It would imperil the usefulness of the Institute to do routine work in any other line. The Institute, except in the respect mentioned, should be devoted to research wholly. If routine work were included in its activities, even at first ever so little, it would ever tend to increase and ultimately greatly lessen its research work. The present Food and Drugs Laboratory, the Customs Laboratory, and the Laboratories of the Department of Mines must, therefore, continue to be maintained as they are now as must likewise those under the Department of Agriculture.

That the establishment of a National Research Institution for Canada is of the most pressing importance is the unanimous opinion of the Research Council. It has, let it be repeated, urged this establishment for the past four years. It earnestly urges that legislation should be enacted at the coming session of Parliament to bring about this establishment. The final hour of opportunity has arrived. If it passes unheeded it may be irretrievably lost. It may then fall to sciolists and amateurs to advise as to what should be done to meet the extreme urgency which Canada will face in the next few years. If that should eventuate, then, to paraphrase an ancient utterance: "If it befalleth me as befalleth the fool why should I labour to be more wise"?

In closing this part of his report the Administrative Chairman deems it opportune to place before the readers of it the views on the part which scientific research may play in promoting the welfare of a nation expressed in a portion of an address delivered on April 27, 1921, by the Right Hon. A. J. Balfour, whose sanity of thought and outlook and whose long experience in public affairs give his views on this subject a special value. The occasion for the address was the inaugural meeting of the British Institute of Physics:—

> "The public knows very little about the work which the Council of Industrial Research is carrying on—the public very seldom knows much about the things which most deeply concern it.
>
> "Industrial research is one of the things which most deeply concern the public, and I confess that when I see great industrial disputes going on about the distribution of the results of industry I cannot help thinking. "Why do you not devote half the amount of money involved to increasing the power of man over nature, which would increase the share and increase the total result to be divided among the members of the community, instead of devoting your energies to saying how the relatively petty amount we produce is to be divided among the producers?
>
> "I do not believe that the mere expenditure of money, the mere growth of laboratories, or the mere multiplicity of students is going to produce a larger

crop of men of genius, but a large amount of work which does not itself bring to maturity some great discovery is required if great discoveries are to be made.

"I believe that no money is better spent than that devoted to scientific research; no money gives a greater spiritual return; no money is going to have a greater pecuniary return.

"I am often surprised that the imagination of great magnates is not stimulated by the idea that they can really add to the wealth of the whole world by encouraging industrial research. There is nothing selfish about it, and nothing narrow about the results of an increase in physical knowledge.

"What is discovered at the University of Cambridge, of which I happen to be Chancellor, is equally of use in Paris, Chicago, Japan and at the ends of the earth. It is a gift of mankind.

"When I reflect, as I think political economists are rather slow to reflect, on the prodigious changes which discovery has made on the lot of mankind, I am surprised that more is not done by men who do not lack either the spirit of liberality or the means of exercising it.

"I cannot help thinking it is in part due to an imperfect appreciation of the real facts of the case and to the fatal desire to see an immediate result.

"Sometimes an immediate result is obtained, sometimes the discovery lurks undeveloped from the industrial point of view for a generation, but it matters not which—the life of the nation and the life of the community of nations is long, and anything which adds to our knowledge of the physical universe, either in our lifetime or that of our remote descendants, adds something material to the happiness of mankind.

"The hope I have for the world is that by the growth of science invention will give comfort and leisure where at present discomfort and labour are the only means of producing an article and that the people will learn how to use their leisure.

"That is the idea of progress which I think holds out most hope for the future, and that is based on the work of men who are engaged upon probing to the bottom the secrets of nature."

It suffices to add, by way of comment, that the constituted authority of a nation should, as a Government chosen from and by its best, be as appreciative of what industrial research may do to promote national prosperity as Mr. Balfour supposes "great magnates" ought to be.

APPENDIX "A"

REPORT OF THE ASSOCIATE COMMITTEE ON MINING AND METALLURGY FOR THE YEAR 1920-21

The Associate Committee on Mining and Metallurgy during the year devoted its attention chiefly to one of the most important problems which faces Canada at the present time from the standpoint of its economic development, viz, that of the utilization of the deposits of low grade iron found in the Dominion. Notwithstanding diligent research by many persons well qualified for the task, but few bodies of high grade iron ore have hitherto been discovered in the Dominion of Canada. On the other hand, many large bodies of low grade ore are known in localities which are comparatively easy of access.

The development of a large iron industry in Canada, so far as can be seen at present, is therefore dependent on the possibility of the utilization of those great bodies of low grade ore. The difficulty of utilizing such deposits is increased by the

fact that in the adjacent territory of the United States large deposits of high grade ore occur which are easily worked and are now mined on a very large scale. Ores from these deposits are imported very largely into the Dominion of Canada, and the Canadian low-grade ores must be made available at a cost which will enable them to compete with these ores from the United States.

The present time, however, seems to be a very opportune one for a thorough study of the possibilities of the utilization of the low-grade ores of the Dominion, seeing that extensive experiments on the low-grade ores in the Mesba region are now being carried out by large operators in the United States, indicating that they consider the supplies of high-grade ore are threatened with serious depletion.

The Committee has accordingly carried out its work along two lines.

In the first place it has collected all the reports on the iron ore deposits of Canada which have been made by Government surveys, commissions, etc., and has also been given access to a great number of reports on Canadian iron ores made by geologists and engineers to companies and private individuals, which reports are confidential and have never before been made available for public use. Many of these, however, are of great value. The Committee has carefully studied all these reports, with a view to ascertaining whether there are any considerable bodies of iron ore which have not hitherto been carefully examined, and which warrant further study with a view to their eventual exploitation.

In the second place the Committee has arranged to have smelting tests made on a large scale in the case of certain ores which seem to lend themselves most easily to beneficiation. This work has been already commenced and is still under way, but it is not considered advisable at the present time to make any statement concerning the results which have been attained until the investigation has been further advanced and final results secured. It is expected, however, that the investigation will, when completed, be a very important contribution to the final solution of the problem of the utilization of Canadian ores for the establishment of a national iron industry.

APPENDIX "B"

REPORT OF THE ASSOCIATE COMMITTEE ON PHYSICS AND ENGINEERING PHYSICS FOR THE YEAR ENDING MARCH 31, 1921

At a meeting of the Honorary Advisory Council for Scientific and Industrial Research held on December 12 and 13, 1919, it was decided that an Associate Committee on Physics and Engineering Physics should be appointed, to act as a consultative Committee for the Council on problems presented for consideration and solution in these two departments of science, and also to bring to the attention of the Council all matters relating to physics and engineering physics, upon which, in the judgment of the Committee, the Council should take action.

The members of the Committee as constituted, are as follows:—
Professor J. C. McLennan, University of Toronto, Chairman.
Dr. J. S. Plaskett, Dominion Astrophysical Laboratory, Victoria, B.C.;
Professor T. C. Hebb, University of British Columbia;
Professor Frank Allen, University of Manitoba;
Professor R. W. Boyle, University of Alberta;
Mr. H. O. Keay, Grand Mere, P.Q.;
To retire in May, 1922.
Professor A. L. Clark, Queen's University, Kingston;
Mr. Louis Bourgoin, Ecole Polytechnique, Montreal;

Mr. John Patterson, Meteorological Office, Toronto;
Professor H. L. Bronson, Dalhousie University, Halifax;
Professor A. G. McGougan, University of Saskatchewan;
To retire in May, 1923.
Professor L. A. Herdt, McGill University, Montreal;
Professor T. R. Rosebrugh, University of Toronto;
Mr. W. P. Dobson, Hydro Electric Laboratory, Toronto.
Professor A. S. Eve, McGill University, Montreal;
To retire in May, 1924.

Two meetings of the Associate Committee were held during the year, the first on May 21, 1920, in the rooms of the Advisory Council at Ottawa, and the second on January 14 and 15, 1921, in the Physical Laboratory of the University of Toronto.

At these meetings the following matters, among others, came up for discussion:—

1. *National Research Institute.*

At both meetings this subject was considered and discussed. Preliminary sketch plans were presented by the Administrative Chairman of the Council who explained very fully the need for the Institute and the nature of the researches likely to be carried on in it. The subject was fully discussed by all members of the committee and it was finally decided to recommend to the Council that steps should be taken in formulating plans for the Institute to make provision for the erection of (1) a boiler and power-house, (2) workshops, (3) a building containing rooms equipped for carrying on a variety of researches of a scientific and technical nature. In this building temporary provision should be made for the administrative offices.

2. *Scientific Training of University Students in Undergraduate Courses on Physics and Engineering Physics.*

In this connection the Committee were of the opinion that for a perfectly co-ordinated development of industry in Canada, there should be available in addition to the types of scientifically trained men who gradute from our universities at present, a continuous supply of men who, besides possessing good training in mathematics and chemistry, are specialists in physics and engineeirng physics and who have received a training in research work in these two fields. Such men would have scientific knowledge of a character likely to lead them to the discovery of new methods of utilizing our natural resources, and they would also possess a practical knowledge of affairs which would be likely to enable them effectively to put into operation the methods of manufacture which they should devise.

A resolution was passed by the Committee and sent to the president of each University in Canada asking that consideration be given to the establishment of a combined course in physics and engineering physics in each University.

3. *Marine and Naval Research.*

During the Great War a number of the physicists of Canada were engaged under the British Admiralty in developing means of detecting submarines and in devising measures for minimizing the menace with which this type of naval vessel threatened the safety and well-being of the Empire. In the progress of this work it was found that special devices could, if more fully developed, be provided, that would obviate the dangers of collision between ships at sea, that would facilitate the prosecution of hydrographic work, and that would vastly improve navigation in the neighbourhood of rocky coasts, and icebergs, when the areas in which these were located, were covered with fog or were shrouded in darkness.

With a view to making progress in this direction it was recommended by the Committee to the Council that steps should be taken to co-operate with the Department of Marine and Naval Affairs in Canada, in organizing a scheme by which there would be provided a marine station and workshop with a small ship attached for the

investigation of improvements and new methods in sounding, fog signalling, iceberg detection, and all matters connected with navigation in the inland waters of Canada, and in the ocean areas bordering on the Canadian coastline.

4. *Air Research Problems.*

The chairman of the Associate Air Research Committee, Professor Eve, of McGill University, gave an account of the work of his committee, and placed before the Associate Committee on Physics and Engineering Physics, a list of problems in need of solution.

5. *Bursaries, Studentships and Fellowships.*

A good deal of discussion took place in the committee on the advisability of having the grants given for Bursaries, Studentships and Fellowships increased. Owing to the increase in the cost of living and to the necessity of a research student being free from financial worry, it was finally decided to ask the Council to make the grants for Bursaries, Studentships and Fellowships $750, $1,000 and $1,200 to $1,500 respectively, instead of $500, $750, and $1,000.

6. *Institute of Physics.*

Another question which was considered by the Committee was the formation of a branch in Canada of the Institute of Physics of Great Britain. The Committee consider that the chief need of physicists in Canada at present is a Canadian journal that will enable them to publish scientific papers promptly. A sub-committee was appointed to make inquiries as to the probable advantages likely to accrue from the formation in Canada of a branch of the Institute of Physics of Great Britain, and to report its findings to the next meeting of the Committee.

7. *Toronto Conference on Recent Advances in Physics.*

The second meeting of the Associate Committee on Physics and Engineering was held in Toronto in January, 1921, and was coincident with a Conference in Physics which was held at the University of Toronto. By this arrangement it was made possible for the members of the Committee to attend the lectures and take part in the discussions of the conference. Courses of lectures were given by Dr. L. Silberstein on General and Special Relativity and Spectroscopy, by Dr. Irving Langmuir on Atomic Structure, by Professor J. C. McLennan on the Structure of Matter and the Origin and Character of Radiation, and by Professor E. F. Burton on Colloidal Solutions.

8. *Research Problems.*

A number of problems that were presented for solution were laid before the Committee. Among these were:—

(a) *Methods of preventing the deterioration of cement and concrete in Manitoba and the other Western Provinces.*—In regard to this subject it was decided that the arrangements which the Council were making to have the matter investigated by a committee of the Engineering Institute of Canada under the chairmanship of Professor C. J. Mackenzie, of the University of Saskatchewan, were adequate and were such as would likely lead to a satisfactory solution of the problem.

(b) *Earth Temperatures.*—Professor McGougan made a report on the work being carried on in connection with this problem at Saskatoon, and it was decided to recommend that the Advisory Council should urge upon the Meteorological Department of Canada the advisability of gathering information regarding earth temperatures in different localities in summer and winter at various depths.

At the close of the Second Meeting of the Associate Committee on Physics and Engineering Physics it was decided to hold the next meeting at Ottawa while the Royal Society of Canada was in session.

APPENDIX "C"

REPORT OF THE BRITISH COLUMBIA ADVISORY COMMITTEE FOR YEAR ENDING MARCH 31, 1921

During the year 1920-21, the British Columbia Advisory Committee, originally composed of fourteen members, lost a number of these by resignation and departure from local activities. At the request of the chairman, R. F. Hayward, Esq., a Secretary was appointed in February, 1920, to attend to technical and other matters brought before the Committee and to make preliminary surveys of problems in British Columbia which would merit the attention of the Research Council. It was suggested by the Secretary that the Committee as then consituted was too cumbersome and, with the approval of the Chairman of the Council, a small executive committee of three was appointed, to act when required. Messrs. J. M. Turnbull, H. R. MacMillan, and C. McLean Fraser consented to act on this committee.

During the past year the following problems have received attention from the secretary in British Columbia:—

Complex silver-lead-zinc ores,
Iron and steel development,
Utilization of fish offal and non-edible fish,
Wood waste and preservation,
Wood fireproofing.

THE COMPLEX ZINC ORE PROBLEM

This problem has been the subject of very considerable research in many countries and has also been the subject of considerable bounties in British Columbia, with the object of developing a more economic method of treatment than is now possible.

At the request of the Chairman of the Council the Secretary submitted a scheme for research on these ores, and subsequent to approval by the Sub-committee on Mining and Metallurgy, a grant was made for the purpose of carrying on the investigation in the city of Vancouver. A commencement was made on this work in November, 1920, under the personal charge of the Secretary. Valuable information in this direction has already been obtained and the research is still in progress, a report on which will be presented in due course.

IRON AND STEEL DEVELOPMENT IN BRITISH COLUMBIA

There is a very keen desire in British Columbia for the development of an iron and steel industry to utilize the ores, fuels, water powers and labour of the Province. Such a development would have a very far reaching effect upon economic conditions and for this reason it has received the attention of individuals, syndicates, Boards of Trade, the Provincial Government and many other organizations.

The ores of British Columbia are mainly magnetites, often carrying high sulphur and up to 2 per cent copper, existing in the form of large and small deposits widely distributed, on the coast and in the interior.

This ore in its raw state is not suitable for blast furnace operation, as it would be difficult to separate the sulphur and copper so as to produce a good grade of pig-iron.

Furthermore, magnetite is not considered good material for blast furnace operation owing to its refractory nature, necessitating high furnace temperatures which are destructive to brick linings and also requiring a greater consumption of coke, although from a chemical point of view, magnetite, containing less oxygen than hæmatite, requires actually less carbon to remove the oxygen.

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A third objection to the blast furnace method exists in the poor quality of the coke available on the coast, which is high in ash and often carries sulphur.

The above technical obstacles, more than lack of market, have prevented development of the industry in the Province.

In order to overcome them it has been proposed to utilize the electric reduction method, with its available high temperatures and using charcoal as the reducing agent. The advocates of the electric reduction furnace do not seem to have realized the necessity for very cheap electric power and for large and cheap supplies of charcoal of a dense nature for the purpose. To reduce a ton of pig-iron requires 2,600 K.W.H. of electric energy costing (at 1½ cents) $39. This is almost the value of the pig-iron laid down on the coast. It does not seem possible to develop electric power in the Province at the extremely low price that this method of reduction calls for. The charcoal which might be made available from mill waste is not well suited for this process as it is too soft to carry the weight of ore in the furnace.

A great deal of investigational work is now being conducted in various parts of the world, on the low temperature reduction of magnetite ores by solid and gaseous reducing agents such as powdered coal and producer gases. It has been well shown that magnetite ores can be reduced in this matter at temperatures far below the fusion points of either the ore, the gangue or the iron itself. The iron remains in the form of a powder.

It appears to the writer that this method offers a solution of the difficulties met with in the development of the industry in British Columbia. The following outline will indicate the advantages to be gained.

The magnetite ore containing sulphur and copper is crushed and subjected to magnetic separation. An iron concentrate is obtained, containing over 60 per cent iron and a very much reduced sulphur and copper content. The copper concentrate contains 20 per cent iron, most of the gangue, and up to 10 per cent copper as well as most of the sulphur. This concentrate would be smelted for copper content.

The iron concentrate is reduced in a rotary kiln with a reducing flame of powdered coal, producing iron in the form of powder, which is subjected to magnetic separation to eliminate the ash of the coal and other impurities. It is then melted down in the electric furnace.

The advantages to be gained from the application of this method to British Columbia conditions would be as follows:—

Sulphur and copper can be largely eliminated by mechanical means and copper values recovered.

Local coals can be used irrespective of ash or sulphur content.

The operation of melting down the iron powder requires only one-tenth the expenditure of electric energy that is required in the electric reduction furnace to produce the same amount of iron, consequently the cost of electric power is not so important.

Magnetite ores can be treated without the addition of hæmatite.

Sulphur and phosphorus can be entirely eliminated in the electric melting furnace at will of the operator, the carbon content can be regulated and almost any grade of pig-iron, steel or alloy can be produced in the same furnace as desired.

Heavy electric installations will not be required.

The plant could be installed in units as required by the market and various products of iron and steel could be made in any unit as required, a very important consideration when opening the industry.

The above and other considerations are of prime importance and should receive the closest attention from those organizations in the Province which are endeavouring to promote the industry.

PRODUCTION OF FISH MEAL AND FISH OILS

In connection with the utilization of fish waste and non-edible fish, the Secretary visited a number of plants during the year. A considerable number of treatment plants have been erected from time to time on the Pacific coast but without any general success. For some years past this industry has been regarded as unprofitable by local banks, which now seldom give support to enterprises of this nature. The causes of failure are several.

The material treated consists of

Salmon offal from canneries,
Halibut offal,
Condemned herring and pilchard,
Dog fish.

Dog fish are caught by Japanese fishermen who usually operate on contract and receive about seven dollars per ton delivered at the reduction plant.

The yield of oil and meal from salmon offal is approximately one ton of meal and eighty (U.S.) gallons of oil per thousand cases of salmon packed. This year British Columbia pack of 400,000 cases therefore is equivalent to 400 tons of meal and 32,000 gallons of oil, worth approximately $30,000 and $10,000 respectively.

The rendering process employed on the coast is often extremely crude from a technical point of view. The raw fish is cooked usually with live steam and with agitation to the state of a thick slurry. It is sometimes allowed to drain before being pressed in hydraulic presses. The liquors are run into settling tanks where the oils separate and are skimmed off. Much oil is lost by the crude methods employed in some plants. The pressed fish is now dried in steam or direct heated driers with agitation. The product is termed fish meal and is graded according to its oil content. It contains up to 15 per cent oil and is then liable to heat up when stored. It commands a market as an ingredient in stock and poultry feed, for which there is a rapidly increasing demand in the Province. The oil from the pressing agitation is sold as body oil to distinguish it from liver oil. When dog fish are treated the livers are separated and rendered separately in steam-jacketed kettles.

In considering this industry and its possibilities for development there will be required:—

A continuous supply of raw material.
A uniform method of treatment for all kinds of raw material, producing uniform products.
A local and reliable demand for those products.

In dealing with the first it is obvious that a large industry could not be built up on salmon offal alone or dogfish alone, although were it possible to use all the raw material available in one and the same plant an industry of some value and providing considerable employment could be established.

It is comparatively easy in the existing type of plant to produce an excellent meal low in oil content from salmon or herring, but difficult to make a meal low in oil from dogfish. It is not easily possible for the existing plants to change the mode of operation with varying shipments of raw material. Furthermore, the oils from these raw materials vary greatly in their qualities and in the prices they command. In order therefore to produce uniform products to conform to the market a considerable change in the processing method will be required.

A meal practicaly free from oil is greatly to be desired and for this reason the writer would favour the solvent extraction process. In order to obtain a reliable market for the oils these should be hydrogenated and made available for soap manufacture on the coast. There is a very considerable market throughout the province for poultry feed. The soap manufactures in Canada for 1920 were valued at sixteen

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million dollars and the imports at one and a half millions. The majority of this is laundry soap in the manufacture of which hydrogenated fish oils can be used to advantage.

The hydrogenation process consists in passing hydrogen gas into the heated oil in contact with finely-divided nickel or specially treated nickel turnings. As an alternative the oil may be heated in a nickel lined ball mill containing nickel balls. The mill is revolved while the gas is pumped in through a hollow shaft. The hydrogen gas is absorbed by the oil which when saturated and cooled is in the form of saponifiable fats suitable for soap and other manufactures. The process is a simple one and is very largely employed in Europe and the United States for treating vegetable and fish oils. Its development on the Pacific coast will depend on the development of a reasonably cheap source of hydrogen gas. If oxygen could be utilized in any manner in connection with the refining or treating of these oils both gases could be economicaly generated from water by electrolysis.

In order to process all varieties of raw fish and offal by a uniform method it is suggested that the following general outline be adopted.

The raw material should be cooked with the addition of little or no water in a steam-jacketed vacuum pan with agitation. After sufficient cooking the vacuum is applied and the moisture is extracted leaving an oily sludge containing all of the solids and oils, none of the soluble portions having escaped. Some ammonia would be recovered from condensers attached to the vacuum system.

The moisture-free sludge can now be removed and transferred to an extractor wherein the oil is extracted by a suitable solvent such as gasolene. The writer has produced a meal by this means almost entirely free from oil and without any taint of the solvent by subjecting the meal to a final short heating in vacuum. The solvent can be continuously separated distilled from the oil which remains in a state quite suitable for hydrogenation.

In this matter the maximum yield of meal and oil is obtained and as the operation is conducted throughout in closed vessels, it is free from the usual objections urged against rendering plants.

WOOD WASTE AND PRESERVATION

The wood waste problem of the Province was reported on by the Secretary in the annual report of the chairman for 1920. Since that time no commercial attempts have been made to utilize the waste in any manner.

Attention might very profitably be given to the production of charcoal and wood oils from this waste. If it could be shown that the oils from this waste have a value in the mineral flotation process, they would undoubtedly be produced cheaply.

There is at shingle plants a considerable amount of red cedar waste. Investigation into the insecticidal and germicidal properties of cedar oil as well as its properties as a frothing agent in flotation would be in order. It is possible that cedar oil might be utilized in connection with tarry oils from other mill waste as these possess a value as collecting agents. Cedar wood wool is valued for packing nursery stock for shipment. Cedar oil might have considerable value as a plant spray. It is poisonous. These are matters for research.

In dealing with all classes of mill waste the writer recommends that an attempt be made to carbonize the waste by utilizing an existing mill burner. For this purpose means for restricting the amount of air admitted, and for washing the exit gases so as to collect tar and oils could be provided.

It would also be necessary to provide means for quenching the charcoal produced and for allowing it to dry. As most of the mills concerned are located on waterfront the last points should readily be overcome.

Data on the best values and yields of charcoal and oils from mill waste were given in the report for 1920.

In connection with the treatment of wood for preservation it should be noted that zinc chloride is not as yet used for the purpose in the Province. Creosote is the only preservation used. Should a local manufacture of zinc chloride develop it is highly probable that a considerable export trade would be established to countries with dry climates where chloride treated railroad ties are used.

WOOD FIREPROOFING

An outstanding problem of the shingle industry in the Province was brought to the attention of the Secretary by Mr. F. H. Lamar, of the Shingle Manufacturers' Association of British Columbia.

The cedar shingle manufactures of British Columbia are valued at approximately ten million dollars annually, but this industry is now meeting with severe competition from compounded and so-called fireproof roofings and shingles. Most of these compounded roofings are classified within Class C Fire Underwriters' Association and cedar shingles are not classified. It is believed that but small improvement in the fire resisting properties of the wooden shingles would bring them within the classification.

A very carefully conducted series of tests at the University of Washington has demonstrated that Edge Grain Red Cedar Shingle is quite superior in its fire resisting properties to many of the high-priced prepared roofings that come within the Fire Underwriters' specifications for Class "C". Nevertheless it is highly desirable that a scientific research be made into the treatment of wooden shingles with a view to improving still further their fire resisting properties. Any method developed for the purpose should conform to the following requirements:—

It must be cheap enough to allow competition with compounded roofings.
It must not suffer from, or interfere with, the kiln drying of the shingles.
It must be permanent in effect and weatherproof.
It should not affect undesirably the colour of the shingle or prevent staining of the shingle any desired colour.
It would not be undesirable to treat and stain in one operation.
It should be susceptible of application at the point of manufacture of the shingle, so as to ensure a uniform and standard product.

A variety of substances have been used in various ways for this purpose, but a comprehensive research on the subject would be of great advantage to this industry. Such a research could be conducted within the confines of a small laboratory and combined with advantage with investigation into the by-product possibilities of the red cedar waste of the shingle mills.

CONCLUSION

The above preliminary survey outlines but briefly the more outstanding industrial problems in British Columbia. Each of these problems constitutes a subject for organized scientific research. The solution of these problems would have a very great influence on economic conditions and would provide fields for a great amount of industry and employment.

It is to be regretted that graduates in applied science of the Universities from the Dominion are unable to find employment in their chosen profession within the country and in many cases leave for more profitable fields or abandon their training.

A remedy would be provided in the building of an organization the function of which would be the application of scientific research and discovery to the economic development of the existing industries and the undeveloped resources of the Province.

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APPENDIX "D"

REPORT OF THE PETAWAWA FOREST EXPERIMENT STATION, PETAWAWA MILITARY RESERVE, 1920

Since the last report was submitted, the data collected on the forest survey of the Military Reserve, west of the Canadian Pacific Railway track, have been compiled, and a forest type map of the area has been completed. The types are classified as follows:—

Productive Areas—
White and red pine,
Poplar, birch,
Jack pine,
Balsam, spruce,
Spruce bog,
Hardwoods,
Mixed,

Non-productive Areas—
Fields,
Burns,
Cut over areas,
Open muskeg,
Bog with growth of little value,
Flooded areas.

This series of types is typical of burnt over areas in the range of white pine in Eastern Canada.

As indicated in the last report, the two most extensively distributed types on the reserve are the poplar-birch, and white pine—red pine types. These two types are closely associated, and there are all gradations of mixture from pure pine to pure poplar-birch. This growth appears to have followed fire, that on the main part of the area being about forty-five years old, and that on a smaller area about twenty-five years old. There are considerable areas of jack pine, spruce and balsam and oak and other hardwoods.

As a considerable amount of investigative work on spruce and balsam was in progress during 1920, on cut over pulp lands in Ontario, Quebec and New Brunswick, it was considered advisable to devote the main part of the work at the Petawawa Experiment Station to study of an association of types not being investigated extensively elsewhere. The main part of the work was, therefore, carried on in the white pine-red pine and poplar-birch types.

White pine-red pine type.—There are numerous areas in the white or red pine type scattered over the reserve. While the growing conditions are generally good, one or two large areas show considerable overstocking, and are in need of thinning.

Mixed type, poplar-birch, white pine-red pine.—It appears that, as a general thing, the poplar and birch establish themselves more readily after fire than do the two pines. Where the pine and hardwoods are growing together, the poplar-birch, under certain conditions, gets the upper hand in the early stages and may retard the growth of the pine to a greater or less extent. However, if the pine is once fairly established, it may be expected to grow through the shorter lived hardwoods and eventually reach merchantable size.

Poplar-birch type.—This type is distinguished by the fact that there are practically no pine or other softwoods present. There may be a few isolated well grown pine and some very much suppressed small pine growth; this small growth, however, we cannot expect to reach merchantable size.

The following is a brief outline of the work that has been undertaken during the past year:—

1. Study of the association of poplar-birch type with white and red pine and other softwoods, including a study of the possibilities of increasing the proportion of softwoods and thus improving the general condition of this mixed type of forest.

(*a*) Growth of softwoods mixed with poplar-birch.

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Eleven permanent plots have been established in stands in different age classes and in a variety of mixture of the species. In course of time it will be possible to trace the development or mortality of the species represented, and eventually, it is hoped, indicate the conditions of growth under which pine will or will not survive under poplar-birch. This knowledge would assist, in any particular case, in deciding whether it is economic or not to make a release cutting.

(*b*) Experiments in release of softwoods already established, to determine the conditions under which release of this nature will succeed.

Four permanent plots have been established in stands of different variety, and the poplar and birch have been removed; in order to demonstrate the possibility of carrying out an operation of this nature on a commercial basis, the material to be removed was sold on the stump to local residents for fuel wood.

(*c*) Natural regeneration of white pine and other soft woods under poplar-birch, and an attempt at converting a poplar-birch to a soft wood type.

For the attempt at type conversion, an area of four acres was set aside in a thick stand of poplar and white birch, with a scattering of white pine, red pine and spruce. The poplar, birch and other hardwoods have been cut to a diameter limit of 4 inches; this is the first stage in the proposed plan of operation, and, while it is not expected that anything like a pure softwood stand will be the final result of the experiment, it is hoped that there will eventually be the foundation of a stand, in which white pine and other softwoods will play a very much larger part than they did in the original one. An effort has been made to keep the operation on a commercially practicable basis. For that reason it was considered advisable to sell the material on the stump, under suitable regulations, rather than carry out the work ourselves. The timber was sold to local residents, and yielded about $45 per acre. The slash was piled for burning and the work was carried out in a satisfactory manner.

This experiment provides material for study of natural regeneration, and the three permanent plots established in the experiment area, can be combined with four other permanent pots, to form a series of plots for study of natural regeneration of pine and other softwoods under poplar and birch. These seven plots differ from one another in various respects; they differ in density and to a certain extent in composition, and experiments have been made with various methods of treatment.

2. Study of the use of natural methods in restocking areas at present not productive.

Eleven permanent plots have been laid out for this study; the majority of these plots differ from one another in some important respect. In most cases seed trees are available, and an attempt is being made to discover the reasons for absence of young growth. Cultivation by different methods has been carried out on nine of the plots.

3. Study of normal yield of different species and of the factors influencing yield.

One of the first essential for proper management of forest land on a forestry basis, is information as to the amount of timber that will be produced on a given area in a given time. Normal yield tables are intended to represent the growth that may be expected with normal or fully stocked pure stands, and are classified according to the different site qualities. We look to yield tables when we want to forecast the growth of timber we may except on a given area, or when we have to decide on a species to grow or system of management to adopt.

The factors that influence yield are:—

(*a*) Quality of site.

Site quality is a combination of climatic and soil conditions, the physical factors of site. A system of site classification is essential in the preparation and application of yield tables.

(*b*) Degree of stocking.

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There is for each species, site quality and age, an optimum degree of stocking. On understocked areas we may expect loss in volume and quality of timber produced; on overstocked areas, also we get loss of volume, owing to the small diameter of the timber grown, and in more extreme cases stagnation of growth may result.

(*c*) Intrusion of other species.

In certain cases this does no harm. In other cases, however, the intrusion of less valuable species has a considerable effect on the volume of merchantable timber produced.

European yield tables are constructed, as a rule, for thinned stands. Thinnings are undertaken with several objects, the main one being to secure the highest yield, in volume and quality, on a given area. Tables based on thinned stands may, therefore, be presumed to represent the best growth possible for the species concerned.

As no thinning practice has yet been developed on this continent, yield tables here are generally based on naturally grown stands, stands that have reproduced themselves by natural means and which have been allowed to grow to maturity without any attempts at improvement. There is no question that stands sufficiently stocked in the first place, and thinned as occasion demands, will produce a higher yield, in volume and quality, than stands originally similar but not so treated.

The following studies have been undertaken at Petawawa on the young white and red pine available. Before any final results are obtained it will be necessary to extend the work to older timber and to a number of different localities within the range of the species.

(*a*) A start has been made in the construction of a yield table. Volume measurements have been taken on twenty-seven (27) sample plots; nineteen (19) of these have been established for periodic examination.

(*b*) Seven (7) plots in the above series of nineteen have been thinned. Thinnings have been carried out by different methods, and a number of plots have been left unthinned in order to provide a comparison between the subsequent growths of thinned and unthinned stands.

The main objects of these experiments in thinning are as under:—

(i) To discover the optimum degree of stocking for each species at different ages and on different site qualities.

(ii) To study the effects of different methods of thinning on the growth of timber and on soil conditions.

(iii) To discover the thinning method or methods best suited to the economic situation in this country.

(*c*) Data have been collected for site classification, in connection with this work. No special studies have been made for this purpose, but a large amount of data becomes available in connection with measurements of volume, and a site classification is being proceeded with as the material accumulates.

4. Study of methods of determining volume of standing timber.

These methods find two main uses:—

(*a*) Estimation of timber for commercial purposes.

The old-time timber cruiser depends on his experience in the woods to tell him how many board feet or how many ties are available on a given area. More modern methods entail some system of selection of sample areas; volumes of these sample areas are determined and the timber on the whole area may then be calculated. The basis of this method is the volume table; this may be in terms of board feet, cubic feet, ties or in terms of any other product. The use of volume tables involves measurement of diameters at a certain height, breast height generally, and may involve measurement or estimation of heights. These tables are based on examination of a large

number of trees and may be prepared with the idea of being general tables for a certain species, or may be made for local use only. It is found that general tables for any given species are not necessarily applicable over the whole range of that species; for this reason local volume tables are prepared and it is found that a local table in one watershed does not necessarily apply to the same species a few miles away.

The volume of a tree is a function of its diameter, height and taper; trees of the same height and diameter but with different tapers, may be expected to have different volumes. Taper may be the main factor causing differences in volume tables generally and is undoubtedly the main reason for differences in volume tables based on diameter and height.

In Sweden it has been found that the main species there, spruce, Scotch pine and larch, each follow the same law of taper and Professor Tor Johnson, of the Royal Forestry College at Stockholm, has developed an easy practical means of classifying trees according to their taper or form. It follows from this, that one volume table prepared on the basis of diameter, height and taper or form-class, can be applied to all of the three main species in Sweden. If it is found that Canadian species submit to the same laws of taper as the species in Sweden, it may be expected that one volume table, prepared on the lines of the Swedish table, can be developed and used for estimation of standing timber in Canada. If it can be shown that the application of these methods is feasible, as it is in Sweden, we would do away to a great extent with the present confusion of general and local volume tables for each species.

(*b*) Accurate determination of volume for scientific work, such as is required in the preparation of yield tables and in studies of the effects of thinning.

The most accurate method of determining volume is to cut and measure all trees. This is possible in a logging operation but not possible in connection with permanent plots established for periodic examination. The methods of determining volume of standing timber commonly used in scientific work involve the cutting and measurement of a number of representative sample trees. This amounts to the preparation of a local volume table for that particular piece of timber. If a permanent plot is established for the study of yield, a repetition of this operation would be necessary at each periodic examination. In connection with sample plot work, particularly permanent sample plot work, there would be a distinct advantage in a method of determining volume of standing timber accurately without cutting trees. It is claimed that the Swedish volume tables already mentioned give a result accurate enough for scientific purposes, and the application of these tables does not involve cutting trees.

From both a commercial and scientific standpoint, therefore, it was considered advisable to continue the work already started at Petawawa on the study of the application of these Swedish tables to Canadian species.

From the results obtained so far, it appears that the Swedish tables apply fairly accurately to white and red pine at the ages represented, forty (40) to sixty (60) years. It appears also that the methods of applying the tables, used in Sweden, might be used for white and red pine with slight modification.

It will be necessary to extend this study to other species and to older timber in different localities within the range of the various species.

In addition to the above work at Petawawa, a start has been made in a study of the reproduction of cut-over pine lands. As there are no operations available for this study at the Experiment Station, it was necessary to secure the co-operation of some lumber company. Messrs. Graves and Bigwood, of Toronto, kindly consented to our carrying on this work on their limits, and a series of five permanent sample plots was established in connection with one of that Company's operations in the Algoma District.

The work planned for the season of 1921 includes the following:—

(1) Continuation of the study of methods of improving the general condition of the mixed poplar-birch and pine type of forest.

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Authority has been obtained from the Department of Militia and Defence to cut over 200 acres in this type. Only a small proportion of the timber on this area is merchantable, but the operation will enable us to extend the studies grouped under this head.

(2) Extension of studies of yield to merchantable jack pine and spruce over the reserve, and to merchantable white and red pine in connection with logging operations off the reserve.

(3) Studies of methods of determining volume of standing timber are carried out simultaneously with studies of yield, and these two lines of work will be carried out together.

(4) Studies of the reproduction following logging of pine will be extended to recently cut-over pine lands.

A study of the use of natural methods in re-stocking unproductive areas is dependent on a supply of seed. As last year was a seed year for the main species represented at Petawawa, it is not expected that any of these species will produce seed this year; no plans have therefore been made to extend this work during the coming season.

APPENDIX "E"

FIRST PROGRESS REPORT OF THE ASSOCIATE COMMITTEE ON THE NUTRITIONAL PROBLEMS OF THE FOX INDUSTRY

At its first meeting, on November 15, 1919, the Committee being assured of the co-operation on the one hand of the Health of Animals Branch of the Department of Agriculture, and on the other of the fox breeders of Prince Edward Island, decided to institute a small experimental ranch with attached laboratory, at which, through the agency of a specially appointed resident Biochemist, it might undertake a study of the metabolism and nutritional requirements of the fox.

On December 10, 1919, at the second meeting of the Committee, Mr. G. Ennis Smith was selected to be Biochemist in immediate charge of the experimental work; while Doctors Torrance and Hadwen were appointed to act with the chairman of the Committee as an executive sub-committee dealing with any emergency that might arise during the progress of the research.

Mr. Smith assumed his duties on February 1, 1920, and was instructed in the first place to proceed to Prince Edward Island, establish personal relations with the fox-breeders, and make himself acquainted upon the grounds with the methods and problems of the industry. Upon his return he prepared plans and specifications for the ranch and laboratory, supervised their construction and equipment, and conducted the negotiations which led to the acquisition of the necessary foxes. A report of his activities in these directions, as well as of his visit to Prince Edward Island during the mating season, was received and discussed by the Committee at its third meeting on May 20, 1920.

The experimental ranch was completed on July 8, 1920. Its construction had been made possible only by the co-operation of the Health of Animals Branch of the Department of Agriculture, which provided at its Research Station in Hull, Que., not only the necessary ground-space, but also the pens and kennels for the accommodation of the foxes, and the rooms required for office and laboratory.

The six pairs of foxes with which the ranch was stocked were given to the Research Council, for the purposes of the proposed investigation, by Messrs. Peter G. Clark, Norman McLeod, E. H. Rayner, E. H. Monkley, B. Graham Rogers and George McCallum, all of Summerside, P.E.I. They were received on the very day on which the ranch was finished. The actual work of experiment could be begun therefore about the middle of July.

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The first experiments undertaken had for their object the determination of the maintenance ration for the adult fox. The six pairs of animals were placed upon diets, each composed in the main of meat, milk, fox-biscuit, and porridge, but varying in average heat value from 75 to 155 calories per kilogramme per day. The protein content of the diets was also varied, so that while half of the foxes received about 33 per cent of their total calories as protein, the others received about 39 per cent. (It had been intended to make the variation in this respect greater, but the food analysis showed too late that the object in view had not been fully attained.) The different diets were persisted in during the months of August, September and October, a careful record being kept of the weight, behaviour and general appearance of each animal. The results showed that foxes of about ten pounds weight (most of our animals were of this rather small size) can maintain their weight upon a daily ration furnishing 90, but not less than 90, calories per kilogramme. The ration apparently most satisfactory in its general effects was one yielding about 100 calories per kilogram—only a little above the maintenance level. Greater quantities of food than this effected, to say the least, no obvious improvement in the condition of the animals. It may be taken therefore as fairly well established that for adult foxes of about ten pounds weight, a daily ration furnishing 100 calories per kilogramme, of which about a third are derived from protein, meets adequately the energy and protein requirements of the interval between breeding seasons.

As the breeding season approached, the plan of the experiments was changed slightly so as to yield as much information as possible upon (1) the quantity of food required during the periods of pregnancy and lactation, and (2) the possible effects of variations in food suply upon the many factors concerned in the production and rearing of a numerous and healthy progeny. To avoid complicating the problem too much it was thought best to vary deliberately only the supply of protein and of energy; and to compound the diet always of such ingredients that the essentials, such as calcium, phosphorus, and vitamines, were certain to be abundantly supplied. To this end each dietary was so constructed as to include (1) a fairly wide variety of meat products and offal, (2) several kinds of cereals combined in biscuit form with a proportion of edible tankage, (3) milk, (4) eggs, (5) a certain amount of yeast. These ingredients were combined in six different rations. Each of these had practically the same amount of milk and of eggs; but the meat and cereals were so varied in quantity that (1) three of the rations furnished each approximately 100 calories per kilogramme (i.e., little more than a maintenance ration), while the other three furnished between 130 and 140 calories, and (2) within each set of three one had a relatively low, one a medium, and one a relatively high content of protein. Each pair of foxes was then confined to one of these diets (see appendices I and II).

Unfortunately one female (that on the low calorie—low protein diet) died on December 29, 1920. Of the remaining five, two (high calorie—low protein and high calorie—high protein) did not become pregnant. Three females only (low calorie—medium protein—low calorie—high protein, and high calorie—medium protein) produced litters of six, four and five pups respectively. Two of these litters were either still-born, or killed by the parents within a day or two of birth. The one litter raised to maturity was that of four pups produced by the pair on a low-calorie high-protein ration. As the male parent of this litter, as well as the female of the "low-calorie, medium protein" diet, sickened and died at a later date, the first season's work ends with a net increase of one in the total number of foxes.

Such a record is of course on first thought extremely disappointing; yet, as the outcome of an experiment deliberately planned to test the effects of diet, it ought not to be ascribed, without further consideration, to mere ill-luck. It would be equally rash to conclude at this stage of the work that the diets had much, or even anything, to do with the failure of certain pairs to breed, or that of others to raise their offspring; but the possibility that they were effective factors in such directions deserves at least to be further tested. Meanwhile, from the very limited number of

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experiments made only one definite deduction is permissible, namely, that the "low-calorie, high-protein" diet is a satisfactory one for the mating season and the period of gestation. The characteristics of that diet are that it furnishes about 100 calories per kilogramme (not much more than a maintenance ration); that approximately half of the calories are supplied by meat products, a quarter by cereals, and the remainder by milk and eggs; and that the meat products include a considerable proportion of offal. The Committee feels that such a diet can be recommended with considerable confidence as suited to the requirements of the pregnant fox.

For several weeks after parturition the mother fox has to meet not only her own requirement, but also, through the provision of milk, that of the rapidly growing litter of pups. Her total requirement therefore increases considerably beyond that of the period of pregnancy. It would be important to determine experimentally just what quantities of food will meet the total requirement at various stages of lactation and for litters of various sizes. As only one nursing mother was available this year no extended series of experiments with this object could be undertaken. The best that could be done was to observe the effect of feeding to the mother throughout the period of lactation, a ration calculated upon a fairly liberal basis. This ration provided during the first week of lactation about 150 calories per kilogramme, and during the second, third and fourth, 180, 220 and 250 calories respectively. The result was excellent. The mother had apparently always plenty of milk, and the four pups (the combined weight of which at birth is estimated at eight ounces) weighed at four weeks of age a total of five pounds.

The problem of the food requirement during the growth period is one which the Committee feels should be given especial consideration, since it is more than probable that certain faults of diet in early life have consequences that can never afterwards be entirely remedied. Unfortunately the number of young foxes raised on the ranch was too small to permit of this problem being attacked in any comprehensive fashion. It seemed best under the circumstances not to place the four pups after weaning on different rations, but to administer to all an identical diet, and to observe its effect upon the entire group. The pups were separated from their mother at nine weeks of age. Their diet for the next four weeks consisted of milk, eggs, fox biscuits, bread, and porridge. The porridge was made of equal parts of whole wheat flour, rolled oats, corn meal and rice, to which were added a little meat, tankage, yeast and salt. The whole ration furnished about 250 calories per kilogramme, of which 100 were contained in the milk and eggs. When the pups were three months old the standard ration was reduced to 225 calories, of which as before 100 were supplied in milk and eggs, but only 75 as cereals, while meat was now included to the extent of 50 calories. Under this regime each of the four pups has shown very satisfactory growth, with no sign of rickets or other nutritional disorder. At five months of age they were all bigger and heavier than either of their parents. Although the sire was a woolly fox with fur of a pronounced brown shade, none of his offspring shows these undesirable characteristics. All have fur of good silky lustre, and clear jet-black colour. Even when compared with their dam they are better-looking, and probably more valuable animals.

It cannot be claimed as yet that diet was responsible, either wholly or in part, for the apparent improvement of breed here reported. If it was, the diet of the mother fox during pregnancy had probably nearly as much to do with the result as that of the pups themselves. But it may at least be said that the diet chosen for the pups permitted the development of such good qualities as they may have inherited, and brought them to maturity in an excellent state of nutrition. Whether it represents from every point of view an optimum ration is rather unlikely, and must in any case be tested by more extensive experiments.

The problems of the maintenance requirement, and of the special requirements of pregnancy, lactation and growth are all which it has been possible as yet to attack by direct experiment; and for most of these problems only a partial solution has yet

been found. Nevertheless, as the experiments proceeded, a number of incidental observations have been made bearing upon other questions, such as, for example, the possible influence of diet upon the abundance and quality of the fur. Data upon this and other matters of practical importance are steadily accumulating, but the Committee feels that it is too early even to attempt to estimate their significance.

In conducting the investigations here briefly reported the Committee has been greatly encouraged from time to time by evidences of the interest taken in its work by those actually engaged in the business of fox breeding. This has been shown not only by the demand for the Research Council's Bulletin (No. 8) already published, but also by many inquiries reaching both the Chairman and the Biochemist in charge, and by visits paid by individuals and deputations to the experimental ranch. In view of this interest the Committee decided at the fourth meeting on October 8, 1921, to have Mr. Smith prepare for publication a bulletin reporting, in non-technical language, the conclusions already arrived at. At this meeting it was also decided that, if funds were made available, the experiments carried out in 1921, should be repeated upon a larger scale. It was felt that in no other way would it be possible to decide how far the actual outcome of the season's work was attributable to dietary factors.

The Committee regrets to record the loss of two of its original members—Professor John Tait by resignation, and Dr. Seymour Hadwen by departure from Canada. In their place Dr. E. A. Watson has been appointed a member both of the Associate Committee and of its executive sub-committee.

Exhibit 1 of Appendix E

Daily Rations per pair during Breeding and Gestation Periods.

Description of Diet	Low Calorie			High Calorie		
	Low Protein	Medium Protein	High Protein	Low Protein	Medium Protein	High Protein
Number of diet	13	14	15	16	17	18
Weight of pair, lbs	20	23	21	22½	19½	19½
Cereals, ½ oz	4¼	3¼	2	7¼	4½	3¾
Meat, oz	6½	11	13½	9	12½	16
Milk, fl. oz	10½	12	11¼	12	10½	10½
Eggs	1	1	1	1	1	1
Cereals, calories	405	346	190	718	468	360
Meat, calories	225	388	475	328	450	558
Milk and eggs, calories	270	315	285	307	270	270
Total calories	900	1,049	950	1,353	1,188	1,188
Protein, calories	237	340	359	340	377	422
Nitrogen, gms	9·3	13·3	14·0	13·3	14·7	16·

½ or, alternatively, a caloric equivalent to fat.

Exhibit 2 of Appendix E

Average Actual Consumption per Kilogram per Day during Breeding and Gestation Periods.

No. of Diet	Total Calories	Protein Calories		Gms. Nitrogen
		Actual	% of Total	
13	103	27·1	26·3	1·06
14	102	33·0	32·4	1·29
15	103	38·9	37·8	1·52
16	132	33·3	25·2	1·30
17	134	42·5	31·7	1·66
18	137	48·6	35·5	1·90

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APPENDIX "F"

REPORT OF THE COMMITTEE OF THE HOUSE OF COMMONS, APPOINTED TO CONSIDER THE MATTER OF THE DEVELOPMENT IN CANADA OF SCIENTIFIC RESEARCH, PRESENTED TO THE HOUSE OF COMMONS ON APRIL 27, 1920.

The special Committee appointed last year to consider the above question presented their report thereon to this House on the 2nd day of July, 1919. In that report the establishment of a Bureau of Standards was recommended, but while a generous national support for scientific research was unanimously favoured, for the reasons then stated no decision was reached as to the precise method whereby that support could be most effectively applied.

Your Committee, the majority of whom served in a similar capacity last year, having further considered the whole matter in the light of the evidence and material already adduced have no hesitation in stating that the urgency of action to be taken to establish a National Research Institute to promote scientific and industrial research in Canada is patent to all who know what is being done abroad in this line.

There is in Canada no organization which even distantly approaches the character of any of the Research Institutes abroad or now being establishe.

Great Britain has the National Physical Laboratory at Teddington, near London. Germany has two Research Institutes, one Physical and the other Chemical. In France and Italy measures are being taken to organize Research Institutes. The United States has a National Bureau of Standards at Washington, to which is now attached a laboratory building of exceedingly ample accommodation to be devoted to industrial research. The amount spent by the Bureau exceeds two million dollars a year. The Commonwealth Government of Australia is establishing an Institute of Science and Industry. An Institute for Research known as the Cawthorn Institute is being established at Nelson, New Zealand, by private benefaction. Japan is founding a National Research Institute, for which already ample funds have been obtained from the Emperor, the Government and from private sources.

It is evident, therefore, that Canada, to meet the international competition which the work of these laboratories will serve to accentuate very greatly, must have a National Research Institute, which will place at the command of the country all the resources of Science and further the development of the natural wealth of the country to meet the huge burden of debt imposed by the war. The developed wealth of Canada as compared with that of the United States is small. If the natural resources of the Dominion were appropriately utilized, its developed wealth might readily be as much as ten times what it is now. The conversion of our natural resources into developed wealth, however, can only be accomplished through the application to them of science of the most highly advanced type.

To take one instance only, to show how vital research is to Canada, it may be pointed out that the high grade iron ores of the world are being exhausted, and, in consequence, the lower grades must in the very near future be alone available. Of these Canada has an enormous supply in areas distributed from the Atlantic to the Pacific. We are to-day importing annually at least $150,000,000 worth of ore, iron, steel and their products. If research could show us how to utilize commercially our own low grade iron ores in competition with foreign high grade ores we would not only build up important mining and manufacturing industries throughout Canada, but as well avoid remitting vast sums abroad.

It may be pointed out also, that in Great Britain the industrial firms in a large number of lines of industry are now being organized under the auspices of the Department of Scientific and Industrial Research into Trade Associations for Research. These industries will thereby be put in a position of enormous advantage as regards production. The National Research Council of the United States is organizing similar associations in the United States to meet competition from abroad. In Canada the

organization of similar bodies, "Guilds for Research," must be encouraged by being associated with a National Research Institute.

Your Committee believe the first step towards providing for the research required is the establishment of a National Research Institute whose functions will be to carry on researches, not only parallel to those of the Bureau of Standards at Washington, but such also as will assist in the development of the natural resources of the country and will promote the application of the most advanced scientific knowledge to all lines of industrial production in Canada.

In this connection your committee have considered the following matters:—

1. The scope of the work of the proposed Research Institute and the form of its government.

2. The site of the Institute and the character of the buildings which should first be erected.

3. The appropriation that should be made by Parliament during this session for the purchase of a site. The erection of the buildings and the maintenance of the Institute.

1. The work of the Institute should include the following:—

(*a*) The investigation and determination of standards and methods of measurements including length, volume, weight, mass, capacity, time and heat, light, electricity, magnetism and other forms of energy; and the determination of physical constants and the fundamental properties of matter.

(*b*) The standardization of the scientific and technical apparatus and instruments for government service and for use in the industries of Canada; and the determination of the standards of quality of the materials used in the construction of public works and of the supplies used in the various branches of the Government service.

(*c*) The investigation and standardization upon request of the materials which are or may be used in the industries, and of the products thereof.

(*d*) Researches undertaken with the object of improving the technical processes and methods used in the industries and of discovering new processes and methods which may promote the expansion of the existing industries or the development of new Canadian industries.

(*e*) Researches undertaken to assist in the development of the natural resources of Canada.

(*f*) Researches undertaken to promote the utilization of the waste products of industries.

2. The Institute should have charge, direction or supervision under conditions to be determined in each case of the researches which may be undertaken by or for individuals or industrial firms or by such organizations, to be known as Trade Guilds for Research, as may desire to avail themselves of the facilities offered for this purpose by the Institute.

Your Committee strongly recommend:—

1. That a National Research Institute for Canada endowed with the functions and of the character indicated in the foregoing be established in the vicinity of Ottawa, on a site fifty acres in area, of easy access and conveniently located for water, gas and electric power supply.

2. That the first building to be erected for the Institute should be of the best modern construction suitable for laboratory work and of such dimensions as to provide accommodation for some years to come.

3. That there be appropriated by Parliament $500,000 for the purchase of the site and the construction of the building, $100,000 for the scientific equipment of the Institute, and $50,000 for salaries and maintenance during the first year of its operation.

4. That legislation be enacted at this session to provide for the establishment of this National Research Institute and the government of the same.

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APPENDIX "G"

REPORT OF THE WORK OF THE ASSOCIATE AIR RESEARCH COMMITTEE FOR THE YEAR ENDING MARCH 31, 1921

During the year seven meetings of the Associate Air Research Committee were held—April 17, May 18, July 8, October 9, October 23, November 27, January 18, 1921.

The work of the Committee has been carried on as far as possible in consultation and co-operation with other committees on aeronautical research. Communication has been maintained with the Director of Research, Air Ministry, London; Aeronautical Research Committee, Teddington; the various Departments of the Dominion Government, including the Air Board, Department of the Interior, and the Dominion Meteorological Service. The Committee has been in correspondence with the National Advisory Committee for Aeronautics, Washington, and the Bureau of Standards, endeavour being made in every case to avoid duplication of work and to interchange information as far as possible. The relations with the Technical Department of the Air Board have been especially close, and it is to be noted that the funds for research have hitherto been provided exclusively by the Air Board.

In September, 1920, the Chairman of the Committee, Dr. Eve, paid a visit to Washington, and had the fullest opportunity of becoming acquainted with the aeronautical research work in progress in the United States. Experimental work on the following, among many others, was being carried out:—

Wind channel work, including experiments on the resistance of the velocity of falling bombs;

Investigations on aeronautical instruments, including compasses, altimeters, drift indicators, wireless direction finding;

Investigations on the cause of statics in radio work, determination of the inclination of an aeroplane with regard to the vertical;

Photographic survey work from an aeroplane, the method adopted at the Bureau of Standards being to use a triple camera having a centre plate horizontal and two side plates making an angle of 30 degrees with the horizontal. In this way a strip of country six or seven miles in width can be covered.

Dr. Eve was particularly impressed with the desirability of confining our aeronautical research work in Canada to problems which naturally arise in Canada, not attempting in any way to compete in general research with countries having enormously greater experimental and monetary facilities. It may be added that the Committee has steadily followed this policy.

Dr. Eve was also impressed with the difficulty experienced in the United States, as elsewhere, owing to the dearth not only of trained research workers but also of skilled mechanics competent to develop and construct the necessary apparatus. This matter has been discussed at several meetings of the Associate Air Research Committee but so far no means of getting over the difficulty has been discovered. It is hoped that the establishment of the proposed Research Institute will enable some progress to be made in this matter.

Dr. Eve received the heartiest welcome in Washington and was permitted to see everything without reservation.

During the summer of 1920, Dr. Batho proceeded to England and continued his work at the Royal Aircraft Establishment, Farnborough, furnishing an interesting report of his observations on his return. His report deals with the work then in progress in England, for example, full scale experiments, wind channel work, stability studies, slip stream investigations, wing forms, stalling angles and speeds, air screw

experiments, aeronautical instruments, automatic control of aeroplanes, problems relating to the structural strength of aeroplanes, fire prevention, torque reaction from engines, supercharging and other engine problems.

During the year the Committee has been furnished with copies of R. & M. from Teddington; with the reports of the United States National Advisory Committee for Aeronautics, with the Progress Reports of the Air Board and other current documents regarding research.

Sir Richard Glazebrook has kindly consented to act as the British corresponding member of the Committee, and Dr. McLennan, during his visit to England in the summer of 1920, was also good enough to act as our representative.

At the fifth meeting of the Committee, a sub-committee on Radio Research Work was appointed, the members being Dr. Eve, Professor King, Commander Edwards, Professor Rosebrugh, and Mr. F. C. Higgins of the Air Board. Questions regarding proposed researches in connection with radio work are to be referred to this sub-committee.

As regards the general work of the Committee, the following subjects were dealt with during the year:—

EFFECT OF CLIMATIC CONDITIONS ON DOPE AND AEROPLANE FABRIC

After some preliminary enquiry, it was decided that as no special difficulty has as yet manfested itself owing to Canadian climatic conditions, investigations on this matter are not at present necessary.

VISUAL RECEPTION OF RADIO SIGNALS

This subject has been brought to the attention of the Committee on several occasions and preliminary enquiries as to work carried on elsewhere have been made but it does not appear that the facilities at the command of the A. A. R. Committee are sufficient to warrant embarking on this research.

LANDING GEAR FOR WINTER FLYING

This subject is of considerable interest to Canadian air men and some progress has already been made by the Air Board in the development of suitable winter landing gear. The committee has had under consideration an experimental programme designed to assist in this work.

STRAYS OR ATMOSPHERICS IN RADIO WORK

This question was brought up by the Chairman in October, 1920, and the Committee has endeavoured to enlist the services of a number of observers in different parts of Canada whose simultaneous observations would tend to throw light upon the origin of these disturbances. Very little progress, however, has been made in this respect.

TESTS OF AERONAUTICAL INSTRUMENTS AT LOW TEMPERATURES

A suggestion from the Topographical Surveys Branch, Department of the Interior, with regard to the provision of the necessary equipment for experimental work on this subject was received in October, 1920, and an estimate was made of the cost of the necessary apparatus. In view of the fact, however, that work of this kind is being actively carried out elsewhere it was not felt that the expenditure was justified and the special equipment necessary was therefore not provided.

OPERATION OF CARBURETTORS AT LOW TEMPERATURES

Professor Angus, Department of Mechanical Engineering, University of Toronto, has undertaken a series of experiments with a view of finding out how to avoid

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certain difficulties arising in the operation of aero engine carburettors at low temperatures, and a grant of $3,000 for this work was voted by the Air Board in November, 1920. Considerable delay, however, has been experienced in obtaining the necessary apparatus and equipment and little progress has been made during the year.

OPERATION OF AERO ENGINES AT LOW TEMPERATURES

Owing to the favourable climatic conditions existing at Edmonton, Professor Robb, of the University of Alberta, was asked to undertake a series of experiments intended, especially, to develop the necessary technique for starting aero engines which have been exposed to extremely low temperatures, and a grant of $1,000 was made for this work by the Air Board in November, 1920, the Board also furnishing for the purposes of the experiments a Liberty 12 engine and propellor and the necessary subsidiary apparatus. The services of a suitable mechanic have been obtained and the work has been actively prosecuted with very encouraging results.

ANTI-FREEZE MIXTURES

Work on these materials has been carried out by Professor McKergow, Department of Mechanical Engineering, McGill University, a grant of $200 having been voted by the Air Board for the work. These experiments cover the determination of the freezing and boiling points of various commercial anti-freeze mixtures, the investigation of the changes which take place in them during evaporation, and an enquiry as to the injurious effect, if any, which they have on the pumps, radiators, and connections through which they pass. A preliminary report was made in March, 1921, and the investigations are being continued, the information already furnished having proved of considerable value to the officers of the Air Board.

EFFECT OF LONG STORAGE ON LUBRICATING OIL

This question was considered by the Committee in January, 1921, and arrangements are being made for an investigation with a view of determining the changes, if any, which take place in various lubricating oils suitable for aero engine purposes when these oils are stored for considerable periods at low temperatures. This question is of importance as considerable quantities of such materials are necessarily stored for long periods at various points in the Northwest so as to be available for use if needed.

EFFECT OF CLIMATIC CONDITIONS AND STORAGE UPON THE WOODEN MEMBERS OF AEROPLANE STRUCTURES

Long continued storage of aeroplanes built during the war has been found to affect the wooden members of the fuselage, wings, etc., considerably, owing to the effect of drying out and changes in humidity. An investigation regarding this has been carried out under the auspices of the Committee by the Forest Products Laboratories and the interesting results obtained were embodied in a report to the Air Board.

USE OF QUARTZ FOR BAROGRAPH DIAPHRAGMS

Mr. Stanley Smith, University of Alberta, has undertaken a research with a view of finding whether quartz is a suitable material for barograph diaphragms and whether its employment will avoid the difficulties due to lag and hysteresis which are so prominent in barographs of ordinary construction. A grant of $500 has been made by the Air Board for this work. A similar problem is being dealt with in a different manner by Mr. W. C. Way, of the Surveys Laboratories, Department of the Interior. Mr. Way, with the permission of Dr. Deville, the Surveyor General, is endeavouring to develop a novel form of barograph construction which will eliminate the difficulties above referred to, and has obtained encouraging results.

WIND CHANNEL WORK

A considerable amount of wind channel work has been carried out by Professor J. H. Parkin at the University of Toronto, but no grants have so far been applied for in connection with his investigations. His work has dealt chiefly with the calibration of the wind channel and its equipment and with an investigation on the effect of variation of plan form of wing tips on efficiency, the results having been published as a Research Bulletin by the University of Toronto.

The amount actually expended by the Associate Air Research Committee on account of grants up to March 31, 1921, is $450.

The Committee continues to feel very strongly the need for further interest in air research work on the part of the scientific public, and constant efforts have been made to add to the somewhat scanty list of researchers at present available. The committee would also draw attention to the difficulties arising in connection with research work in Canada owing to the lack of facilities for instrument making and precision mechanical work.

APPENDIX "H"

THIRD SPECIAL REPORT ON THE OPERATIONS OF THE LIGNITE UTILIZATION BOARD, FROM JUNE 1, 1920 TO OCTOBER 31, 1921

The Lignite Utilization Board of Canada was created during the summer of 1918 by Dominion Order in Council. In its relation to business interests, it has the general power of an incorporated company, and in relation to the Governments of the Dominion of Canada, the Province of Manitoba and the Province of Saskatchewan it acts as a trustee.

The personnel of the Board is as follows:—

R. A. Ross, D.Sc., E.E., M.E.I.C., Chairman;
Representing the Dominion of Canada.
J. M. Leamy, Esq., M.E.I.C.,
Representing the Province of Manitoba.
The Honourable J. A. Sheppard, Moosejaw;
Representing the Province of Saskatchewan.

The history of the formation of the Lignite Board, its relation to the Research Council, and a general review of the work carried on from October 1, 1918, to May 31, 1920, are covered succinctly in appendices "E" appearing in the annual reports of the Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research for the years 1918-19 and 1919-20. It therefore seems inadvisable to repeat such information in this report.

At the close of the period covered by the last report the Board stated that the construction contracts had just been awarded for plant buildings, briquetting machinery, power equipment, conveyers, etc.

At to-day's date the Board can report that the construction of its plant is completed. Appended hereto is a diagrammatic perspective showing the general appearances of the plant. With this perspective is a plot drawing showing the arrangement of all the buildings, which layout also illustrates the routing of the material through the plant.

The initiation of production at any new plant is always attended by certain difficulties and trials. New machinery is rarely in a position to operate immediately up to capacity, and small errors and weaknesses must be discovered by trial operation

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and corrected before capacity operation can be attained. It is the intention of the Board to get each department of the plant under operation separately and then to attempt a continuous through-put.

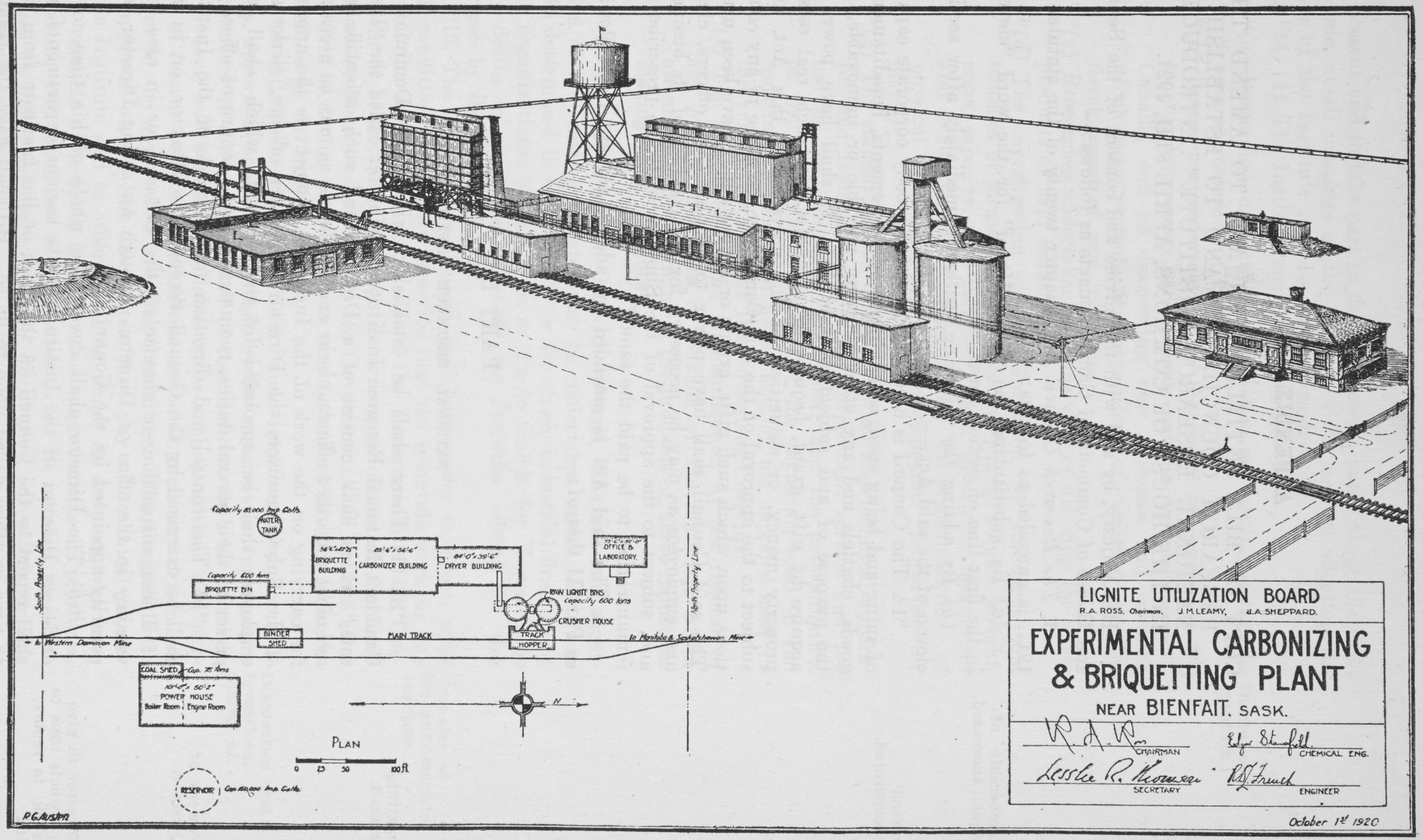
When in addition to the difficulties of starting production with standard apparatus is added the difficulty of initiating entirely new processes, the size of the task before the Lignite Board can be appreciated. At date of writing, the power equipment, the conveyer systems, the dryers and the briquetting machinery have been tested and placed under operation, with, on the whole, successful results. The new carbonizers, of novel design, to which reference has been made in previous reports, have been operated once or twice and have developed minor defects which are confined entirely to auxiliary equipment. Nothing has occurred that cannot be corrected by comparatively unimportant changes, and the Board is still engaged in conducting continuous trials of the carbonizers.

The remaining equipment of the plant calls for no special comment in such a report as this. All the machines are standard, and are such as may be found in any ordinary power plant. The detailed information in connection with these matters will be submitted to the Governments in a complete report at the termination of the work.

The question of the cost of the finished briquettes is one that deserves a word or two. At present the Board proposes to place the briquettes on the market through two distributing agencies, one for the Province of Saskatchewan and one for the Province of Manitoba. The price of these distributors will be in the neighbourhood of $12.50 per short ton of briquettes, f.o.b. plant, and the price to the consumer will be this figure plus freight plus dealers' handling charges.

In order to familiarize the public with the use of carbonized lignite briquettes, the Board has prepared a special memorandum to be distributed very widely, outlining the best methods of firing the briquettes, and giving a certain amount of elementary information on the theory of combustion. Carbonized lignite briquettes, while possessing almost the same heating value as the market grades of American anthracite, possess very different burning qualities, and therefore must be fired in domestic furnaces in a different manner. Copies of this instruction sheet can be obtained on application to the Board's office, Montreal, or to the Souris Coal Sales Company, of Winnipeg, or to the Skingle Coal Company, Moosejaw.

In closing, the Board wishes to record its appreciation of the continued co-operation of the Mines Branch, Department of Mines, Ottawa.



LIGNITE UTILIZATION BOARD

R.A. ROSS, Chairman. J.M. LEAMY, H.A. SHEPPARD.

EXPERIMENTAL CARBONIZING & BRIQUETTING PLANT

NEAR BIENFAIT, SASK.

R. A. Ross — CHAIRMAN

Edgar Stansfield — CHEMICAL ENG.

Lesslie R. Thomson — SECRETARY

R.D. French — ENGINEER

October 1st 1920

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Bill 116

APPENDIX "I"

COPY OF BILL ENTITLED "AN ACT TO AMEND THE RESEARCH COUNCIL ACT AND TO ESTABLISH A NATIONAL RESEARCH INSTITUTE" INTRODUCED IN THE HOUSE OF COMMONS, APRIL 8TH, 1921.

His Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

1. *The Research Council Act,* chapter twenty of the statutes of 1917, is amended as follows:—

Membership of Council Increased.

(*a*) By substituting the word "fifteen" for the word "eleven" in the first line of section three thereof.

(*b*) By adding the following section immediately after section eleven of the said Act:—

Council Incorporated.

"12. The Council is hereby constituted a body corporate capable of suing and being sued, of holding lands, tenements, hereditaments, goods, chattels and any other property movable or immovable, for the purpose of and subject to this Act. It shall have power to acquire by gift, grant, bequest or otherwise any such real estate, property money, or securities for the purposes of this Act, and, subject to the approval of the Sub-Committee, to agree to any conditions upon which such gifts, grants or bequests may have been made. The said Council shall have power to appoint such officers, clerks and employees as may be necessary for the conduct of its business, and, subject to the approval of the Sub-Committee to prescribe the remuneration to be paid the same."

2. The said Act is amended by adding thereto the following as Part II thereof:—

PART II

"NATIONAL RESEARCH INSTITUTE"

Institute created.

"13. (1) There shall be established within the Dominion of Canada a National Research Institute, hereinafter called the "Institute," which shall consist of a Director and such scientific and technical and other officers, clerks and employees as may be necessary for carrying on the work of the Institute. Subject to the approval of the Sub-Committee, the Director and other officers, clerks and employees shall be appointed by the Council, which shall also prescribe their several duties, remuneration and tenure of office.

Powers of Director.

"(2) The control and direction of the work of the Institute shall be exercised by the Council through the Director, or, in case of illness, suspension or absence of the Director, or in case of a vacancy in the office of Director, through an acting Director temporarily appointed by the Council.

Director to give his whole time to work, to report, etc.

"(3) The Director shall devote the whole of his time to his duties as Director of the Institute in its various departments, and shall report to the Council on the work of the Institute from time to time or when called upon to do so. He shall have the right to

be present and to take part in the discussions, but without the right to vote, at all meetings of the Council while matters affecting the work of the Institute may be under consideration.

"14. (1) The Institute shall have charge of— Duties of Institute.

"(*a*) Researches undertaken to promote the utilization of the natural resources of Canada;

"(*b*) Researches undertaken with the object of improving the technical processes and methods used in the industries of Canada, and of discovering new processes and methods which may promote the expansion of existing or the development of new industries;

"(*c*) Researches undertaken with the view of utilizing the waste products of said industries;

"(*d*) The investigation and determination of standards and methods of measurements, including length, volume, weight, mass, capacity, time and heat, light, electricity, magnetism and other forms of energy; and the determination of physical constants and the fundamental properties of matter;

"(*e*) The standardization of the scientific and technical apparatus and instruments for the Government service and for use in the industries of Canada; and the determination of the standards of quality of the materials used in the construction of public works and of the supplies used in the various branches of the Government service;

"(*f*) The investigation and standardization at the request of any of the industries of Canada of the materials which are or may be used in, or of the products of, these industries making such a request.

"(2) The Institute shall have the charge, direction and supervision of the researches which may be undertaken under conditions to be determined in each case by or for single industrial firms or by such organizations, to be known as Trade Guilds for Research, as may desire to avail themselves of the facilities offered for this purpose by the Institute.

"15. The Governor in Council shall have power to direct, upon such conditions as he may prescribe that the scientific work or any part of the scientific work of any of the Departments of the Government or of any part of the public service or of any of the Commissions or Boards constituted by the Government shall, on and after such date or during such period as may be named in such order, be carried on by the Institute. Transfer of Scientific work to Institute.

"16. All discoveries, inventions and improvements in processes, apparatus or machines, made by the members or any number of members of the technical staff of the Institute shall be vested in the Council and be made available under such conditions and payment of fees or royalties or otherwise as the Council may determine, subject to the approval of the Sub-Committee. The Council, with the approval of the Sub-Committee, may pay to technical officers of the Institute and to others working under its auspices who have made valuable discoveries, inventions or improvements in processes, apparatus, and machines such bonuses as in its opinion the commercial or industrial value of such discoveries, inventions or improvements may warrant. Discoveries and inventions, control of.

Money, how to be expended.

"17. The money annually appropriated by Parliament for the work of the Institute, or which the Council may receive through bequest, donation or otherwise, shall be expended under the direction of the Council, subject to the approval of the Sub-Committee, for the carrying on of the work of the Institute.

Financial returns.

"18. All the receipts and expenditures received by or made on behalf of the Institute shall be subject to examination and audit by the Auditor General, and the Director of the Institute shall submit through the Council a statement of such receipts and expenditures to the Sub-Committee at such times and containing such details as the Sub-Committee may prescribe. A statement of receipts and expenditures during each fiscal year shall be laid by the Council before both Houses of Parliament within fifteen days after the close of the fiscal year if Parliament is then sitting, and if not, then within fifteen days after the opening of the then next session of Parliament.

Annual Report.

"19. A report of the work done by the Institute, containing such information and details as the Council and the Sub-Committee may require, shall be made by the Director to the Council and through the Council to the Sub-Committee after the close of each fiscal year, and the said report shall be laid before both Houses of Parliament."

APPENDIX "J"

LIST OF FELLOWSHIPS, STUDENTSHIPS AND BURSARIES, 1920-21

FELLOWSHIPS

Name	Where held	Subject of Research
H. J. C. Ireton.....	Department of Physics, University of Toronto	Part I. "Selected radiations emitted by specially excited mercury atoms." Part II. "Piezo-Electricity and its application to the measurement of Explosive Pressures."
J. A. McRae.....	Chemical Laboratories, Manchester University.	An investigation into the formation of substituted succinic acids from cyanoacetic aldehydes and hydrogen cyanide.
Miss M. Newton.....	University of Minnesota, St. Paul, Minn.	On biologic forms of wheat stem rust. (*Puccinia graminis*).
E. G. Young.....	Biochemistry Laboratory, Cambridge University.	1. Research on the optical rotation of crystalline ovalbumin and serum albumin. 2. The coagulation of protein by sunlight.
J. F. T. Young.....	Department of Physics, University of Toronto.	The crystal structure of magnetic alloys.
H. R. Foreman.....	Department of Physics, University of Toronto.	Resigned.
A. G. Shenstone.....	Department of Physics, University of Toronto.	Resigned.
F. H. S. Warneford...	Department of Chemistry, McGill University.	Resigned.

STUDENTSHIPS

Name	Where held	Subject of Research
G. H. Berkeley.....	Department of Zymology, University of Toronto.	Fermentation of sulphite liquor.
J. W. Burns.....	Department of Chemistry, Queen's University.	Utilization of the common milkweed.
Miss C. W. Fritz.....	Botanical Laboratory, University of Toronto.	An investigation on wood-destroying fungi.
C. Greaves.....	Department of Chemistry, McGill University.	Report on some attempts to prepare metallic beryllium
W. F. James.....	Department of Geology, McGill University.	The alteration of the quartz diabase dike at the Old Helen Mine, Michipocoten District, Ontario.
W. A. Lawrance.....	Chemistry Laboratory, University of Toronto.	Friedel and Craft's Reaction. Some substituted phthalic anhydrides with aluminium chloride and toluene.
A. H. Leim.....	Department of Biology, University of Toronto.	Study of the life-history of the shad.
J. W. McKinney.....	Department of Chemistry, McGill University.	The kerogen in oil shale.
Miss Irene Mounce....	Department of Botany, University of Manitoba.	Monosporic cultures of some six species of *Coprinus* with a view to finding out whether or not monosporic Mycelia are able to produce fruit-bodies.
W. W. Shaver.....	Department of Physics, University of Toronto.	1. The absorption spectrum of liquid and gaseous ogygen. 2. Thalofide cell experiments.
P. V. Rosewarne.....	Department of Ind. Chemistry, McMaster University.	Deferred until 1921–22.
A. W. McCallum.....	Botanical Laboratory, University of Toronto.	Resigned.
J. H. Mennie.....	Department of Chemistry, University of British Columbia.	Resigned.

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LIST OF FELLOWSHIPS, ETC.—*Concluded.*

BURSARIES

Name	Where held	Subject of Research
Miss M. Anderson.....	Bacteriology Laboratory, McGill University.	The growth of *B. pyocyaneus*, *B. typhosus*, *B. coli communis* and *B. coli communis* with *B. subtilis*.
A. H. Bell.....	Department of Geology, University of Toronto.	Special scholarship.
Miss E. M. Hill.....	Department of Chemistry, McGill University.	The autohydrolysis of fats.
A. B. Jackson.....	Department of Botany, University of Toronto.	On a group of parasitic fungi widely destructive of economic plants.
J. F. Lehmann.....	Department of Physics, University of Alberta.	On the properties of ultra-sonic oscillations.
C. A. Mackay.....	Department of Physics, Dalhousie University.	The effect of thermo-luminescence on electrical conductivity.
H. N. Stephens.....	Chemical Laboratory, University of Toronto.	Friedel and Craft's Reaction: Brom-phthalic anhydries with Benzene and Aluminium Chloride.
E. F. Whyte.....	Department of Chemistry, Dalhousie University.	A study of the extraction of potash from orthoclase feldspar by carbon dioxide and sulphur dioxide.
E. P. Dolan.....	Department of Geology, McGill University.	Deferred until 1921–22.
D. W. Bates.....	Department of Physics, University of Toronto.	Resigned.
Miss A. E. Dempscy..	Department Biochemistry, University of Toronto.	Resigned.
P. Lowe.....	Department of Physics, University of Toronto.	Resigned.
W. E. Mooney.....	Department of Physics, University of Toronto.	Resigned.
G. M. Shrum.....	Department of Physics, University of Toronto.	Resigned.
J. A. Sonley.....	Department of Physics, University of Toronto.	Resigned.

APPENDIX "K"

LIST OF ASSISTED RESEARCHES, 1920-21

Grantee	Where carried on	Subject of Research	Amount awarded
			$ cts.
Forestry Branch, Department of the Interior, Ottawa.	Petewawa Forest Reserve.	Forestry studies.....	8,006 32
Prof. R. W. Boyle....	Department of Physics, University of Alberta, Edmonton, Alta.	Research on ultra sonics embracing experiments to develop the transmission and reception in water of elastic (acoustic) waves of a very high periodicity and short wave lengths.	2,500 00
Prof. A. C. Neish....	Department of Chemistry, Queen's University, Kingston, Ont.	Investigation on the utilization of the common milkweed as a substitute for flax; also, for the production of paint oil from the seeds and the production of insulation and other commercial materials from the coma.	250 00
Prof. Wilfrid Sadler..	Department of Dairying, University of British Columbia, Vancouver, B.C.	To continue investigations on the grading of cream and butter in relation to the bacterial content of the cream or milk used in the preparation of these products.	1,000 00
Assoc. Committee on Industrial Fatigue.	.....	To continue investigations on industrial fatigue problems in selected industries, with a view of supplementing the results of previous investigations.	3,000 00
Prof. J. B. Porter....	Department of Mining Engineering, McGill University, Montreal, Que.	To complete investigation on the flotation method of separating Canadian ores, from different sources, by waste oils from wood distillation.	1,500 00
Associate Committee on Mining and Metallurgy.	.....	Investigation on the utilization of the iron ores of Canada with a view to their utilization for the production of pig-iron and steel.	3,000 00
A. F. G. Cadenhead.	Department of Metallurgy, Queen's University, Kingston, Ont.	To continue an investigation on the smelting of titaniferous iron ores.	5,000 00
H. Freeman.....	Special Laboratory, Vancouver, B.C.	Investigation of new processes for the separation of silver, lead and zinc in the concentrates of complex silver-lead-zinc sulphide ores of British Columbia.	10,000 00
Prof. F. M. G. Johnson, Prof. Otto Maass.	Department of Chemistry, McGill University.	Investigation of the surface energy of solids.	85 0 0
Prof. J. C. McLennan	Department of Physics, University of Toronto.	To continue research on the liquefaction of helium.	3,000 00
Prof. J. C. McLennan	Department of Physics, University of Toronto.	Investigation of the spectrum of the infra-red rays, that is, the rays which are not revealed in the ordinary spectrum.	1,000 00
Associate Food Research Board.	.....	Research on the isolation of a pure vitamine to determine its character.	1,200 00
Associate Committee on the problems of the Fox Industry.	.....	To continue an investigation of the problems affecting the fox industry by means of an experimental ranch.	5,500 00
Prof. F. Allan.....	Department of Physics, University of Manitoba, Winnipeg, Man.	Research on colour vision.....	1,000 00

OTTAWA, January 15, 1923.

The Honourable JAMES A. ROBB,
Chairman of the Sub-Committee of the Privy Council
for Scientific and Industrial Research,
Ottawa, Ont.

SIR,—I have the honour of presenting to you herewith the report on the work of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1922.

Your obedient servant,

FRANK D. ADAMS,
Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research.

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The Honourable WILLIAM R. MOTHERWELL, *Minister of Agriculture.*

The Honourable JACQUES BUREAU, LL.B., *Minister of Customs and Inland Revenue.*

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H. M. TORY, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S., President, University of Alberta, Edmonton, Alta.

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George A. Guess, M.A.	Prof. of Metallurgy, University of Toronto, Toronto, Ont.
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W. Fleet Robertson, B.Sc.	Provincial Mineralogist, Dept. of Mines, Victoria, B.C.
F. H. Sexton, D.Sc.	Pres. Nova Scotia Technical College, Halifax, N.S.
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John T. Stirling, Esq.	Chief Inspector of Mines for Alberta, Dept. of Public Works, Edmonton, Alta.
R. H. Stewart, B.Sc.	Consulting Mining Engineer, 736 Granville St., Vancouver, B.C.
J. B. Tyrrell, B.Sc., M.A., M.I.M.M., F.R.S.C.	Consulting Mining Engineer and Geologist, 534 Confederation Life Bldg., Toronto, Ont.
O. E. S. Whiteside, M.Sc.	General Manager, International Coal & Coke Co., Coleman, Alta.

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John Patterson, M.A., F.R.S.C., Secretary .... Physicist, Meteorological Office, Toronto, Ont.

Frank Allen, M.A., Ph.D., F.R.S.C. ..... Professor of Physics, University of Manitoba, Winnipeg, Man.

R. W. Boyle, M.A., Ph.D. ..... Prof. of Physics, University of Alberta, Edmonton, Alta.

Louis Bourgoin, I.Ch. ..... Prof. of Physics, University of Montreal, 228 St. Denis St., Montreal, Que.

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C. A. Robb, B.Sc., M.Sc., A.M.E.I.C.	Prof. of Mechanical Engineering, University of Alberta, Edmonton, Alta.
Stanley Smith, M.A., B.Sc.	Lecturer in Physics, University of Alberta, Edmonton, Alta.
Sir Fredrick Stupart, F.R.S.C.	Superintendent and Director, Meteorological Service, Toronto, Ont.
W. R. Turnbull, M.E., F.R. Ae. S., F.R. Met. S.	Consulting Engineer, Rothesay, N.B.

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A. H. R. Buller, D.Sc., Ph.D., F.R.S.C.	Professor of Botany, University of Manitoba, Winnipeg, Man.
F. C. Harrison, B.S.A., D.Sc., F.R.S.C.	Principal, Macdonald College, Ste. Anne de Bellevue, Que.
Canon V. A. Huard, D.Sc., F.R.S.C.	2 Richelieu St., Quebec, Que.
Andrew Hunter, B.Sc., M.B., M.A., Ch.B., F.R.S.C.	Professor of Biochemistry, University of Toronto, Toronto, Ont.
A. P. Knight, M.A., M.D., F.R.S.C.	Emeritus Professor of Physiology, Kingston, Ont.
A. H. Mackay, B.A., B.Sc., LL.D., F.R.S.C.	Superintendent of Education, Halifax, N.S.
J. J. R. Macleod, M.B., Ch.B., D.P.H., F.R.S.C.	Professor of Physiology, University of Toronto, Toronto, Ont.
W. T. MacClement, M.A., B.Sc.	Professor of Botany, Queen's University, Kingston, Ont.
J. P. McMurrich, M.A., Ph.D., LL.D., F.R.S.C.	Professor of Anatomy, University of Toronto, Toronto, Ont.
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Frank D. Adams, Sc.D., LL.D., F.R.S., Hon. M.E.I.C.	Chairman, Research Council of Canada. (Ex-officio).
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J. M. Turnbull, B.A.Sc., Chairman	Professor of Mining and Metallurgy, and Head of the Department of Metallurgy, University of British Columbia, Vancouver, B.C.
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P. H. Moore, B.S.A.	Superintendent, Colony Farm (B.C. Government Farm), Easondale, B.C.
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Campbell Sweeny, Esq.	Vancouver, B.C.
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ASSOCIATE COMMITTEE ON THE NUTRITIONAL PROBLEMS OF THE FOX INDUSTRY

Andrew Hunter, M.A., B.Sc., M.B., Ch.B., F.R.S.C., Chairman	Professor of Biochemistry, University of Toronto, Toronto, Ont.
Frank D. Adams, Sc.D., LL.D., F.R.S., Hon. M.E.I.C.	Chairman, Research Council of Canada. (Ex-officio).
V. J. Harding, D.Sc.	Professor of Pathological Chemistry, University of Toronto, Toronto, Ont.
G. Spencer Melvin, M.D.	Professor of Physiology, Queen's University, Kingston, Ont.
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Arthur Vallée, M.D.	Professor of Pathological Anatomy, Laval University, Quebec, Que.
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SPECIAL CANADIAN COMMITTEE ON PACIFIC INVESTIGATIONS

J. P. McMurrich, M.A., Ph.D., LL.D., F.R.S.C., Chairman	University of Toronto	Biology.
C. McLean Fraser, M.A., Ph.D., F.R.S.C., Secretary	University of British Columbia	Biology.
Frank D. Adams, Sc.D., LL.D., F.R.S., Hon. M.E.I.C.	Chairman, Research Council of Canada (Ex-officio)	
R. W. Brock, M.A., LL.D., F.G.S., F.R.S.C.	University of British Columbia	Geology.
Chas. Camsell, B.Sc., LL.D.	Deputy Minister of Mines, Ottawa, Ont.	Geology.
Otto Klotz, LL.D., F.R.A.S.	Dominion Observatory, Ottawa, Ont.	Seismology and Allied Sciences.
J. S. Plaskett, B.A., D.Sc., F.R.S.C.	Dominion Astrophysical Observatory, Victoria, B.C.	Astronomy and Allied Sciences.
Sir Frederick Stupart, F.R.S.C.	Meteorological Office, Toronto, Ont.	Meteorology and Allied Sciences.
Arthur Willey, M.A., D.Sc., F.R.S.	McGill University	Biology.

REPORT

OF THE

ADMINISTRATIVE CHAIRMAN

OF THE

HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

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1. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL

Eight meetings of the Council were held during the year, with an average attendance of seven members. Five of these meetings were held in Ottawa and three in Montreal.

The National Research Institute—which the Council considers to be a prime necessity for the further development of its work—not having been erected as yet, the Council has been obliged to confine its activities to those lines of work which it has followed during former years. It has in fact been obliged to "mark time" awaiting the establishment of a National Research Institute whose foundation will make possible new advances and the opening of further fields of investigation and research, for the benefit of Canadian industry and the development of the resources of the Dominion.

The work of the Research Council during the year under consideration may, therefore, be set forth under the following heads:—

(*a*) The training of research workers through the provision of Bursaries, Studentships and Fellowships.

(*b*) The investigation of a number of special problems by grants to investigators, known as "Assisted Researches."

(*c*) The encouragement and development of research by the organization of the research workers of Canada into Standing Associate Committees of the Research Council—and by the appointment of certain special committees to the same end. The scope of the work carried out under each of these heads will be described briefly.

II. TRAINING OF RESEARCH WORKERS

This work has been undertaken by the Research Council in order to develop in Canada a body of university graduates thoroughly trained in the methods of scientific investigation and research to the end that when research workers are required by Canadian industries, the Research Council or the Canadian universities, there will be men in the Dominion prepared and ready to fill the positions as they arise. This training is provided by the establishment of Bursaries, Studentships and Fellowships—each tenable for one year and having a value respectively of $750, $1,000, and $1,200. They are given only to men (or women) who have already graduated from a university and have shown distinct

aptitude for or ability in the field of scientific research. Ordinarily the successful candidate is first appointed to a Bursary, and if he proves to have the requisite capacity may be promoted to a Studentship in his second year, and in his third year may receive a Fellowship. These Bursaries, Studentships and Fellowships are tenable only at Canadian universities, except under certain very exceptional conditions, as for instance, when a man following some special line of research which cannot be carried out in Canada is allowed to study in Great Britain or in some foreign country.

There are each year many more applicants for these positions than there are Bursaries, etc., to be awarded, the successful candidates, therefore, represent an especially able group of young Canadians.

The following table shows the number of Bursaries, Studentships and Fellowships awarded annually during the last five years and the expenditure represented by these awards:—

Year	Fellowships	Studentships	Bursaries	Expenditure	Additional awards resigned		
					Fellowships	Studentships	Bursaries
				$ cts.			
1917–18	3	4	.....	5,550 00	.....	2	
1918–19	3	5	.....	7,150 00	1	4	
1919–20	5	16	5	20,100 00	1	3	2
1920–21	5	10	8	16,925 00	3	3	7
1921–22	7	9	30	37,725 00	.....	3	5
Totals	23	44	43	87,450 00			

The Council has decided to limit its annual expenditure under this head to a sum not exceeding $40,000, which represents the same proportion of the grant voted to the Council by the Dominion Government as is devoted to this purpose by the Research Council of Great Britain from the much larger grant made to it by the Imperial Parliament.

A list of the Bursaries, Studentships and Fellowships awarded during the present year will be found in appendix J of the present report. As will be seen the holders of these awards come from all parts of the Dominion and receive their advanced training in research chiefly in the larger universities of Canada, since in these alone is the requisite staff and equipment for advanced work in science provided.

It may be said in conclusion that these awards have already stimulated scientific research in Canada to a marked degree, and returns which have just been made to the Council show that the 123 persons who have held Bursaries, Studentships or Fellowships, with scarcely an exception, are now engaged in research in connection with industry or hold positions on the staff of our universities where their training enables them to carry on research in addition to their regular instructional work.

III. ASSISTED RESEARCHES

1. *Preservation of Concrete from the Destructive Action of Alkaline Waters.*—A few years ago the destructive effect on concrete of the alkaline waters found in the soil of certain parts of Western Canada was brought forcibly to the attention of engineers and builders when structures of great importance and magnitude, situated in the Prairie Provinces, were found to be slowly but surely disintegrating under this destructive agency. A brief survey showed that structures involving millions of dollars were endangered, and the problem was so

serious that certain engineers of standing decided that until more was known concerning the action of these waters concrete could not be safely used under conditions where alkali ground water would be encountered. The importance of such a conclusion is evident and the Engineering Institute of Canada, considering the problem to be one of the most important facing the profession in Western Canada, decided to appoint a committee to make a thorough investigation of the whole question. Prof. C. J. Mackenzie, M.E.I.C., of the University of Saskatchewan, was appointed chairman of the committee in January, 1922, and the expenses of the investigation were provided for during a period of three years by annual subscriptions during this period from the following bodies:—

Research Council of Canada	$5,000 00
Province of Saskatchewan	3,000 00
Province of Alberta	1,000 00
Canada Cement Company	3,000 00
Canadian Pacific Railway	1,000 00
City of Winnipeg	200 00
	$13,200 00

It was decided to carry on the investigation along two lines (*a*) physical field tests (*b*) chemical research. The blocks for the field tests, numbering about 250, were made at Saskatoon and were placed during the summer of 1921 at selected sites near Winnipeg, Calgary and Saskatoon. The field work was conducted under the direction of Professor Williams, of the University of Saskatchewan. The chemical research has been placed under the direction of Professor Thorvaldson, who is devoting his entire time to the problem for a year, and is assisted by five chemists. A considerable amount of work has been done elsewhere on the physical side and investigators elsewhere are to-day working on various phases of the chemistry of the problem, but the work being done by this committee is the only comprehensive investigation which is being carried on anywhere, aiming at a thorough understanding of the causes which underlie the wholesale destruction of valuable concrete structures in Western Canada. It is not expected that any results will be available for publication till the expiry of another year at least, since the field specimens have to be exposed to alkaline waters of the soil for that period before an examination is made. The research work of the chemists, furthermore, is only in its preliminary stages.

2. *The Preservation of Iron Pipes from Corrosion by Alkaline Waters.*—To investigate the causes of the corrosion of iron piping and other iron structures buried in the soil in the western provinces, the sum of $1,700 was granted to Prof. John W. Shipley, of the University of Manitoba. This corrosion, which causes a very large annual loss in these provinces, is due to the action of soil waters, but what chemical action takes place is not known. This must be ascertained before preventive methods of treatment can be introduced. Prof. Shipley, before receiving this grant, was engaged on this problem for over a year at his own expense, and, from the results he has obtained so far, he is confident that the causes of corrosion can be definitely ascertained.

3. *Determination of the Cause and Treatment of Soil Acidity.*—For the purpose of making a thorough study of the cause and treatment of acidity in the soils of Quebec and New Brunswick, $2,000 was granted to Principal Harrison, of Macdonald College. This condition, which is common in the soils of eastern North America, interferes seriously with the growth of alfalfa, red clover and probably, to some extent, with the majority of useful crops. The numerous methods proposed for the determination of the quantity of lime

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required to correct the acidity of a given soil (the " lime requirement " or " lime absorption coefficient ") have yielded discordant results. Recently, evidence has been advanced to show that the concentration of the hydrogen ion in the soil solution has an important influence upon the growth of certain plants and it is contended that measurements of this concentration are of more importance than those of the quantity of titratable acid in the soil and lead to more reliable estimates of the lime requirement. Equipment for the electrometric and colorimetric measurement of hydrogen ion concentration has been purchased, and with the co-operation of the Quebec Department of Agriculture a few samples of soil have been collected in various parts of the province. Work began on November 1, 1921, using the samples on hand in comparing methods, with a view to selecting one or more, for use on a larger number of samples, which will be collected during the spring and summer. It is hoped that eventually provision may be made for supplementing this chemical work by culture experiments and field tests.

4. *A study of the Crushing Action in Ball Mills.*—Professor H. E. T. Haultain, University of Toronto, received a grant of $400 to continue his work done during the past two years in attempting to analyse the paths of the balls, in ore crushing tube mills, by means of photography. Some five hundred photographs were taken, and a definite advance in the understanding of the process was made. The attempt was then made to secure quantitative results in connection with certain operations which the photographs had illustrated, and the work now in progress promises to give further valuable results. This research has been much aided by a film made with an ultra-rapid camera, taking 120 photos per *second,* which was shown and explained by Prof. Haultain at the meeting of the Canadian Institution of Mining and Metallurgy, held in Ottawa last spring.

5. *Determination of the Character of the Bacteria found in Milk and Butter.*—A grant of $400 was made to Professor Wilfrid Sadler, Department of Dairying of the University of British Columbia, for the completion of his investigation into the character of the bacteria and other germs found in milk and butter. The studies made throw much light on the bacterial flora of graded butter and suggest the importance of the water supply as a possible agency of contamination. They emphasize the possibility of bacterial recontamination subsequent to the pasteurization of the cream, indicate the necessity for bacteriological control in the management of cream and the manufacture of butter, and define cases where specific deterioration of grade has been eliminated or rendered less acute by putting into practice the advice given as a result of the laboratory findings.

6. *The Cultivation of Drug Yielding Plants in British Columbia.*—To ascertain the possibility of cultivating economically in British Columbia several essential oil and drug yielding plants, a grant of $850 was made to Professors R. H. Clark and J. Davidson, of the University of British Columbia. The investigations made indicate that the results obtained by storing the bark of the Cascara Sagrada for three years previous to use, can be produced quickly by chemical means; for this purpose, the bark is submitted to the action of hydrogen peroxide, and tests made at the Vancouver General Hospital with bark so treated have been satisfactory. The Cascara Sagrada wood was next examined to see if it contained enough active constituent to pay for extraction; solutions are being tested at the Vancouver General Hospital and by the Parke, Davis Company, Detroit. A preliminary report from the hospital shows the surprising result that the wood is practically as active as the bark, and this result, if fully confirmed, will mean a wonderful conservation of the fast

disappearing Cascara tree, as the bark does not constitute more than 5 per cent of the tree. Investigations of British Columbia Digitalis Purpurea indicate that the strength of the extract compares most favourably with standards. Hydrastia Canadensis (Golden Seal), Mentha piperita, Mentha spicata, Polygala senega (Seneca Snake Root) and other drug plants are being grown at the University experimental farm. Investigations have also been made into the Salicin content of British Columbia willows and poplars, and the Tanin content of Pacific Coast conifers.

7. *An Apparatus for Determining the Amount of Oil in Shales.*—Mr. Louis Simpson was granted $300 to enable him to purchase a portable apparatus for the preliminary testing of oil shales. As a result of work carried out in New Brunswick, he has designed an apparatus to reduce the time and the expenditure of gasoline required in making such tests.

8. *Investigation into the Relations of Infra-red Rays.*—Professor J. C. McLennan was awarded a grant of $1,500 to enable him to continue his investigations concerning the relations of the infra red rays to the structure of atoms and he has made a special study of the ionization of atoms of mercury. The spectrum of luminous mercury has been photographed far into the infra red rays up to 11,000 Å.U. the limit of visible light being about 7,000 Å.U. In particular it has been shown that the wave length λ 10,140 Å.U. is not absorbed by non-luminous mercury vapour, indicating that the resonance and ionization potentials are definite magnitudes and are equal respectively to 4.9-10.2 volts. Previous to this research there were indications that mercury atoms had two resonance and two ionization potentials. The research has shown exactly how much energy must be expended to ionize a given quantity of mercury vapour. This information is very useful in connection with the problem of determining the energy required to be expended in disrupting atoms and releasing the atomic energy locked up in them.

9. *Research on Ultra-violet Light.*—A grant of $500 to Professor A. L. Hughes, Queen's University, for purchase of a specially designed motor generator, to study the gap in ether waves between ultra-violet light and X-rays. Ultra-violet light of wave length as short as 200 x 10 cms. has been recently demonstrated. X-rays have a wave length shorter than 12 x 10 cms. and the properties of X-rays of wave lengths from 12 x 10 cms. to 0.1 x 10 cms. have been studied in some detail. Radiation of wave length between that of the softest X-rays and that of the most extreme ultra-violet light undoubtedly exists, but hitherto has not been produced. It is the purpose of this investigation to explore this region. The behaviour of matter toward radiation in this region merits investigation, as the results with ultra-violet light and with X-rays suggest interesting effects. There are certain fundamental differences between the method of production of light and of X-rays. It is important therefore to investigate whether, or not, these differences merge into each other in the unexplored region. These results should be of value in giving information about the structure of the atom, particularly concerning the outer boundary of the atom, and should also give information as to the bearing of the Quantum theory on these radiations.

10. *Research on Sugar and Starch in Indian Corn.*—A grant of $250 was made to Professor H. F. Roberts, of Manitoba, to meet the expenses of an investigation on the inheritance of the capacity to form and store up sugar and starch in the endosperm of different varieties of Indian Corn. This investigation, which will involve a large number of chemical analyses, is expected

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to yield results of interest and value in connection with the cultivation of Indian Corn in Canada. Such work has not formerly been undertaken either in Canada or elsewhere.

11. *Research on the Reduction of Complicated Sulphide Ores in British Columbia.*—During the year, Mr. Horace Freeman continued his researches on the reduction of complicated sulphide ores and made very substantial progress toward the development of a new process. This investigation has reached the stage at which the process should be tested on a large scale and it is expected that arrangements to this end will be made before long.

These complicated sulphide ores occur at so many places and in such large quantities in British Columbia that a new and thoroughly satisfactory commercial process for their reduction and the separation of the metals which they contain would be of great value to the province.

IV. THE STANDING ASSOCIATE COMMITTEES

1. *The Associate Committee on Mining and Metallurgy.*—This committee has devoted its attention more particularly to the question of the utilization of the low grade iron ores of the Dominion. This is the most important problem which confronts the iron industry of the Dominion, for while very little high grade iron ore has been discovered in Canada, there are immense deposits of low grade iron ores which, if some method can be devised of smelting them profitably, represent an immense accession to the raw materials available for industry within the borders of the Dominion. The committee, therefore, shortly after it was constituted, appointed a sub-committee under the chairmanship of J. G. Morrow, Esq., to make a thorough study of this question. This sub-committee consists of the following members:—

J. G. Morrow, Esq., Chairman.
Frank D. Adams, D.Sc., LL.D., F.R.S.
Lloyd Harris, Esq.
Geo. A. Guess, M.A.
Arthur Surveyer, B.A.Sc.
J. B. Tyrrell, B.Sc., M.A.
Th. Denis, B.Sc.
H. E. T. Haultain, C.E.
A. Stansfield, D.Sc., F.R.S.C.
A. Mailhiot, B.A.Sc.
C. V. Corless, M.Sc., LL.D.

The sub-committee first turned its attention to the possibility of profitably smelting titaniferous iron ores, of which many deposits, some of them of large extent, are known in various parts of the Pre-Cambrian area of Ontario and Quebec. Several attempts have been made to smelt these ores in Canada but without success. The results of the experience of the blast furnace superintendents in charge of these operations were obtained and a visit was then made to Port Henry, N.Y., on lake Champlain, where these ores had been smelted at one time. Here a complete examination was made of the records of the ore, fuel and flux charges, as well as of the blast pressure, tonnage produced, slag and iron analysis, etc., and the sub-committee had the advantage of being able to discuss the whole problem with the men who had carried out the work. A visit was then made to Mineville, N.Y., another point in the same neighbourhood, where the concentration of local ores, costs, tonnages, etc., were studied. As a result of these and other studies the sub-committee reached the conclusion that few if any of the titaniferous iron ores of Canada could under present conditions be profitably smelted on a large scale in competition with the non-

titaniferous ores which are available. The Committee then took up the question of the utilization of the large bodies of low grade iron ore which occur in various parts of the Dominion. Such ores to be used must be "beneficiated," that is to say they must be submitted to some process whereby the barren mineral matter mixed with the ore is partially removed and the percentage of iron in the ore is correspondingly increased. One of the commonest methods of "beneficiation" is to crush the low grade ore, concentrate the oxide of iron by some mechanical or electrical process and briquette the purified material. Another process which has been recently invented and promises to be still more efficient is that known as the Jackling Process. This is now being tried out on a very large scale on some low grade iron ores occurring in the Mesabi iron range of Minnesota. These ores resemble rather closely some of the low grade iron ores of Canada, which lends a very marked interest to these experiments in the present connection.

The sub-committee went to Minneapolis and Duluth, and made a careful examination of the trials of the Jackling Process which are being carried out at these points. They also visited the plant at Babbitt, where about four million dollars is being spent in the erection of a plant for the operation of this process. It is believed that this Jackling Process, if it works out as successfully as it promises to do, will be directly applicable to many low grade iron ores in Canada. The committee then visited Sellwood, Ont. (Moose mountain). After carefully studying the ores of that locality, it was decided to send a large shipment of this ore, after concentrating and briquetting, to a blast furnace for an actual trial on a large scale. This trial could not be carried to a successful conclusion at the time, but it will be made during the year 1923 by the aid of a grant from the Ontario Government.

The sub-committee has also studied the question of the utilization of the large deposits of low grade siderite ores which occur in certain parts of Eastern Canada. While a certain measure of success has been attained by improving the grade of these ores through roasting, much yet remains to be done to make this process a complete success. Satisfactory results, however, can only be obtained by researches carried out on a large scale and entailing large expenditures.

In conclusion, the sub-committee is convinced that Canada possesses large bodies of iron ore but these require treatment or benefication before they can be profitably worked. The decreasing iron content of the Minnesota ores, proportionately increases the value of this Canadian ore and will eventually create another Canadian industry in which our transportation system will also play its part. The sub-committee is also convinced that the future of our iron ore industry is associated with large tonnage blast furnace pig iron production rather than with the smaller tonnage which could be secured by electric smelting. Large tonnages of ore must be mined and beneficiated to compete with the Lake Superior ore now imported from the United States.

2. *The Associate Committee on the Nutritional Problems of the Fox Breeding Industry* has continued its investigations and has arrived at tentative conclusions on the following problems:—

The proper maintenance ration for the ranch fox.

The minimum protein requirement of the ranch fox.

Food requirements during (*a*) breeding season, (*b*) gestation period, (*c*) lactation period.

Growth curve and food requirements of pups.

Influence of diet on production of fur.

Digestibility coefficients of some constituents of diet.

These experiments have been followed with great interest and generously supported by the various breeder's associations, and a report on the work, entitled "Food Requirements of the Ranch Fox," by Mr. G. Ennis Smith, Biochemist in charge of the ranch, has had a wide circulation.

The Council has also issued a Bulletin by Professor A. Hunter, entitled "Some Problems of the Fox-Raising Industry." The results of the most recent investigations of the Associate Committee will be found in Appendix C of the present report. It is believed that results of very direct benefit to the industry will accrue from the valuable work which is being done by this Associate Committee.

3. *The Associate Air Research Committee.*—This committee has devoted its attention chiefly to the consideration of the influence of the intense cold of a Canadian winter on flying. Among the special problems studied by the committee were:—

The effect of low temperatures on the diaphragms of recording instruments.
The strength of riggings, steam line wires, etc., at low temperatures.
Anti-freeze mixtures.
The action of intense cold on lubricating oils.
Snow friction on runners.

4. *The Associate Committee on Flax.*—This committee has been engaged in determining whether Canadian flax straw, which is available in large quantities in the western provinces, could be utilized for the manufacture of paper. Failing the requisite facilities, in Canada, samples were sent to the Bureau of Standards, Washington, where, by the courtesy of the officials, trials have been made which indicate that high grade papers suitable for a variety of purposes may be made from this raw material.

5. *Associate Biological Committee.*—The research work of this committee was carried out by Principal Harrison, of Macdonald College, and his assistants. An extended account of an investigation by Dr. Harrison into the causes of the red discolouration of cured codfish and the means of preventing this, appeared in the Transactions of the Royal Society of Canada and a more popular statement was published as Report No. 11 of the Research Council which appeared in 1922 under the joint authorship of Principal Harrison and Miss Margaret E. Kennedy, many copies of which were distributed to persons engaged in the fishing industry of the Maritime Provinces.

Principal Harrison, assisted by Dr. E. G. Hood and under a grant from the Research Council, then commenced what has proved to be a most important investigation into the *Discolouration, Smut or Blackening of Canned Lobster.*

An experimental laboratory was established in the neighbourhood of a canning factory at Rustico, P.E.I., owned by the Portland Packing Company. Arrangements were made for securing the necessary lobsters, and the American Can Company placed at Dr. Harrison's disposal some three thousand quarter-pound cans. The work accomplished during the lobster season consisted of—

1. Heat Penetration Studies, which showed that the length of time necessary to bring the contents of the cans to boiling temperature was:

For 4 ounce cans, 30 minutes.
For 7 ounce cans, 40 minutes.
For 16 ounce flats, 95 minutes.

For cans placed in a retort at a temperature of 240°F., the time required to bring the temperature of the contents to 240°F. was:

For 4 ounce cans, 15 minutes.
For 7 ounce cans, 20 minutes.
For 16 ounce flats, 60 minutes.

2. A long series of experiments was started in connection with tin cans made from plate carrying various weights of tin as follows:—

(*a*) Coke quality, approximately 1·5 pounds of tin per base box.
(*b*) Kanner's special quality, approximately 2·0 pounds of tin per base box.
(*c*) 2a. Charcoal plate, approximately 2·5 pounds of tin per base box.
(*d*) 3a. Charcoal plate, approximately 30 pounds of tin per base box.

Experiments were also made with the coke enamel cans.

3. Other experiments were started with lobsters put up under the following conditions:—

(*a*) Dead lobster, either long delayed between catching and boiling, or lobsters which have died in the cars or crates where they have been kept in sea water for twenty-four hours or longer.
(*b*) Reboiled meat in shell.
(*c*) Coagulated blood adhering to meat for a long period of time.
(*d*) Boiled lobster kept in factory over night or over week-end.
(*e*) Delayed on cooling table when in shell.
(*f*) Delayed tail meat, as a result of running out of claw meat.
(*g*) Delay in cans previous to sterilization.
(*h*) Tests of various kinds and amounts of pickle.
(*i*) Comparisons of cans with and without parchment or paper linings.
(*j*) The influence of exhaust on cans and meat.

4. The acidity and alkalinity of a large number of lobsters were ascertained. The method used was by determining the hydrogen-ion concentration by colorimetric tests and occasionally by the potentiometer.

Bacteriological tests were also carried out in order to obtain information as to the character of the bacteria in spoiled and normal cans. The thermal death point of many spore-forming organisms was determined.

A large pack was put up using a pickle made with varying quantities of acetic acid. After a sufficient number of cans were packed to allow of monthly examination for eighteen months, they were crated and expressed to the laboratory at Macdonald College, and every month cans representing each kind of experiment were opened and examined chemically and bacteriologically.

In September of 1922, a similar series of experiments was carried out at Borden, P.E.I., under somewhat different conditions. An outstanding feature of the work here was the discovery that fall caught lobsters gave reactions very different from those caught in the spring. The hydrogen-ion concentration of these lobsters was considerably higher than in those caught in the spring, and the probable explanation for this curious phenomenon is the changed reaction of the lobster at the moulting period. At this time the lobster shell is very thin, the meat somewhat watery, and the live lobster actively growing and adding calcareous matter to its shell. In all probability this material is kept in solution by an acid fluid.

Series of experiments similar to those carried out at Rustico were carried out with the fall catch. Dr. Harrison also experimented with a pickle containing citric acid and repeated the acetic acid tests.

During the remainder of the year these cans were examined monthly, but as the packers claim that cans should be kept at least one year and possibly eighteen months, before final results are determined, it seems advisable not to give the detailed results of these experiments in progress at the end of March, 1922, but to defer the full report until eighteen months have lapsed from the date of packing. A report of this character is now being printed under the supervision of the Honourary Advisory Council for Scientific and Industrial Research, and it is suggested that all interested in this investigation await the publication of this report. Suffice it to say here that the results have been

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extremely satisfactory, and Dr. Harrison is of the opinion that by following out certain methods advocated in this report it will be possible for lobster packers to ensure their pack remaining in perfect condition even after eighteen months' storage.

6. *The Associate Committee on Physics and Engineering Physics* met in Toronto in January and again in Ottawa in May. An account of the work of this committee is given in Appendix B.

7. *The Associate Committee of Chemists* met in Montreal in August and discussed the following subjects, which are of special importance to Canadian industry at the present time:—

The standardization and certification by Government of materials for export.

The importance of the authorization by the Government of a large number of denaturants for alcohol to be used for various industrial purposes, and, particularly, a denatured alcohol containing only five per cent of methyl alcohol, which is now extensively used in the United States.

The establishment of an industry in the growing of Canadian medicinal plants, more specially in British Columbia, where the conditions appear to be especially favourable.

Research in the packing industry.

The deterioration of iron and steel in alkaline soils.

8. *The Associate Food Research Committee.*—The work of this committee has been carried on under the direction of Dr. A. Bruce Macallum and deals chiefly with the important subject of vitamines and the indication of the amount of vitamine present in any material by determining the rate of growth of yeast cells in the medium. An apparatus for the removal of carbonic acid from the culture media has been devised, which will enable this relation to be more accurately studied than has been possible heretofore.

9. *Special Committee on Industrial Alcohol.*—Dr. Ruttan, chairman of this committee, reports that the committee has been in close communication with the Department of Customs and Excise and that they have on several occasions requested the authorization of an increase in the number of denatured alcohols for use in Canada. The Associate Committee of Chemists, unanimously and strongly advocated the introduction of ethyl alcohol, containing five per cent of methyl alcohol as a denaturant; this alcohol is used in connection with 169 preparations, pharmaceutical and commercial. The Department of Customs and Excise asked for advice concerning the best composition for a bathing alcohol for use in hospitals. Several formulæ were suggested, and it was finally decided to recommend the use of $2\frac{1}{2}$ per cent di-ethyl phthalate, and five grains of brucine per gallon. The properties of di-ethyl phthalate were studied, and, on Dr. Ruttan's recommendation, the department authorized this alcohol, which can be sold at about $1.10 per gallon for bathing alcohol.

V. ADMINISTRATION AND FINANCE

Dr. R. F. Ruttan, who, during the earlier portion of the year held the position of acting chairman, was succeeded in October, 1921, by Dr. R. A. Ross, who was appointed Chairman of the Research Council. Dr. Ross before the close of the fiscal year found that, owing to pressing professional duties, he was unable to remain on the Council and consequently on March 6 he resigned his membership. His resignation was accepted with much reluctance and regret.

His services had been of great value to the Council and his departure was a very distinct loss. On May 30, 1922, Dr. Frank D. Adams was appointed to succeed Dr. Ross as chairman.

Last session Parliament voted the sum of $120,000 for the use of the Council, being the same amount as allocated for the previous fiscal year. The following comparative tables show the manner in which these sums were expended during the years in question:—

	1921-22	1920-21
Fellowships	$ 8,700 00	$ 5,800 00
Studentships	8,400 00	7,125 00
Bursaries	20,625 00	4,000 00
Assisted Researches	24,617 28	51,779 05
Salaries and general expenses	29,801 82	30,935 07
Travelling expenses	7,419 27	9,938 36
Refunded to Receiver General	20,436 63	10,422 52
	$120,000 00	$120,000 00

In 1921-22 the sum of $20,000 was loaned by the Research Council to the Lignite Utilization Board to enable this board to continue its experimental work on the carbonization and briquetting of the lignites of southeastern Saskatchewan, which was being carried on at Bienfait, near Estevan, in that province. This work had been temporarily suspended awaiting the granting of a further Government subsidy. The subsidy in question, however, was not received by the Lignite Utilization Board until after the close of the fiscal year, and therefore when refunded, the sum loaned was no longer available for the purposes of the Research Council and had to be returned to the account of the Receiver General.

VI. THE NATIONAL RESEARCH INSTITUTE

In the spring of 1921 the Government introduced into the House of Commons a Bill—on the lines of a draft Bill proposed by the Research Council—for the establishment of a National Research Institute. This Bill passed the House by an almost unanimous vote, receiving the third reading on May 10, but was rejected by the Senate. The House of Commons then passed a vote of $100,000 for the purpose of preparing the necessary plans and commencing the erection of the Institute, but under the circumstances of the case the Research Council was not able to avail itself of the grant in question.

In the fall of the year that Government was defeated and it was judged inadvisable for the Research Council to press for the reintroduction of the Bill in the session of Parliament which followed almost immediately upon the new Government taking office, but rather that the Bill for the establishment of the National Research Institute with such alterations, if any, as were deemed advisable, should be introduced in the following session, that of 1922-23, when it could receive the full consideration which it deserved.

As has been already stated, the Research Council considers the erection of a National Research Institute to be necessary to the further progress of the work for which the Government brought the Council into existence, namely, the furtherance of Scientific and Industrial Research in the Dominion of Canada.

Having developed its work on the lines set forth in the preceding pages, the next step which the Council should take is to organize in the various industries of Canada Guilds of Research, as has been done so successfully in no less than twenty-four industries by the Research Council of Great Britain. The

Research Council in the Mother Country, having received a grant of £2,000,000 and dealing with industries which are developed on a much larger scale than in Canada, has arranged for the creation of a separate research laboratory for each industry, in which the special problems facing that industry may be studied and solved, and has assisted these separate laboratories by special grants of money supplementary to those provided by the respective industries themselves. In Canada this is impossible since the funds at the disposal of the Research Council of Canada are insufficient and the industries are not as a general rule in a position to provide such laboratories without direction and assistance.

The establishment of a National Research Institute would, it is believed, meet Canadian conditions. In it the Government could make its contribution, in co-operation with the several industries of the Dominion, by providing ample laboratory accommodation for all investigations and two or three highly trained research workers of wide knowledge and experience, under whom investigations for all the industries might be carried out by chemists, physicists, etc., whose salaries would be defrayed by the several industries by whom they were engaged for the solution of their special problems. Thus the Government would co-operate with the industries—supplying the laboratories or workshops, with their equipment and the necessary direction—while the several industries would provide for the payment of the investigators and a portion of the expenses of conducting their respective researches. This plan presents some features of that adopted by the Mellon Institute of Pittsburg and others which are found in the work of the Bureau of Standards at Washington, or in the National Physical Laboratory in London. In this National Research Institution provision might also be made for research in pure science and for any other work which might be assigned to it by the Government.

As has been stated in the Report of the Administrative Chairman of the Research Council for the year ending March 31, 1921:—

> " Elsewhere Research Institutes have been or are being founded. Of those already in operation there are the National Physical Laboratory of Great Britain, the Bureau of Standards with its Industrial Research Institute at Washington, the Commonwealth Institute of Science and Industry for Australia, the Cawthron Institute for New Zealand, the National Institute of Japan, the Physikalische-Technische Reichs Anstalt of Charlottenburg, and the Chemical Institute at Dahlem, Germany, and the Research Institute at Brussels for Belgium.
>
> " Besides the Central Research Institute at Dehra Dun, India, which is to be enlarged to cover industrial research on a semi-commercial scale, the Government of India has accepted the proposal to found another central Research Institute advanced by the Chemical Services Committee of the Government. Further, the establishment of a Research Institute for Burmah is now under consideration.
>
> " The National Physical Laboratory of Great Britain, as its name implies, concerns itself with research in physical, electrical and engineering problems of all kinds and with the standardization of technical instruments and apparatus, of measurements of length, volume, weight, capacity and energy in its different forms. It, however, also undertakes researches on metallurgical problems in co-operation with the Iron and Steel Institute, the Institution of Mechanical Engineers and other technical organizations. It performs a very great service in the development of many technical processes of the industries.
>
> " The function of the Bureau of Standards was until 1919 indicated by its name. Since then it has taken on industrial research work. A building of a very large capacity and of the most solid construction,

erected in the immediate vicinity of the laboratories of the bureau and designed for engineering problems for war service, but completed only in November, 1919, was given to the bureau by President Wilson and is devoted to industrial research which will be carried on on a large scale. In it can be located a large number of industrial plants on a semi-commercial scale and some are installed therein already. All these will be engaged on problems of special importance to various lines of industry as the need for the investigation of these arises.

"The lesson for Canada is an obvious one. Almost everywhere there is a recognition of the value of scientific research as a factor in the promotion of national prosperity, scientific research, not casually pursued as was the case in the past, but organized and directed to the economic utilization of the natural resources of each country and the promotion of human welfare.

"In the United States, research, especially in connection with industry, is now being carried on on an enormous scale. There are, it has been claimed, more than 2,000 firms which maintain laboratories specially equipped and staffed to carry on research each in its own line. The Dupont Company, the Western Electric, the General Electric, the Nela Company and a number of other firms spend annually huge amounts to this end. Further, it is estitmated that about $30,000,000 will have been spent in 1921 for research of which amount one-third is voted by Federal and State Governments, the remainder being derived from private sources. Research is fostered there as it is nowhere else to-day.

"The people, the Parliament, and the Government of Canada cannot be and ought not to be indifferent to this situation. The nation must not be forced in the matter of new knowledge to live on the crumbs that fall from a wealthy neighbour's table. The establishment of a National Research Institute is the first and the earliest measure that should be taken to put Canada in a position to hold her own, to develop her natural resources and thereby to permit a great increase in her population.

"The Research Institute should, as advocated by the Research Council, be under its control, subject of course to the approval of the sub-committee of the Privy Council for Scientific and Industrial Research in such matters as the appointments to and the salaries of the staff of the Institute, and the acceptance of grants, donations or bequests given under conditions by private individuals or companies to support special lines of research. The Council should be made a body corporate to administer such and other funds and to acquire and hold property of all kinds necessary for the carrying on of the work of the Institute."

The establishment of a National Research Institute in Canada has, furthermore, been very strongly advocated by no less than seventy-two of the most important and influential public bodies representing the industries of the Dominion, including the Canadian Council of Agriculture, the Canadian Manufacturers' Association, the Trades and Labour Congress, Boards of Trade all over the Dominion, as well as the Canadian Clubs of our leading cities, the scientific and technical societies including the Royal Canadian Institute, the Canadian Branch of the Society of Chemical Industry, and by every important newspaper in the Dominion from the Atlantic to the Pacific. It is hoped that in the session of 1922-23 effect will be given to the widespread public desire thus expressed and that the National Research Institute of Canada will be brought into being.

APPENDIX A

PROGRESS REPORT OF THE SUB-COMMITTEE ON UTILIZATION OF CANADIAN IRON ORES

Since the last report presented in March of 1921 at Montreal, two new members have been added to the committee—Mr. Lloyd Harris, in April; and Dr. C. V. Corless, in October. Both these gentlemen have broad experience, the former in the iron and steel industry, and the latter in the nickel industry. The committee is now composed of the following eleven members:—

J. G. Morrow, Esq. (Chairman)	Inspecting Engineer, Steel Company of Canada, Hamilton, Ont.
Frank D. Adams, Ph.D., Sc.D., LL.D., F.R.S. (Ex-officio)	Dean, Faculty of Applied Science, McGill University, Montreal, Que.
C. V. Corless, M.Sc., LL.D., M.E.I.C.	Mgr. Mond Nickel Co., Coniston, Ont.
T. C. Denis, B.Sc.	Dept. of Colonization, Mines and Fisheries, Quebec, Que.
George A. Guess, M.A.	Prof. of Metallurgy, University of Toronto, Toronto, Ont.
H. E. T. Haultain, C.E., M.I.M.M.	Professor of Mining Engineering, University of Toronto, Toronto, Ont.
Lloyd Harris, Esq.	110 Brant Ave, Brantford, Ont.
A. Mailhiot, B.Ap.Sc.	Professor of Geology, University of Montreal, 228 St. Denis St., Montreal, Que.
A. Stansfield, D.Sc., A.R.S.M., F.R.S.C.	Professor of Metallurgy, McGill University, Montreal, Que.
Arthur Surveyer, B.A.Sc.	Room 715, 145 St. James St., Montreal, Que.
J. B. Tyrrell, B.Sc., M.A., M.I.M.M., F.R.S.C.	Consulting Mining Engineer and Geologist, 534 Confederation Life Bldg., Toronto, Ont.

The sub-committee endeavoured during the year to carry out a large scale test of beneficiated Canadian ore in a Canadian blast furnace. The attempt of 1920, which involved the delivery of fourteen cars of ore to one of the furnaces was brought to an untimely end. The ore, however, has since been used in small quantities. This large scale test would have been accomplished either at the works of the Algoma Steel Corporation at the "Soo," or at Hamilton in the furnaces of the Steel Company of Canada, but for the unfortunate depression which settled upon all Canadian industries. While negotiations were as yet in progress, these furnace companies realized they had sufficient iron ore on their stock piles to serve their greatly reduced requirements, without further commitments, for the season of 1921-2. Furnaces were blown out during the year as pig iron accumulated with idle or only partially operating open-hearth departments and mills. Just sufficient ore was purchased to balance the stock on hand. The uncertain industrial outlook forced these heavy reductions.

Large sums of money have been expended by private companies on development and experimental work in an endeavour to mine and beneficiate, for blast furnace use, Canadian siderite as well as magnetite ores.

The committee visited the siderite workings of the Algoma Steel Company at the Magpie and Helen mines. A huge body of ore has been proven The

pumps at the Magpie mine are not being operated and the mine is flooded. Bush fires have swept over the Helen mine and everything above ground has been destroyed. The reopening of the mine will require the expenditure of a considerable sum of money. Much experimental work has been done on both the Magpie and Helen ores. This work covers experiments with sintering machines and with a rotary kiln plant. Considerable tonnages of ore have been put through these processes of beneficiation and more or less satisfactory results have been obtained. The costs of beneficiation have, in each case, been prohibitive when the product is compared with the competing American Lake Ores.

In the opinion of the committee these siderite ores will not be used in the immediate future.

Plans are now maturing for a trial of two hundred tons of magnetite ore from the Moose Mountain mine at Sellwood, to be put over the sintering machine of the Algoma Steel Company at Sault Ste. Marie. The ore, in the form of concentrates, is frozen and as there is no heat at the mills the tonnage cannot be obtained or the test made before May.

Shipments are expected to be made in June of this year from the beneficiation plant at Jackling, though delays have been experienced in the completion of the plant.

The work of the committee is partially held up until such time as the large scale test, referred to above, can be carried out. It does not seem possible that this can be put through until there is renewed activity in the iron and steel industry.

APPENDIX B

REPORT OF THE ASSOCIATE COMMITTEE ON PHYSICS AND ENGINEERING PHYSICS FOR YEAR 1921-22

1. Meetings.

Two meetings of the committee were held during the year, one on the 17th and 18th of May, 1921, at Ottawa, and the other on the 31st of December, 1921, at Toronto.

2. Subjects Discussed.

Among the subjects discussed the most important were:—

(*a*) University courses involving special work in physics.
(*b*) Research in marine and naval problems.
(*c*) Aeronautical research.
(*d*) A National Research Institute for Canada.
(*e*) Problems suitable for investigation in a National Research Institute in Canada.
(*f*) The Institute of Physics of Great Britain.
(*g*) Publication of papers by research workers in physics in Canada.

(*a*) *University Courses involving special work in Physics:*

Medical Research.

To those who have followed recent progress in Medical Research it has become fairly clear that more rapid advances can be made if the workers in this branch of science can be induced to enter upon their investigations with a better training in the principles of physics than the majority of them possess at present. The Associate Committee having considered the matter at length decided to put forward a suggestion to the presidents and the medical faculties

of the universities of Canada, that senior medical students and recent graduates in medicine be given an opportunity of acquiring a more extensive knowledge of the principles of physics than can be obtained from the general course of lectures and demonstrations on the subject usually provided in the primary year of the ordinary medical curriculum. The suggestion has also been made, in this connection, that the medical faculties of other universities might possibly, with advantage, consider the advisability of following a procedure similar to that recently adopted in the University of Toronto, where through a series of options in the higher years of their course, senior medical students have available advanced instruction, including demonstrations in electricity, molecular physics, colloidal solutions, optics, acoustics, radiation, radiology and radioactivity. The Associate Committee has also drawn attention to another feature of the plan of training adopted at Toronto, whereby graduates in medicine may, by taking for a period of eight months, a course of post-graduate instruction in the last three of the subjects just mentioned, qualify for a special university diploma in radiology.

Courses of Instruction in Mathematics, Physics and Engineering.

Under the novel conditions that frequently prevailed during the great war, it often became necessary both for purposes of offence and defence, to invent, construct and use new devices, instruments, and apparatus that demanded for their creation the powers and knowledge of mathematicians and physicists, and for their development and use the skill and special knowledge of well trained engineers.

As examples of these developments one might cite—

(*a*) Instruments for the detection and location of aeroplanes in flight.

(*b*) Devices for the radio control of torpedoes or vessels of war travelling through water.

(*c*) Power transmission by wave motion in water confined pipes.

(*d*) Hydrophones and other devices for receiving or emitting sound waves.

(*e*) Thermionic valves for amplifying sounds, rectifying electric currents, and for producing high frequency electric oscillations.

(*f*) Piezo electric appliances for measuring and recording explosion pressures.

(*g*) Appliances for sound ranging in air and in water.

(*h*) Apparatus for the emission and reception of infra-red and ultra-violet radiations for signalling purposes, etc., etc.

Having in mind these examples of the products of research the Associate Committee is of the opinion that they are but typical of the developments that are likely to be required to be made in the near future in the course of scientific and industrial research. For research of this character workers will be required who are highly trained, not only in mathematics and in physics but in certain phases of engineering practice as well. The committee has therefore taken steps to emphasize the importance of our universities providing courses of instruction that will embrace not only thorough training in mathematics and physics, but also special training in chemistry and engineering as well.

With a view to disseminating information on this subject the Associate Committee recently prepared through a subcommittee, a pamphlet in which was set forth the fields of activity open to students who elect in our universities to study more especially the subjects of mathematics, physics and engineering.

This pamphlet has been distributed to the principals of secondary schools of Canada, and through them to the teachers in these schools and to the parents of pupils likely to attend them. The committee hope in this way, as well as in others, to add to the supply of research workers that are likely to be required in the near future to develop through their efforts the industries of Canada, and to meet the needs of the scientific life of the country generally.

(*b*) *Research in Marine and Naval Problems.*

In the war it became evident that navigation in the neighbourhood of rocky coasts, and in fog covered areas in the Atlantic and Pacific could be vastly improved by the utilization and development of submarine sound signalling and directional wireless and leader gear direction of ships.

Sound ranging, too, proved a valuable aid in carrying out hydrographic surveying for by means of it the master of a ship can have its position located with great exactness by night as well as by day, and in fogs as well as in clear weather.

In view of all this, your Associate Committee has given careful consideration to a number of problems connected with this important subject of increased safety in navigation.

(*c*) *Aeronautical Research.*

Although aeronautical research comes particularly within the province of the Associate Air Research Committee, and will, no doubt, be reported on by that body, it also comes naturally within the scope of those activities with which the Associate Committee on Physics and Engineering Physics is most legitimately concerned. The members of the Associate Committee were therefore anxious to become familiar with the problems awaiting solution in this field, and to this end Lt.-Colonel Stedman, Director of the Technical Staff of the Air Board, was invited to address the committee on problems confronting the Air Board. He pointed out that the main problems to be faced in Canada were associated with winter flying. What was wanted was an engine or fuel or some modification in one or the other that would enable one to start an aeroplane flying in cold weather, whenever one wished to do so. He also pointed out that new types of radiators were required and that suitable anti-freeze mixtures were urgently needed. As flying boats could be used over the greater part of Canada in summer these would require to be suitably modified for winter flying. Research in the direction of making such modifications was likely to lead to useful and important results.

Lt.-Colonel Stedman also pointed out that research in the design and construction of altimeters was urgently required.

(*d*) *A National Research Institute for Canada.*

Bill No. 116, in which it was proposed to establish a National Research Institute for Canada at Ottawa, was submitted for the consideration of the Associate Committee. In dealing with the matter the members of the Committee expressed the desire to be placed on record as strongly supporting the proposal to establish such an Institute.

(*e*) *Research Problems.*

Following a request received from the Honorary Advisory Council for a list of problems of a character suitable for investigation in the proposed National Research Institute, the secretary of the Associate Committee brought the matter to the attention of the members, with the result that the titles of more than eighty suggested researches were sent in to the Council. These dealt with matters relating to heating and ventilation, standardization of weights and measures, navigation, concrete and cement, building materials, fish, fish curing and preservation, aeronautics, meteorology, ceramics, fertilizers, electricity, light, radiology, helium, etc.

(*f*) *The Institute of Physics of Great Britain.*

Consideration was given to a proposal received from the Institute of Physics of Great Britain, that physicists in Canada join the Institute either directly as individual members or fellows or indirectly by becoming associated with the

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parent Institute through the formation of a local branch in Canada. The conclusion reached in regard to the matter was to leave the question of the formation of a Canadian branch of the Institute in abeyance and for the time being to allow the physicits of Canada to act directly and independently in establishing relations with the Institute of Great Britain.

(*g*) *Publication of Papers.*

The Associate Committee is of the opinion that one of the most pressing needs of the physicists in Canada is a journal suitable for the application of the results of their investigations.

After inquiry and discussion the conclusion was reached that it would be impossible to finance the publication of a new journal devoted solely to recording the results obtained in research by physicists in Canada. The proposal put forward to use the Transactions of the Royal Canadian Institute for the purpose was rejected as it was the unanimous opinion of the members that publication should take place more frequently than once a year. It was finally decided to suggest to the Advisory Council the advisability of co-operating with the Royal Society of Canada in an attempt to publish, at intervals during the year, the papers presented to the Society at its annual meeting in May as well as others embodying the results of investigations carried out by holders of Bursaries, Studentships, and Fellowships from the Council, and the results of researches supported in whole or in part by grants from the Advisory Council.

APPENDIX C

SECOND PROGRESS REPORT OF THE ASSOCIATE COMMITTEE ON THE NUTRITIONAL PROBLEMS OF THE FOX INDUSTRY

At its fourth meeting, on October 8, 1921, the committee decided to repeat, but upon a larger scale, the experiments described in its first progress report. To make this possible it was necessary to have more foxes and ampler accommodation. With the aid of funds provided by the Department of Agriculture the large pens existing were subdivided, two additional pens and two small dog-pens were constructed, and eight additional kennels were purchased. The foxes needed, to the number of eleven, were generously donated by Messrs. P. G Clark, E. H. Rayner, B. Graham Rogers, the Pure Canadian Silver Fox Company—all of Summerside, P.E.I.—and Dr. A. Jamieson, Arnprior, Ont. The new season was begun therefore with twenty-four foxes, of which four were born on the ranch. It may be stated here that thirteen pups were born during that season. Two of these have died, and one adult was accidentally killed. The season of 1922 closes therefore with thirty-four foxes (eighteen miles and sixteen females), fifteen of which were born on the experimental ranch.

The diets selected for the breeding season were six in number, and were practically identical with the six diets used in 1921. Two pairs were placed on each diet. Those which had been on diets of high calorific value during 1921 were now placed on low calorie diets, and vice versa. Three only of the twelve females became pregnant and produced litters. Of these, one was on the high calorie-high protein diet, one on the high calorie-low protein, and one on the low calorie-low protein diet; the last had in 1921 produced (but killed) a litter when on the high calorie-medium diet. Of the nine pairs which failed to produce litters none of the males (six of which were adults, three pups of the previous season) has ever been known to impregnate the female. On the other hand, all males positively known to have had offspring have sired litters in both years. It

would seem that in the experimental ranch the small number of litters is to be ascribed to the impotence, permanent or transient, of the males. We have no evidence that fertility is dependent on diet.

By far the finest of the three litters raised was that of the vixen upon a low calorie-low protein diet. As already stated, this animal in the previous season produced a litter upon a high calorie diet; but she had then very poorly developed milk glands and she killed the litter a day or so after its birth. This year she developed very large udders and had always an abundant supply of milk. The pups, four in number, grew at a rapid and uniform rate, and at four weeks were 20-50 per cent heavier and 16-25 per cent longer than pups of the other litters. At four months they exceeded the mother in length and weight. The other two mothers, who had been fed high-calorie diets, were less successful. They had poor appetites during the lactation period, and produced less milk. Their litters (numbering four and five pups), grew slowly, and at four months were still about three weeks behind normal; in spite of the fact that the parents were bigger than those of the first-mentioned litter. It would seem therefore that the diet of the mother during gestation had a striking influence upon her subsequent success in rearing progeny. The results of both seasons agree in emphasizing the harmful effects of overfeeding, and in indicating 100 calories per kilo as the proper ration for the pregnant fox. The optimum protein content of the diet is not so clearly defined; but something between 1·2 and 1·5 grams nitrogen per kilo appears to be a safe allowance.

In order to make sure that the vixen secures neither more nor less than her prescribed ration, the committee considers it advisable that during pregnancy she should be isolated from the male.

With the three litters available an attempt was made to determine experimentally the food requirement of the lactating mother. It is known that growing dogs require for every 1,000 grams of growth from 7,000 to 9,000 calories of ingested food. It was therefore planned to observe the effect upon the three litters of feeding the mothers respectively 5,000, 7,000 and 9,000 calories (in excess of their maintenance requirement), for every 1,000 grams of growth normally to be expected in the offspring. Unfortunately it was only in the case of the fox fed at a 9,000 level that the ration was quantitatively consumed; this being the fox which had been fed during gestation a low-calorific diet. In spite of this it was found that the ratio of growth in the litter to extra food consumed by the mother was practically constant for all three families during the first eight weeks; each kilogram of gain on the part of the sucklings corresponded to the ingestion by the mother of 8,800, 8,400 and 8,800 calories respectively in excess of her maintenance requirement. This agrees with the recorded data for growing dogs, and obviously furnishes a basis from which it will be possible to calculate the actual requirement during lactation of any vixen.

It may be noted in passing that opportunity was taken to analyze the milk of two of the nursing vixens. The following data were obtained:—

Fox number	26	26	8	Average
Days after partuition	28	35	28	
Total solids ..Per cent	22.81	20.94	18.02	20.59
Ash .. "	1.204	0.942	0.919	1.022
Fat (ether extract) .. "	12.03	10.9	7.91	10.28
Total N. .. "	1.466	1.325	1.114	1.302
Total protein .. "	9.36	8.46	7.14	8.32

Attention has been given also to the question of the food requirement of the growing pup after weaning. The data so far accumulated are not sufficient to justify a positive statement upon this head, but indicate that a ration beginning at 250 calories per kilo and diminishing gradually to 120 will in general satisfy the requirements of the five months during which growth continues. The gain in weight of the pups has been found, as might be expected, to be proportional

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to the caloric value of the food ingested. The ratio between these factors, for the first litter raised on the ranch, was 1 to 12 for the third month, 1 to 15 for the fourth and 1 to 42 for the fifth, during which growth was slowing up.

It is satisfactory to be able to record that the litter produced in 1921 has shown excellent results as regards the quality, and especially the colour, of the fur.

The fur had a clear jet-black or silver-black colour and an excellent silky lustre and even at the end of the winter did not show any signs of going off colour, which was in very marked contrast to the parents and the other foxes. Fox breeders have made a practice of pelting early in the season before the fur and hide have really reached their prime because the fur goes off colour. Also many foxes acquire a brown shade long before they could possibly be pelted. If the result obtained with these pups can be reproduced, the source of a great loss of revenue to the fox industry will be eliminated.

During the year a bulletin on the food requirements of the ranch fox was published. The biochemist in charge of the experimental ranch also co-operated with the animal pathologist in charge of the Fox Research Station of the Health of Animals Branch of the Department of Agriculture at Charlottetown, P.E.I., in preparing a bulletin, to be published by that department, on Fox Ranching in Canada, with special reference to the construction management and sanitation of ranches and diseases and nutrition of foxes.

It is intended to publish a pamphlet containing the diets of a ranch fox, the live weight and measurements of a fox pup at different ages and other information which might be contained on a single page; such as could be tacked up in the place where the food is prepared.

APPENDIX D

REPORT OF THE ASSOCIATE FOOD RESEARCH COMMITTEE FOR THE YEAR 1921-22

The Committee begs to submit the following report regarding the investigation of the water soluble vitamin content of rich polish undertaken by it.

The investigation has been carried out for the past year in the Laboratory of Food Chemistry, Household Science Building, of the University of Toronto. The work has been largely under the supervision of Professor C. C. Benson of this department, and Dr. A. Bruce Macallum. It was found necessary to employ paid assistants up until the end of June, 1921, but since October of the current year the work is being carried on by two female assistants in the Department of Food Chemistry who are devoting all their time not otherwise engaged in teaching to the prosecution of this work. These assistants will be available until the end of June, 1922.

A study of the vitamines has been undertaken with the investigation of the vitamin content of rice polish. This material is readily procured in large quantities and the study already made upon its antineuric vitamin supplies a good basis upon which to work while the methods recently announced of estimating the amount of water soluble vitamin in extracts by means of its effect upon the growth of yeast cells in artificial culture media afford a satisfactory method of testing the strength of these extracts. The efforts of the subcommittee have therefore been engaged in, first, investigating the various methods of determining the vitamin, in which the rate of growth of yeast cells on artificial culture media is used as the indicator. The method as used by Bachmann by determining the amount of gas produced by the growth was found to be inaccurate owing to the varying rate of absorption of the gas by the culture media. An alternative method by which the yeast cells were filtered

off, dried and weighed, was also found to have certain objections in that it was very tedious and time consuming. The method as used by Funk in which the yeast cells were grown on artificial culture media and the increment of growth measured by centrifuging in a specially constructed centrifuge tube with a capillary at the bottom, measuring the rate of growth by the height of the yeast cells in the capillary, was found to be the most suitable. It was found, however, in the course of incubating the yeast on the artificial culture media that uniformity of growth could not be readily obtained in all cases where conditions as to the quantities of culture, vitamin solutions, etc., were identical. Some weeks were taken up in an effort to ascertain the reason for this variation in growth, but fortunately some of the workers in the University of Toronto in the Department of Physical Chemistry had studied this problem and were kind enough to give the sub-committee all the details necessary for the solution of this question. This, however, involved the construction of a special piece of apparatus which was not installed and set in working order until the end of June. During the Summer months the work was not carried on owing to the fact that the laboratories in which the experiments were being undertaken were closed. Work, however, was recommenced in the middle of September and is now in progress.

Realizing that the old methods utilized in separating out the vitamin from the rice polish by means of metallic salts and acids have not led very far, the question of separating out the adventitious material by means of various solvents has been investigated. The rice polish is extracted with a dilute aqueous solution of acetic acid from 1/10 to 1 per cent in strength, concentrated to dryness and the residue fractionated with alcohol of various strengths. In this way about 75 per cent to 85 per cent of the adventitious material in the extracts have been removed and a highly concentrated solution containing the active vitamine has been obtained. A large number of experiments have been carried out on the optimum conditions for extraction, and the behaviour of such conditions as temperature, acidity, alkalinity, etc.. on the rate of destruction of the vitamin.

The committee proposes during the coming year to carry out the concentration of the vitamin solution already obtained on a small scale, on a much larger scale and will endeavour to obtain solid residue which will yield a water soluble vitamin in its maximum purity obtainable by these methods. Investigations now under way are being carried out with reference to the use of various grades of alcohol as already mentioned, and with regard to the use of such commercial solvents as butyl alcohol, amyl alcohol and esters of these compounds. Furthermore, these concentrates will be tested as to their colour reactions which will be developed by means of diazotizing the vitamin so that its solutions coupled up with a number of dye stuffs intermediates will give specific colours for certain groups. In this way it is hoped to obtain some insight into the constitution of the compounds associated with a fairly pure vitamin residue and even perhaps of the vitamin itself.

As the residue obtained by the methods stated above is extraordinarily small the ordinary analytical methods of organic chemistry are useless for the identification of its constituents. Professor Chamot, of Cornell University, has published a work recently embodying the use of a specially constructed microscope by means of which the character and constitution, melting point, refractive index and other physical and chemical constants of very small amounts and even one or two minute crystals may be determined. It is proposed to use these methods in the further prosecution of the research. The committee also expect through the courtesy of the Physical Department of the University of Toronto to be able to ascertain the effect of such conditions as low temperature by means of liquid air, and the effect of liquid oxygen, etc., on the stability of the vitamin.

APPENDIX E

REPORT OF THE ASSOCIATE AIR RESEARCH COMMITTEE FOR THE YEAR 1921-22

The Air Research Committee has, on the advice of the technical officer of the Air Board, concentrated its attention more particularly on those problems peculiar to Canada, and chiefly to the starting of machines at low temperatures during the winter months.

This work has been undertaken at the University of Alberta by Professor Robb, who has investigated the effect of low temperature on combustion, lubrication, and cooling. Good progress has been made, but the effect on the carburetor has still to be determined.

Professor McKergow, McGill University, has ascertained the physical properties of the principal anti-freeze mixtures which are on the market.

Professor Stanley Smith, of the University of Alberta, and Mr. W. C. Way, Department of the Interior, Ottawa, are investigating improvements in the aneroid barometer and altimeter which are subject to errors of backlash and hystersis.

Professor Bronson, of Dalhousie University, is investigating the effect of low temperature on rubber used in aeronautical instruments. This is a wide field which requires further workers.

Professor J. H. Parkin, of the University of Toronto, has carried out numerous experiments with the wind channel which is the property of the University of Toronto. He has calibrated the instrument and improved the intake so as to obtain a uniform flow of air in a building with numerous obstacles. He has investigated the best form of wing tips, and, in conjunction with Mr. J. T. Patterson, of the Meteorological Office, experiments have been carried out on the rotating cups of the anemometer. This instrument, used all over the world by meteorologists, is not accurate, and an improved type may be recommended on the results of Mr. Patterson's investigations. The above and other work has been carried out by those named above without payment for their valuable services. Moderate grants have been made for the purchase of necessary apparatus and in one case for the assistance of a mechanic.

The committee desires to acknowledge its appreciation of the wise guidance of Colonel Stedman.

APPENDIX F

REPORT OF THE SPECIAL COMMITTEE ON NITROGEN FIXATION

The appointment of this committee was made early in 1917.

The personnel of the committee is as follows:—

Professor J. C. McLennan, O.B.E., D.Sc., F.R.S., Convener.
The Chairman, ex-officio.
Professor A. B. Macallum, D.Sc., F.R.S.
Professor R. F. Ruttan, D.Sc., F.R.S.C.

In the absence of any definite appropriations by the Government for research work on nitrogen fixation, the work of the committee has so far been confined, necessarily, to the collection of data relating to this highly important subject and to the making of periodical reports indicating the progress which is being made in different parts of the world.

Up to the present time seven such reports have been made:—

Report No.	Date
I	April, 1917.
II	January 1, 1920.
III	April, 1920.
IV	May 17, 1920.
V	October 23, 1920.
VI	April 11, 1921.
VII	February 3, 1922.

As the present report is the first one to be issued by the Nitrogen Fixation Committee for publication in an Annual Report of the Administrative Chairman of the Council, a reference to each of the reports made prior to 1921, as well as to that covering the past year, will not be out of place here.

Report No. 1. April, 1917.

The first report of the Nitrogen Fixation Committee consists of copies of correspondence which passed between the convener and various authorities, in which the former was endeavouring to obtain information that would help the committee and to set forth to the British Government the possibilities of manufacturing nitrogenous products in Canada. It closes with a bibliography of the literature of the subject. An appendix to this report contains a copy of an interesting lecture by Professor Crossley in England on the Utilization of Atmospheric Nitrogen; various extracts from *Engineering* (London) on nitrogen fixation; a summary of data gathered by the Hydro-Electric Power Commission of Ontario, and a fairly lengthy bibliography of the subject.

Report No. 2. January 1, 1920.

This is one of the most important that has yet been issued as it deals in a very full manner with nitrogen fixation matters during the War period and includes many valuable data taken from the Interim and Final Reports of the British Nitrogen Products Committee, which, at the time, were confidential. Other matters covered in the report are the status of nitrogen fixation in the United States and Canada, the information in this case being obtained direct from the foremost authorities in the respective countries.

Emphasis is laid on the need for collecting and tabulating all available statistics regarding this extremely important subject and on the fact that Canada's water-powers ought to enable her to stand in the very forefront in regard to nitrogen fixation, particularly so far as supplies of combined nitrogen needed within the Empire are concerned.

A bibliography of over 130 papers and documents, some of them of a highly confidential nature, which were transmitted to the chairman, is included.

The report concludes with four appendices:—

I. A few data regarding the American Nitrogen Products Company operating the Arc process in British Columbia.

III. An article (in French) copies from *Comptes Rendus* of December 1, 1919, describing the (then) recent work of M. Claude on the synthesis of ammonia.

II and IV. Appendices II and IV are copies of a Bill that was laid before the United States House of Representatives and the United States Senate in 1919, proposing the establishment of a Federal Agency "for the manufacture, production and development of the products of atmospheric nitrogen."

Report No. 3. April, 1920.

The first portion of this report consists of a copy of a circular letter that was sent out to many persons in the Dominion qualified to speak with authority on either the manufacture or the use of artificial nitrogenous fertilizers. The

letter set forth the subject in a general way as it affects this country and requested comments on the whole situation with reference to Canadian conditions.

Brief synopses of various items of information collected from technical publications, concluded this report, which is only a short one.

Report No. 4. May 17, 1920.

The replies received to the circular letter referred to above are synopsised in this report. The information thus obtained is of a valuable character and indicates that a good deal of interest is taken in the subject by those who realize its importance.

Following the above are various data taken from technical journals which indicate the trend of events in various countries. The report concludes with a summary of the information furnished, together with notes as to the outstanding points so far as they relate to Canada.

Report No. 5. October 23, 1920.

This report gives a few data regarding the world's natural supplies of the nitrates of sodium and potassium; some notes on the dye industry, which in war time can be turned to good account for nitrogen fixation; some valuable information regarding nitrogen fixation in the British Empire that was obtained from Dr. Harker, at that time Director of Research for the Munitions Inventions Department of the British Ministry of Munitions; and also notes on nitrogen fixation in the United States.

The most noteworthy part of this report is a report from Dr. Harker on the Claude process for the synthesis of ammonia which was then being developed in France.

Report No. 6. April 11, 1921.

General information regarding progress in various parts of the world is the outstanding feature of this report. The very great importance that Germany attaches to the subject of nitrogen fixation is noted in an article in the *Times Engineering Supplement* which states: "It is common knowledge that Germany intends to raise her production of nitrogen to two and a half million tons per year."

Report No. 7. February 3, 1922.

This report covers a longer period of time than most of its predecessors, and, as it is the most recent, deserves special mention here as bringing the whole subject practically up to date.

Some of the information in this report is of very considerable importance, the principal matters coming under this heading being as follows:—

1. A review of the Statistical Supplement to the Final Report of the (British) Nitrogen Products Committee which was compiled by the Dr. Harker mentioned above in connection with Report No. 5 and was published in 1921. This supplement which is obtainable from H. M. Stationery Office in London, England, gives statistics regarding the fixed nitrogen resources of all countries. Germany of course leading all others by a very wide margin. In fact, all other countries combined do not quite equal Germany's standing in this respect. A copy of the supplement is one of the appendices to the report.

2. A very considerable amount of detailed and highly useful information regarding the Claude process, which shows signs of becoming a formidable rival of the Haber process came into the hands of the committee during the period covered by the report. This consisted of two reports from Dr. Harker and a pamphlet in French by M. Claude himself, copies of all three form appendices to the report.

3. In September, 1921, occurred one of the worst disasters due to explosion in the world's history when the German village of Oppau was practically destroyed, and the great chemical works where the Haber process was in operation suffered very severely. Nearly 200 lives were lost and the property damage was estimated at about 175,000,000 marks.

It is noteworthy that no really satisfactory solution of the cause of this explosion has yet been offered although many theories were advanced both by investigators on the spot and by many chemists of note in other countries. This being the case, it was thought advisable for the guidance of future investigators in Canada, to collect all possible data relating to the Oppau explosion and these are embodied in the report.

4. Details of some interesting experiments by two chemists in England on the manufacture of artificial farmyard manure were published in 1921 and these are reviewed. The publications (two) form appendices to the report.

The remainder of the report consists of miscellaneous items of interest relating to nitrogen fixation in those countries where the subject is being pursued, viz: England, Canada, United States, Germany, Italy, Norway, Austria and Russia. Some notes regarding Chile and its nitrate industry are also included.

The report concludes with a summary and a fairly extensive bibliography of recently published matter.

Summing up the whole subject of nitrogen fixation it may be said that the war greatly stimulated interest in the subject in all civilized countries and that although, of course, there is not the feverish activity to build huge plants and develop new processes that there was during the period of hostilties yet in England, France, Italy and Germany a good deal of work is still going on in actual building of plants, in addition to research work, while in the United States the Fixed Nitrogen Research Laboratory is apparently working very hard on research work. It is unfortunate to have to record that, of all the countries named, Canada is apparently doing the least, notwithstanding that the demand for artificial nitrogenous fertilizers will become of increasing importance as time goes on; that Canada's possession of vast water-powers gives her an advantage of immense value; and that her geographical location as one of the constituent nations of the Empire places her in a peculiarly favourable position for serving the needs of the Empire in war time.

Of course, owing to the after effects of the war and to the fact that her population is small and her aggregate wealth is not yet large, as well as to the fact that, at present, the home market for nitrogenous products is not of very great proportions, it is hardly to be expected that Canada should be actively engaged in large schemes for increasing her facilities for the manufacture of nitrogenous products, but it is much to be regretted that research work is receiving little or no attention either from private enterprise or from the Government.

In lieu of better things the Nitrogen Fixation Committee feels that its labours, in collecting and tabulating a very large amount of information on this most important subject, though not of much present utility, will ere long prove of very great worth, and so long as it is permitted to do so it will continue this comparatively humble but necessary work in the sure confidence that nothing but good can come of its efforts.

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APPENDIX G

REPORT TO THE ADVISORY COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH OF CANADA ON THE MEETING OF THE INTERNATIONAL RESEARCH COUNCIL HELD IN BRUSSELS IN JULY, 1922.

Your chairman during the past summer attended the Second General Meeting of the International Council of Research. This took place in Brussels during the week of July 25 to July 29.

It will be remembered that the First Meeting of the International Research Council was held in the year 1919. The meetings last summer were held in the magnificent Palais des Academies,, situated on the Place du Tône.

Twenty countries are members of this International Research Council, and sixteen of these countries were represented at this meeting. Germany, Austria and Russia were not represented, the first two mentioned were not invited.

The number of representatives present somewhat exceeded one hundred. Professor Picard of Paris—as President—took the chair. Sir Arthur Schuster was Secretary.

Great Britain sent eight delegates, the United States ten delegates, while the various Latin countries had large delegations. Your chairman was the only representative present from Canada.

The Executive Committee reported that since the last meeting Denmark, Spain, Mexico, the Principality of Monaco, Norway, the Low countries, Sweden and Switzerland had joined the Council (these are included in the twenty countries referred to above as members of the Council).

The following members, which are not members of the General Council, have been accepted as members of certain of the Constituent Unions of the Council: Argentina, Brazil, Czecho-Slovakia, Roumania, South Africa, and Uruguay.

The following Unions of the Council are now definitely established:—

The International Astronomical Union.
The International Union of Geodesy and Geophysics.
The International Union of Pure and Applied Chemistry.
The International Union of Mathematics.
The International Union of Radio Telegraphy.

The formation of similar Unions in the Department of Physics, Biological Science, Geology and Geography were under consideration by the Congress.

The Executive Committee reported that meetings of the International Astronomical Union, and of the International Union of Geodesy and Geophysics have been held at Rome on the 2nd of May, 1922, and that three meetings of the International Union of Pure and Applied Chemistry have been held as follows:—

June, 1920, at Rome.
June, 1921, at Brussels.
June, 1922, at Lyons.

Certain matters concerning the further organization and development of the International Council of Research were considered by the Council. Among these the following may be mentioned:—

No. 1. A proposal that the International Union of Biological Sciences, provisionally approved of in 1919, should be replaced by two separate Unions, one of Biological Sciences, and the other of Medical Sciences.

The decision on this question was left to the International Union of Biological Sciences, with power to take such action as it saw fit.

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No. 2. The delegates from the United States brought forward a motion that in order to procure the effective co-operation between the International Research Council and the separate Unions, and further to develop local interest in international and scientific affairs, it was advisable that while retaining the legal seat of the International Research Council at Brussels, the Executive Committee be authorized to arrange for the holding of the Triennial Meetings at such places as may seem most advantageous. This proposal after debate was withdrawn on the understanding that it might be brought up for consideration later if occasion required.

No. 3. It was suggested that the International Research Council should organize international research projects requiring the co-operation of several branches of science. The energy supply of the world (fuel, solar energy etc.) was suggested as a promising field of international research. Action on this matter was left to the Executive Committee.

No. 4. The Swedish representatives proposed that the Statutes of the International Research Council should be altered as soon as possible so as to permit of the admission of all nations to the Council and its Unions.

After an animated discussion, it was decided that this motion should be laid on the table, and that the Council pass on to the order of the day.

There were two meetings of a temporarily appointed committee on Geology to consider the establishment of a Geological Section. Professor Lacroix was president and Mr. Renier acted as secretary of this committee.

Dr. Matthews represented the United States; Colonel Lyons, Great Britain; Dr. Stephani, Italy; Dr. Yamasaki, Japan; your Chairman, the Dominion of Canada, with ten other members as delegates from other countries.

The committee decided to draw up and submit to the International Geological Congress, which was to meet in Brussels some two weeks later, a scheme under which the latter, while retaining its identity, might be taken over as a Geological Union of the International Research Council.

It may be mentioned that while this was adopted by the International Research Council it was not regarded favourably by the International Geological Congress, which did not desire to run any risk of losing its freedom of action which might be curtailed should it join the organization of the International Research Council.

The International Geological Congress will continue, therefore, to remain an independent body.

The financial committee of the International Research Council submitted the following general statement covering the past three years:—

1919	.....	£173.15.11
1920	£240.17.11	631.13.10
1921	294. 1. 9	71. 4. 8
	£534.19. 8	£876.14. 5

There was, therefore, a deficit of £341.14.9 during the first three years of the Council's operations. This was due in part to the fact that there were no receipts in the year 1919. This deficit was covered by two donations, one from the Royal Society of London, amounting to some £350 and the other from the National Academy of Sciences of the United States, amounting to £100.

On the 13th of July, 1922, the International Research Council had a favourable bank balance, amounting to £243.5.6. The resources of the Council will be sufficient to meet its expenses during the coming three years if the franc preserves its present value. It was decided that for the convenience of the Treasurer of the Council the nations contributing to the Council should be asked to deposit their dues with this officer not later than October 1, of each year.

APPENDIX H

The following Report was submitted by the LIGNITE UTILIZATION BOARD OF CANADA for the information of the Honorary Advisory Council for Scientific and Industrial Research.

PROGRESS REPORT No. 25

MONTREAL, December 8, 1922.

Progress Report No. 24 was issued as at July 3, 1922. The present report proposes to cover the development of the board's work from then to date.

Progress Report No. 24 outlined the progress that had been made up to the beginning of July in the reconstruction of three of the retorts, and mentioned that completion of construction was expected by the middle of August. These expectations were not quite fulfilled, and it was September 8 before the first trial run on a carbonizer was made. The next run was made on September 9, the third on September 15, the fourth on September 18, and a long run (of approximately a week) started on September 25. Mr. Edgar Stansfield, the consulting chemical engineer of the board, was present at all these runs. All the trials were made with No. 1 carbonizer which is the retort reconstructed with hollow carbofrax tile. Owing to troubles with the exhauster (hereinafter discussed) it was not possible to institute comparative trials on retorts Nos. 3 and 5. It must be remembered therefore that the subsequent remarks herein apply only to carbonizer No. 1. It is highly probable that carbonizers 3 and 6 will work equally successfully from the point of view of operation. Their capacities still remain to be proved.

At the request of the chairman the writer proceeded on November 14 to the West to make an inspection of the work to date, and to confer with the two provincial Premiers. As a result of this personal study the board wishes to state that:—

By the completion of the fifth run practically perfect operation of the carbonizer had been obtained. Lignite was carbonized regularly and every interruption encountered could be accounted for clearly without any doubt existing as to its cause. Except for exhauster troubles, no outstanding difficulty was met with to prevent the board from carbonizing lignite continuously in this apparatus, with, however, the possible exception of cracks which have developed in the floor material. It will be recalled that in the trial runs of 1921 this was one of the fundamental difficulties encountered, but the manufacturers were insistent that a large improvement had been made in the quality of their product. It is too soon yet to report that the new carbofrax material is a failure. On the other hand, we are disappointed and somewhat anxious that cracks should be developing so soon. It is probable that further cracking may be prevented when operating the carbonizers continuously in the near future, and it is quite possible that the cracks may be due to the very hard treatment that necessarily was present when testing No. 1 retort. In other words, the constant heating and cooling might easily be more than any fire brick construction could withstand.

The difficulties encountered in operation were in the main chargeable to the exhauster. When any attempt was made to bring the combustion chamber up to high working temperature, the amount of gas produced became too great for the exhauster to pull away. This condition was very baffling until it was discovered that the apparatus furnished to the board was not in conformity with the specifications for same originally approved by the Lignite Board.

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This discrepancy could only be made evident upon operation—and when so disclosed, steps were taken to hold the vendors responsible. A written admission of this responsibility together with a written agreement for replacement of apparatus was thereupon obtained. Before the vendors could complete this order, and effect shipment, they went into temporary liquidation, and the matter is being handled now by the board's lawyers. In order not to hold up the work the board has, in the meantime, placed orders for changes and revisions, assuming responsibility of payment themselves. The new motor for exhauster and small steam turbine for driving the machine are now on the way to Bienfait and will be installed within a short time.

To sum up the board states that:—

(*a*) It does not regard the work done to date on No. 1 retort as having proved complete success. On the other hand it is a long way from failure. A retort may be looked at from three points of view. Does it operate? Is the design as nearly correct as present knowledge enables it to be? And thirdly—is the capacity commercial? It is self evident that failure from the first mentioned point of view would spell complete disaster for any retort. From this point of view it can be stated that our No. 1 retort is a success. In other words, it operated for a long period with no serious interruptions to flow of coal, etc. The only qualification of this general statement lies in the possible breakdown of the carbofrax floor material to which reference has been made already. This achievement is a distinct advance gained over last year's work. From the point of view of design, we feel that the amount of research work done by Mr. Stansfield and others, since the construction of this retort, would enable us to prepare to-day a superior design, both as regards economy of heat and transference of same to lignite coal in passage. Under remaining head of capacity, the Board is disappointed with the showing made to date, which is briefly that the discharge is only about 50 to 60 per cent of what it was calculated to be. In addition auxiliary fuel was necessary owing to the large amount of heat that is diverted to the rotary dryers. The figures on capacity are subject to some improvement, and perhaps to a very marked improvement, when our exhauster troubles are solved, and when three or more carbonizers are in operation in parallel. Condensing the Board's opinion on the question of carbonizing, we would say that we have not yet achieved success, but we are a long way from failure. In other words, enough success has been achieved to warrant us in recommending the prosecution of the programme hereinafter referred to.

(*b*) In the departments of raw lignite handling, drying, briquette cooling, briquette storage, power plant, water supply, housing and sewage disposal, the Board would report that everything is in reasonable condition though as yet it has been impossible to undertake full duty trials.

(*c*) In the department of briquetting the board is not at all satisfied with the layout which it possesses at Bienfait, but is of the opinion that successful briquetting can be accomplished there, and that major revisions should only be undertaken when the fuller knowledge that hard continuous operation will produce, becomes available.

In view then of the above situation, the board proposes to recommend at the forthcoming conference, that an operating period of from four to six months' duration be entered upon immediately, even though such operating cannot, in the nature of the case, be termed fully commercial. The reasons for this are that cost for operating will necessarily be high per ton of output, and sale of the product cannot be expected to meet full charges incurred. In spite, however, of this fact, the board feels that only by undertaking such a step can the project be moved forward.

Owing to the long delays in connection with this work, owing to the fact that complete success has not been achieved at date of writing, owing to the

natural desire of the responsible Governments that they be fully acquainted with the situation, and owing to the desirability of pooling of ideas *re* future action in regard to the lignite work, the Honourable Mr. Dunning suggested to Mr. Camsell that a consultation be held between the Federal Government, the two Provincial Governments and the Lignite Board. With this suggestion the Lignite Board is in thorough accord, and on Wednesday last the writer proceeded to Ottawa to discuss the date of conference with Mr. Camsell, when December 21 or 22 was suggested tentatively. The chairman of the board is a member of the Hydro-Electric Inquiry Commission of the province of Ontario. This commission has sat continuously since last April, and owing to the importance of the work and the continuous nature of the sittings, it is out of the question for Mr. Ross to leave for a western meeting for some little time. Mr. Camsell also stated that he could not go to the West until well on in January. Under these circumstances it would appear to be advisable that the meeting be held in the East, especially as Mr. Bracken stated to the writer that he could not attend the meeting if held after Christmas, owing to the fact that his session started on January 1. It is hoped that before this report reaches the hands of its readers, that the above mentioned date may be fixed upon for an Ottawa meeting.

In the interval the board is making the changes in its exhauster, and arranging for a large scale test on the Hood-Odell retort. This retort is one that has been developed within the last few months by the Bureau of Mines, Washington, and seems to the board to be a very important and distinct advance in the art of carbonizing when lignite char is the main objective. The board is also making minor adjustments and changes in the briquetting building, in order to smooth out as many difficulties as possible.

All of the foregoing is very respectfully submitted.

(Signed) LESSLIE R. THOMSON,
Secretary.

APPENDIX I

REPORT OF THE COMMITTEE OF THE HOUSE OF COMMONS, APPOINTED TO CONSIDER THE MATTER OF THE DEVELOPMENT IN CANADA OF SCIENTIFIC RESEARCH, PRESENTED TO THE HOUSE OF COMMONS ON APRIL 27, 1920.

The Special Committee appointed last year to consider the above question presented their report thereon to this House on the 2nd day of July, 1919. In that report the establishment of a Bureau of Standards was recommended, but while a generous national support for scientific research was unanimously favoured, for the reasons then stated no decision was reached as to the precise method whereby that support could be most effectively applied.

Your committee, the majority of whom served in a similar capacity last year, having further considered the whole matter in the light of the evidence and material already adduced have no hesitation in stating that the urgency of action to be taken to establish a National Research Institute to promote scientific and industrial research in Canada is patent to all who know what is being done abroad in this line.

There is in Canada no organization which even distantly approaches the character of any of the Research Institutes abroad or now being established.

Great Britain has the National Physical Laboratory at Teddington, near London. Germany has two Research Institutes, one Physical and the other Chemical. In France and Italy measures are being taken to organize Research

Institutes. The United States has a National Bureau of Standards at Washington, to which is now attached a laboratory building of exceedingly ample accommodation to be devoted to industrial research. The amount spent by the bureau exceeds two million dollars a year. The Commonwealth Government of Australia is establishing an Institute of Science and Industry. An Institute for Research known as the Cawthorn Institute is being established at Nelson, New Zealand, by private benefaction. Japan is founding a National Research Institute, for which already ample funds have been obtained from the Emperor, the Government and from private sources.

It is evident, therefore, that Canada, to meet the international competition which the work of these laboratories will serve to accentuate very greatly, must have a National Research Institute, which will place at the command of the country all the resources of science and further the development of the natural wealth of the country to meet the huge burden of debt imposed by the war. The developed wealth of Canada as compared with that of the United States is small. If the natural resources of the Dominion were appropriately utilized, its developed wealth might readily be as much as ten times what it is now. The conversion of our natural resources into developed wealth, however, can only be accomplished through the application to them of science of the most highly advanced type.

To take one instance only, to show how vital research is to Canada, it may be pointed out that the high grade iron ores of the world are being exhausted, and, in consequence, the lower grades must in the very near future be alone available. Of these Canada has an enormous supply in areas distributed from the Atlantic to the Pacific. We are to-day importing annually at least $150,000,000 worth of ore, iron, steel and their products. If research could show us how to utilize commercially our own low grade iron ores in competition with foreign high grade ores we would not only build up important mining and manufacturing industries throughout Canada, but as well avoid remitting vast sums abroad.

It may be pointed out also, that in Great Britain the industrial firms in a large number of lines of industry are now being organized under the auspices of the Department of Scientific and Industrial Research into Trade Associations for Research. These industries will thereby be put in a position of enormous advantage as regards production. The National Research Council of the United States is organizing similar associations in the United States to meet competition from abroad. In Canada the organization of similar bodies, "Guilds for Research," must be encouraged by being associated with a National Research Institute.

Your committee believe the first step towards providing for the research required is the establishment of a National Research Institute whose functions will be to carry on researches, not only parallel to those of the Bureau of Standards at Washington, but such also as will assist in the development of the natural resources of the country and will promote the application of the most advanced scientific knowledge to all lines of industrial production in Canada.

In this connection your committee have considered the following matters:—

1. The scope of the work of the proposed Research Institute and the form of its government.
2. The site of the Institute and the character of the buildings which should first be erected.
3. The appropriation that should be made by Parliament during this session for the purchase of a site. The erection of the buildings and the maintenance of the Institute.

1. The work of the Institute should include the following:—

(*a*) The investigation and determination of standards and methods of measurements including length, volume, weight, mass, capacity, time and heat, light, electricity, magnetism and other forms of energy; and the determination of physical constants and the fundamental properties of matter.

(*b*) The standardization of the scientific and technical apparatus and instruments for government service and for use in the industries of Canada; and the determination of the standards of quality of the materials used in the construction of public works and of the supplies used in the various branches of the Government service.

(*c*) The investigation and standardization upon request of the materials which are or may be used in the industries, and of the products thereof.

(*d*) Researches undertaken with the object of improving the technical processes and methods used in the industries and of discovering new processes and methods which may promote the expansion of the existing industries or the development of new Canadian industries.

(*e*) Researches undertaken to assist in the development of the natural resources of Canada.

(*f*) Researches undertaken to promote the utilization of the waste products of industries.

2. The Institute should have charge, direction or supervision under conditions to be determined in each case of the researches which may be undertaken by or for individuals or industrial firms or by such organizations, to be known as Trade Guilds for Research, as may desire to avail themselves of the facilities offered for this purpose by the Institute.

Your committee strongly recommend:—

1. That a National Research Institute for Canada endowed with the functions and of the character indicated in the foregoing be established in the vicinity of Ottawa, on a site fifty acres in area, of easy access and conveniently located for water, gas and electric power supply.

2. That the first building to be erected for the Institute should be of the best modern construction suitable for laboratory work and of such dimensions as to provide accommodation for some years to come.

3. That there be appropriated by Parliament $500,000 for the purchase of the site and the construction of the building, $100,000 for the scientific equipment of the Institute, and $50,000 for salaries and maintenance during the first year of its operation.

4. That legislation be enacted at this session to provide for the establishment of this National Research Institute and the government of the same.

APPENDIX J

LIST OF FELLOWSHIPS, STUDENTSHIPS AND BURSARIES, 1921-22

FELLOWSHIPS

Name	Where held	Subject of Research
Miss C. W. Fritz, B.A., M. Sc., (McGill).	Department of Botany, University of Toronto.	Continuation of Research on the determination of cultural criteria for the identification of wood-destroying fungi.
H. J. C. Ireton, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Piezo-Electricity and its application to the measurement of explosive pressures.
J.W. McKinney, B.Sc. (Univ. of Alta.), M.Sc. (McGill).	Department of Chemistry, McGill University.	The kerogen in oil shale.
T. C. McMullen, B.A., M.A. (Toronto).	Department of Chemistry, University of Toronto.	Friedel and Craft's reaction: A study of the intermediate compounds obtained in the reaction between phthalic anhydrides, aluminium chloride and various aromatic hydrocarbons.
W. W. Shaver, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	A test of the modern theory of extra-nuclear electronic configuration.
C. A. H. Wright, B.Sc., M. Sc. (Univ. of B.C.), Ph.D. (McGill).	Department of Chemistry, University College, University of London.	Investigation of an aspect of the physical chemistry of coloured glasses; a study of borax glasses containing gold and copper.
J. F. T. Young, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Continuation of investigation on the X-ray structure of magnetic alloys.

STUDENTSHIPS

Name	Where held	Subject of Research
E. H. Boomer, B.Sc. (Univ. of B.C.), M.Sc. (McGill).	Department of Chemistry, McGill University.	An investigation of the forces of molecular attraction on various substances in the gaseous condition.
C. Greaves, B.Sc., M.Sc. (McGill).	Department of Chemistry, McGill University.	The preparation and properties of metallic beryllium.
G. H. W. Lucas, B.A., M.A. (Toronto).	Department of Chemistry, University of Toronto.	Investigation to isolate by chemical means the growth promoting factor in yeast.
W. C. McQuarrie, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	An investigation of forked X-ray tracks in helium and hydrogen.
H. G. Oddy, B.A., M.A. McMaster), M.A. (Toronto.)	Department of Organic Chemistry, University of Toronto.	A study of the products obtained when maleic acid is treated according to Friedel and Craft's reaction with aluminium chloride and different cyclic hydrocarbons.
D. A. Scott, B.A. (Toronto).	Department of Chemistry, Queen's University.	The action of calcium bisulphite on dextrose.
G. M. Shrum, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Liquefaction of hydrogen and helium.
H. N. Stephens, B.A. (McMaster), M.A. (Toronto).	Department of Chemistry, McGill University.	The constitution of caoutchouc.
Miss M. Anderson, B.A. (Univ. of N.B.), M.Sc. (McGill).	Department of Bacteriology, University of Toronto.	Resigned.
A. G. Dustan, B.Sc.A.....	Macdonald College.....	Award deferred.
A. H. Leim, B.A. (Toronto).	University of Toronto.....	Award deferred.
C. A. Mackay, B.A., M.A. (Dalhousie).	Department of Physics, University of Toronto.	Resigned.
P. A. Petrie, B.A. (Toronto).	Department of Physics, University of Toronto.	Resigned.
W. W. E. Ross, B.A. (Toronto).	University of Toronto.....	Resigned.

BURSARIES

Name	Where held	Subject of Research
F. B. Adamstone, B.A., M.A. (Toronto).	Department of Biology, University of Toronto.	Economic importance of the Mollusca in lake waters of Ontario (with special reference to Lake Nipigon).
Miss F. M. Cale, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	A study of the radiations emitted by atoms of various elements when such atoms are made to absorb certain selected monochromatic vibrations
Miss M. L. Clark, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	A study of the nature of the gases in the potassium bearing minerals, such as sylvyn, the feldspars, etc., with a view to learning whether arogon and helium are occluded and whether these gases are present in proportionate amounts.

LIST OF FELLOWSHIPS, ETC.—*Concluded*

BURSARIES—*Con.*

Name	Where held	Subject of Research
Miss A. E. Dempsey, B.A. (McMaster).	Department of Biochemistry, University of Toronto).	To observe the rate of formation of peptones in protein hydrolysis with the special object of determining at what stage these possess the maximum shock-producing effect.
E. P. Dolan, B.Sc., M.A. (St. Francis Xavier).	Department of Geology, McGill University.	No problem assigned.
V. H. Emory, B.A.Sc. (Toronto).	Department of Zymology, University of Toronto.	A study of protein decomposition by acetone; butyl alcohol bacteria.
T. S. C. Fawcett, B.A.Sc., M.A.Sc. (Toronto).	Department of Mining Engineering, University of Toronto.	A study of the variables in ball milling and their effect on efficiency.
R. E. Foerster, B.A., M.A. (Univ. of B.C.).	Department of Zoology, University of British Columbia.	A systematic study of the medusae of the Vancouver island region and the development of some of the species.
J. C. Forbes, B.A., M.A. (Univ. of Sask.).	Department of Chemistry, University of Saskatchewan.	The solubilities of some of the constituents of Portland cement in salt solutions.
Miss M. A. Fritz, B.A. (McGill).	Department of Geology, University of Toronto.	Examination of some of the local strata in the immediate vicinity of Toronto for the purpose of classification of the fossil organisms.
Miss K. F. Godwin, B.A. (McGill).	Department of Botany, McGill University.	The causes and prevention of the deterioration of ground-wood pulp.
R. H. Harris, B.A. (Univ. of Sask.).	Department of Chemistry, University of Saskatchewan.	The changes in the composition of concrete and cement during the action of alkaline solutions.
Miss E. M. Hill, B.A., M.S. (McGill).	Department of Chemistry, McGill University.	The autohydrolysis of fats.
W. V. Howard, B.A., M.Sc. (McGill).	Department of Geology, McGill University.	Some outliers of the Monteregian Hills.
Miss M. Levi, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	An investigation of the photo-electric sensitivity of the diamond, to be followed up by investigating that of various phosphorescent liquids and crystals.
D. J. MacLeod, B.A. (Queen's).	Bacteriological Laboratiory, Queen's University.	The action of the hydrogen-ion on the mobility of bacteria.
W. H. McCurdy, B.A. (Dalhousie).	Department of Physics, Dalhousie University.	An investigation of the effect of dust and moisture on the conductivity and di-electric strength of transformer oils; also the effect of temperature.
John Melville, B.A.Sc. (Univ. of B.C.).	Department of Chemistry, University of British Columbia.	The vapour pressure of carbon dioxide in equilibrium with mixtures of solutions of potassium carbonate and potassium bicarbonate.
Miss M. E. M. Olding, B.A. (McGill).	Inorganic Laboratory, Department of Chemistry, McGill University.	The solubility of ferrous ammonium sulphate in aqueous sulphuric acid.
J. F. Phillips, B.A.Sc. (Toronto).	Department of Zymology, University of Toronto.	The nature and method of formation of intermediate compounds in the fermentation of carbohydrates by bacillus aceto-ethylicum.
H. N. Racicot, B.A. (McMaster).	Department of Botany, University of Toronto.	The relation of the injury of the crown of a plant to the health of the roots.
Miss J. D. Spier, B.A., M.Sc. (McGill).	Botanical Laboratory, McGill University.	Causes and prevention of the decay of chemical pulps.
H. G. Smith, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	The indices of refraction and dispersion of metallic vapours.
Miss E. M. Taylor, B.A., M.A. (Toronto).	Department of Chemistry, University of Toronto.	The effect of different acids on the growth of yeast.
Miss M. Weinberg, B.A., M.A. (Univ. of Man.).	Department of Physics, University of of Manitoba.	The function of resonance as a part of the physical theory of audition; a study in experimental acoustics.
D. Wolochow, B.A., M.A. (Univ. of Sask.).	Department of Chemistry, University of Saskatchewan.	The effect of alkali and related substances on cement, including an investigation of the behaviour of silicates in water and in presence of various concentrations of different salts.
Miss D. E. Newton, B.S.A., M.Sc. (McGill).	Department of Bacteriology, Macdonald College.	Marine spore-forming bacteria with the object of isolating from marine sources a number of spore-forming organisms, ascertaining their life history, identifying them, and finding out their thermal death points.
Miss J. D. Dart, B.A. (McGill).	McGill University.....	Resigned.
F. Ferguson, B.A. (St. Francis Xavier).	.....	Died.
W. E. Green, B.A. (Toronto).	.....	Resigned.
Miss M. H. Higginson, B.A. (McGill).	McGill University.....	Resigned.
Miss J. V. Lane, B.A. (Toronto).	University of Toronto.....	Resigned.
J. L. McDonald, B.A. (St. Francis Xavier).	Department of Biochemistry, University of Toronto.	Resigned.
D. M. Morrison, B.Sc. (Univ. of B. C.), M.Sc. (McGill).	Department of Chemistry, University of British Columbia.	Resigned.
L. W. Rentner, B.A. (Toronto).	Department of Physics, University of Toronto.	Resigned.

APPENDIX K

LIST OF ASSISTED RESEARCHES, 1921-22

Grantee	Where carried on	Subject of Research	Amount awarded
			$
Prof. Wilfrid Sadler.....	Department of Dairying, Univ. of British Columbia, Vancouver, B.C.	To complete investigation to determine the character of the bacteria and other germs which are found in cream, milk and butter.	400 00
Prof. John Davidson.....	Botanical Gardens, University of British Columbia, Vancouver, B.C.	An investigation of certain economic flora of British Columbia.	850 00
Louis Simpson, Esq., Ottawa, Ont.	Quebec and New Brunswick.	To purchase a field laboratory for the preliminary testing of oil shales.	300 00
Prof. J. C. McLennan.....	Department of Physics, University of Toronto-Toronto, Ont.	Investigation regarding the relations of the infra-red rays of the spectrum to the structure of atoms.	1,500 00
Prof. A. L. Hughes.....	Department of Physics, Queen's University, Kingston, Ont.	To purchase a specially designed motor generator set for giving up to 1,500 volts with a current up to 0·2 amperes with necessary accessories.	500 00
Dr. F. C. Harrison.....	Macdonald College.....	Investigation into the cause and treatment of acidity in the soils in the provinces of Quebec and New Brunswick.	2,000 00
Prof. H. E. T. Haultain....	Department of Mining Engineering, University of Toronto, Toronto, Ont.	To purchase special apparatus to be used in his study of the action of ball mills.	400 00
Associate Committee on the Nutritional Problems of the Fox Industry.	Experimental Station, Dept. of Agriculture, Hull, Que.	To continue the investigation of the problems affecting the fox industry of Canada.	6,500 00
Associate Food Research Committee.	Laboratory of Food Chemistry, University of Toronto, Ont.	To continue investigation on vitamines.....	1,250 00
Committee of the Engineering Institute of Canada.	University of Saskatchewan, Saskatoon, Sask.	Investigation of the causes of the deterioration of concrete in the provinces of Manitoba, Saskatchewan and Alberta, through action of alkali waters of the soils.	5,000 00
Prof. J. W. Shipley.....	Department of Chemistry, University of Manitoba, Winnipeg, Man.	Investigation of the causes of soil corrosion of iron piping.	1,700 00
Prof. H. F. Roberts.....	Department of Botany, University of Manitoba, Winnipeg, Man.	Investigation of the inheritance of sugar and starch in the endosperm of different varieties of Indian corn.	250 00

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APPENDIX L

PUBLICATIONS OF THE HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH OF CANADA

Annual Reports for the Years 1917-18, 1918-19, 1919-20, 1920-21

GENERAL REPORTS

1. The Briquetting of Lignites by R. A. Ross, E.E., D.Sc.
2. The Recovery of vapours from Gases by Harold S. Davis, M.A.; Ph.D., Davis, B.A.
3. The De-tarring of Gas by Electrical Precipitation by J. G. Davidson, Ph.D.
4. Nicotine and Tobacco Waste by A. D. Hone, M.A.
5. Canadian Waste Sulphite Liquor as a Source of Alcohol by Vernon K. Krieble, Ph. D.
6. An Investigation into the Question of early Putrefaction of Eviscerated Fish in which the Gills have been left by Louis Gross, M.D.
7. Survey of General Conditions of Industrial Hygiene in Toronto by Associate Committee on Industrial Fatigue of the Research Council.
8. A Method of Smelting Titaniferous Iron Ore by W. M. Goodwin, B.A. B.Sc.
9. Food Requirements of the Ranch Fox by G. Ennis Smith, B.A.Sc.
10. Fuel Saving Possibilities in House Heating by L. M. Arkley, M.Sc., and James Govan.
11. Red Discoloration of Cured Codfish by F. C. Harrison, D.Sc., and Miss Margaret E. Kennedy, B.A., M.Sc.
12. The Discoloration, Smut or Blackening of Canned Lobster by F. C. Harrison, D.Sc., and E. G. Hood, Ph.D.

BULLETINS

1. The Need for Industrial Research in Canada by Frank D. Adams, Sc.D., LL.D. F.R.S.
2. Researches on Sound Measurement by Louis V. King, M.A., D.Sc., F.R.S.C.
3. How to Handle Frozen Fish by E. E. Prince, D.Sc., LL.D.
4. Hints on Frozen Fish by E. E. Prince, D.Sc., LL.D.
5. Science and Industry by Prof. J. C. Fields, Ph.D., F.R.S.
6. The Heating of Houses, Coal and Electricity Compared by A. S. L. Barnes.
7. The Manufacture of Ethyl Alcohol from Wood Waste by G. H. Tomlinson, B.A.
8. Some Problems of the Fox-Raising Industry by Andrew Hunter, M.A., B.Sc., M.B., Ch.B. (Edin.)
9. The Honorary Advisory Council of Scientific and Industrial Research and its work by Frank D. Adams, Sc.D., LL.D., F.R.S.
10. A Plan for the Development of Industrial Research in Canada by R. F. Ruttan, B.A., M.D., D.Sc., F.R.S.C.

OTTAWA, December 22, 1923.

The Honourable THOS. A. LOW,
Chairman of the Sub-Committee of the Privy Council
for Scientific and Industrial Research,
Ottawa, Ont.

SIR,—I have the honour of presenting to you herewith the report on the work of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1923.

Your obedient servant,

FRANK D. ADAMS,
Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research (1922-23).

71502—1½

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THE SUB-COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

The Honourable Thos. A. Low, *Minister of Trade and Commerce, Chairman.*

The Honourable Charles Stewart, *Minister of the Interior and of Mines.*

The Honourable William R. Motherwell, *Minister of Agriculture.*

The Honourable Jacques Bureau, LL.B., *Minister of Customs and Inland Revenue.*

The Honourable James Murdock, *Minister of Labour.*

THE HONORARY ADVISORY COUNCIL

Administrative Chairman: Frank D. Adams, Sc.D., LL.D., F.R.S., Hon. M.E.I.C., Hon. M.I.M.M., Hon. M.A.I.M.M.E., Dean, Faculty of Applied Science, McGill University, Montreal, Que.

Secretary: S. P. Eagleson, Esq., Ottawa, Ont.

Members:

Hume Cronyn, B.A., LL.B., London, Ont.

Sir George Garneau, B.A.Sc., LL.D., 2 Cook St., Quebec, Que.

W. L. Goodwin, D.Sc., LL.D., F.R.S.C., Emeritus Professor of Chemistry, Queen's University, Kingston, Ont.

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REPORT

OF THE

ADMINISTRATIVE CHAIRMAN

OF THE

HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

I. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL.

The Council met five times during the year with an average attendance of seven members, all these meetings being held in the office of the Council at Ottawa. On October 14, 1922, Lieutenant-Colonel Gaudet, Technical Executive Officer of the Council, resigned to accept a position of responsibility in the Industrial Alcohol Company of Canada, and pending the appointment of his successor the routine office work of the Council at Ottawa devolved upon the secretary, Mr. S. P. Eagleson.

The Council is strongly of the opinion that its work cannot be made as effective as it might be, or as potent a factor in the development of Canadian industry as it should be, until a National Research Institute is established. Great Britain, the United States, France, Germany, Japan, Australia, New Zealand, and most of the other leading countries of the world have recognized that scientific research and the contributions which it can make to industry and to the development of the natural resources of a country are so important that they have all established such Research Institutes which are proving of inestimable value, and the question naturally presents itself as to whether Canada without such aids can hope to compete in the long run with countries which have the means of applying to the development of their resources all the discoveries and advances of modern science. It is hoped that in the immediate future some means of co-operation between the Government and the industries of Canada may be secured, which will lead to the erection of a Research Institute such as the Council has advocated. In the absence of a Research Institute the Council has been obliged during the past year to continue to concentrate its activities on the following three lines of work:—

(*a*) The training of research workers through the provision of Bursaries, Studentships and Fellowships.

(*b*) The investigation of a number of special problems by the aid of grants to investigators, known as " Assisted Researches."

(*c*) The encouragement or development of research by the organization of the research workers of Canada into Standing Associate Committees of the Research Council—and by the appointment of certain special committees to the same end.

The work carried out under these several heads will be briefly described.

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II. TRAINING OF RESEARCH WORKERS.

In a close survey of conditions in Canada which was made by the Research Council when first appointed, the Council found that if industrial and scientific research was to be carried on in Canada on any extended scale, it would be necessary to train workers to undertake such investigations. In the older countries of Europe many men with such a training are to be found, and are engaged in the research departments of the various industries, but in Canada although a not inconsiderable volume of scientific research—more especially in pure science—was being carried on in the large universities, there was no body of research workers who were available for the purpose of carrying out an extensive programme of research either in pure science or in the application of science to industry.

This training the Research Council sought to supply by the establishment of a series of Bursaries, Studentships and Fellowships, having values respectively of $750, $1,000 and $1,200.

A student who has graduated with distinction from a Canadian university and who has shown distinct aptitude for or ability in scientific research may apply for a Bursary, whereas an applicant for a Studentship must have had at least one year of training in research work subsequent to graduation. Fellowships are awarded only to persons who possess very high qualifications and who have had considerable experience in the conduct of research. Usually an applicant, if accepted, is first appointed to a Bursary, and if he proves during this first year of training to have the requisite ability may be appointed to a Studentship in his second year, and in his third year may receive a Fellowship. These Bursaries, Studentships and Fellowships, are tenable only at Canadian universities, except in the case of the Ramsay Memorial Fellowship, or when a man following some special line of research which cannot be carried out in Canada is allowed to study in Great Britain or in some foreign country. The persons to whom the awards are made are selected from a large number of applicants, they come from all parts of Canada, many of them from the smaller universities where the facilities for research are naturally limited, and they are allowed to select the seat of learning in which they desire to pursue their advanced course of study. This is generally one or other of the larger Canadian universities and an interchange of students thus takes place, which is of distinct value in bringing the universities in different and often distant parts of Canada in closer touch with one another, which is a stimulus and encouragement not only to the students but to the universities themselves. The following is a tabulated statement showing the number of Bursaries, Studentships and Fellowships given in each of the years since these awards were instituted, with the expenditure represented by the same:—

Year	Fellowships	Studentships	Bursaries	Expenditure	Additional awards resigned		
					Fellowships	Studentships	Bursaries
				$ cts.			
1917-18	3	4	.....	5,550 00	.....	2	
1918-19	3	5	.....	7,150 00	1	4	
1919-20	5	16	5	20,100 00	1	3	2
1920-21	5	10	8	16,925 00	3	3	7
1921-22	7	9	28	37,725 00	.....	6	7
1922-23	3	22	13	34,975 00	.....	5	7
	26	66	54	122,425 00			

During the six years ending March 31, 1923, therefore, the Research Council awarded 26 Fellowships, 66 Studentships and 54 Bursaries. These 146 awards were held by 96 persons at 15 universities in 12 different departments of

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science. Forty-nine members of the staffs of these universities directed the work carried out by the holders of these awards, and according to returns furnished by the Research Council, 185 papers setting forth the results of their investigations have been published. Sixty of these students have been awarded the degree of M.A., 29 the degree of M.Sc., and 25 have proceeded to the higher degree of Ph.D. Of these 96 persons who have received awards from the Research Council, 21 are still following their courses of study under grants from the Council and 75 have graduated. Of these 75, fourteen are pursuing further courses of study in Canada or abroad, 29 have been appointed to teaching positions, almost all of them in universities where they will prosecute the work of scientific and industrial research, 23 of them have accepted positions in various industries or in the technical branches of the federal or provincial governments; of the remaining number one has died, eight have not as yet furnished information to the Council concerning their present occupations.

It is furthermore gratifying to note that of the 74 living beneficiaries only 10 have taken positions in foreign countries. All the others, so far as it has been possible to ascertain, are domiciled in Canada with the exception of five persons who are continuing their postgraduate studies in the United States or in England and they will probably return to Canada when they have completed their studies.

The establishment of these awards has evidently met a national need, and has been of very distinct value to the Dominion.

The Council has decided to limit its annual expenditure under this head to a sum not exceeding $40,000, which represents the same proportion of the grant voted to it by the Dominion Government as is devoted to this purpose by the Research Council of Great Britain from the much larger grant made to it by the Imperial Parliament.

A list of the Bursaries, Studentships and Fellowships awarded during the present year will be found in Appendix G of the present report.

III. ASSISTED RESEARCHES.

Research on the Reduction of the Complex Sulphide Ores of British Columbia

In the annual reports for the past two years, reference has been made to the investigation which was being carried out under a grant from the Research Council by Mr. Horace Freeman, Secretary of the British Columbia Advisory Committee of the Council, for the purpose of discovering an economic method for the reduction of the complex silver-lead-zinc-iron sulphide ores of British Columbia.

This research has been brought to a satisfactory conclusion and has demonstrated, upon a large scale, that raw sulphides can be separated from gangue material by fusing with sodium sulphide or with sodium sulphate and carbon, the fusing points of the double sulphides so obtained being well below the boiling point of zinc. The separation of the metals and sulphur has been shown to be possible, and sulphur may be obtained in elemental form.

Two patents have been taken out as a result of this investigation; one covering the process of reducing sulphide ores and the other, covering a new process developed in the course of the investigation, for the manufacture of sodium sulphide. As a preliminary to further work on the reduction of the complex ores, it was necessary that the new process for the manufacture of sodium sulphide should be developed on a commercial scale, and an agreement has, therefore, been entered into by the Canada Carbide Company of the first part and Mr. Horace Freeman jointly with the Research Council of Canada of the

second part, whereby the Company agrees to erect and equip forthwith at Shawinigan Falls, Que., a plant with a capacity of approximately four tons of 60 per cent fused sodium sulphide per day or its equivalent, and to carry on therein such development and experimental work as may be necessary to determine as nearly as possible the commercial value of the process. This plant is now in operation.

As a direct result of this investigation, therefore, it is likely a new and important industry is about to be established in Canada, which, it is expected, will be of direct assistance to the mining industry in the near future.

Dr. Harrison's Research on the Discolouration, Smut or Blackening of Canned Lobster

This research which led to the discovery of a very simple method of preventing this smut which was a source of great loss to the lobster industry, was described in detail in the Report of the Administrative Chairman of the Research Council for the year ending March 31, 1922, p. 22 *et seq.* A complete statement of the results of this research, together with recommendations for packing lobster, based thereon, was subsequently published in Report No. 12 of the Research Council.

Since that time unsolicited letters from many large packing firms have been received referring in the highest terms to the value of this piece of investigation to them and to the lobster packing industry. It was pointed out in an editorial in the *Canadian Fisherman* that the loss to the lobster fishing industry through the discolouration of packed lobster amounts to about $700,000 annually, a loss which can now be avoided by the adoption of the very simple modification in canning indicated by Dr. Harrison. This means that through this one investigation an annual saving to the lobster fishing industry will result, larger in amount than the total expenditure by the Research Council for all purposes during the whole seven years in which it has been in existence. (See Appendix J.)

Preservation of Concrete from the Destructive Action of Alkaline Waters

The very destructive action of the alkaline waters which exist in the soil of certain parts of the Prairie Provinces upon concrete structures such as foundations, water mains, etc., has been a source of great concern to all who are engaged in the construction of great public works or in large buildings of any kind. Attention has frequently been drawn to the fact that many of these large concrete structures laid down even in recent years have already been very seriously attacked and will undoubtedly, unless some preventive can be discovered, be destroyed as time goes on.

It was therefore decided to carry out a thorough investigation into the causes of this action with a view to preventing it if at all possible. The Engineering Institute of Canada also decided to appoint a committee to this end. Prof. C. J. Mackenzie, M.E.I.C., of the University of Saskatchewan, was appointed chairman of this committee in January, 1922, and the expenses of the investigation were provided for during a period of three years by annual subscriptions during this period from the following bodies:

Research Council of Canada	$5,000
Province of Saskatchewan	3,000
Province of Alberta	1,000
Canada Cement Company	3,000
Canadian Pacific Railway	1,000
City of Winnipeg	200
	$13,200

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It was decided to carry on the investigation along two lines: (*a*) physical field tests, (*b*) chemical research. This investigation has been vigorously prosecuted and much valuable information has already been secured.

Field tests with concrete blocks are being carried on in selected locations in Manitoba, Saskatchewan, and Alberta, under the direction of Prof. G. M. Williams. In Manitoba this work is being done in co-operation with the city of Winnipeg and in Alberta in co-operation with the Canadian Pacific Railway.

The chemical investigations are being carried on in the Department of Chemistry at the University of Saskatchewan under the supervision of Prof. T. Thorvaldson, Ph.D.

Chemical investigation was first directed to a study of the composition of the ground waters of the areas where failures of concrete foundations were general. This work is still being carried on in connection with the field investigations especially with reference to seasonal variations, etc. Another line of chemical work deals with a study of the changes which take place in cement and concrete during disintegration by the action of sulphate solutions. In this work the problem is being attacked from two sides. First, by studying the action of the various salts, present in ground waters, in the so-called alkali districts, on hydrated cement. Second, by a separate study of the action of these solutions on all the substances present in cement systems, or disintegrated cements. This includes the preparation, in pure state, of all the substances which may be present in such systems, and a study of their solubilities in, and reactions with, the various salt solutions.

In the first part of this work several types of cement have been used. The work so far done, or in progress, includes a number of series of experiments where intimate contact is effected between cement or concrete and the various solutions, and the changes taking place both in the liquid and solid phase are followed as far as possible by chemical methods. Other series deal more directly with the effect of variation of the hydrogen ion concentration. Still others deal with physical changes occurring in set mortars and application of these to the elucidation of colloidal changes during the action of "alkali" solutions. Other series deal with the action of deteriorated concrete on undamaged concrete.

As to the second method of attack the chemical behaviour (with alkali solutions) of the simpler substances, present in concrete and disintegrated concrete, has already been studied. The preparation of the more complex compounds, which is a matter of considerable difficulty, is at present in progress.

In all this work the microscopic methods of the petrographer are used as well as the usual chemical methods for the identification of substances and determination of the composition of the solid phase.

The preparation in the pure state of the various constituents of Portland cement and the study of each separately promises definite results. This preparation requires very much higher temperatures than the burning of Portland cement. Already comparatively pure samples of tricalcium silicate, dicalcium silicate and tricalcium aluminate have been prepared. Series of experiments comparable to those carried out on the hydrated cements are in progress, as well as a number of series of tests carried out on microscopic slides. It is expected later to have large amounts of material available for experimental work.

Results on this last phase of the work are not available as yet. Attention is also being directed to the preparation of other complex silicates and aluminates possessing cementing qualities, and these will be tested with sulphate solutions. The most promising field in a search for cementing materials capable of withstanding the action of sulphate waters seems to be that of substances high in alumina or high in silica.

The Preservation of Iron Pipes from Corrosion by Alkaline Waters

To investigate the causes of the corrosion of iron piping and other iron structures buried in the soil in the western provinces, a grant was made to Prof. John W. Shipley, of the University of Manitoba. This corrosion causes a very large annual loss in these provinces. Professor Shipley has now completed this work, the results of which *in extenso* will appear shortly in one of the technical magazines. Professor Shipley has drawn up the following concise statement with reference to the results obtained in his investigation.

The investigation was largely confined to a study of the corrosion process commonly described as graphitic softening and found in cast iron. The most distinct results were secured from a micrographical examination of the softened areas. This examination, together with laboratory experiments, showed that the corrosion resisting properties of cast-iron were related to the combined carbon content and to the method of the manufacture of cast-iron. Wrought-iron, steel and certain cast-irons corrode out in face and the structure sooner or later is holed. The investigation discovered the reason for this holing as compared with graphitic softening in which the structure retains its original form, although losing a large part of its iron content.

Local differences of potential between adjacent microscopic portions of the pipe and concentration cell effects give rise to corrosion, but the amount is too small to account for the observed effect.

The micrographic examination indicated strongly that corrosion is the result of an electro-chemical reaction between contiguous materials in the iron in the presence of soil water acting as an electrolyte.

The rate of corrosion was found to be directly proportionate to the hydrogen ion concentration, when buffered, as is the case in soil waters. Oxygen accelerates corrosion by increasing the hydrogen ion concentration produced when the solution is saturated with ferric hydroxide as compared with ferrous hydroxide.

A cast-iron pipe made by the de Lavaud process was discovered to have a very high resistance to corrosion. This resistance was due to the formation of a thin annulus of cementite and austenite-cementite eutectic on the surface of the pipe, where the melt had been quickly cooled by the water-cooling system. Annealing destroyed the cementite structure of this annular ring, producing a grey iron quite readily attacked by corrosive agents.

An Investigation into the Cause of Cracks in the Protective Coating of Concrete Applied to the Members of Steel Bridges

A grant of $500 was made to Professor Gillespie, of the University of Toronto, to meet a portion of the expenses of this investigation, it being expected that a grant will also be secured from the University of Toronto to make up the amount necessary to carry the investigation to a successful conclusion.

The aim of the investigation is to determine whether this cracking can be partially or entirely eliminated by a proper control of the quality and relative quantities of the constituent ingredients and possibly by changing the method of applying the protective covering to the steel.

Investigation into the Best Methods of Obtaining Accurate Results in Testing the Yield, etc., of Varieties and Strains of Different Grains

A grant of $15,000 has been made to the committee in charge of this investigation, which will require four field seasons for its completion.

But little has been done in Canada in this line of research and almost as little in the United States, although the American Council of Agronomy has

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since 1912 been urging that the methods of testing the yield of crops be placed on a scientific basis. Early in 1922 Prof. Robert Summerby, of Macdonald College, applied to the Research Council for a grant to enable him to investigate these methods and careful consideration was given to the application but it was recognized that the results which might be obtained would be applicable only to the soil and climatic conditions of western Quebec and eastern Ontario and that to ascertain methods applicable to all the agricultural regions of Canada it would be necessary to enlist the activities of a large number of agronomists in the various provinces of the Dominion who would standardize the methods, each for his own region, and thus place the methods of testing crop yield for each of the agricultural regions of Canada on a scientific basis. In co-operation with the Department of Agriculture a large committee was appointed, including Professor Summerby and representatives from the staffs of the various experimental farms, certain of the agricultural colleges and also certain of the faculties of agriculture in the western provinces, whose function is that of directing the experiments to be carried on, at selected points in the various provinces, during the four years required for this investigation. The chairman of this committee is Dr. J. H. Grisdale, Deputy Minister of Agriculture, who will report to the Research Council the final results of the investigation.

On the Influence of Acidity in Soils upon the Growth of Nitrogen Fixing Bacteria

A grant of $1,000 was made to Principal Harrison, of Macdonald College, to cover the expenses of an investigation on this subject, which is of the greatest importance in the agricultural industry in many parts of Canada. This investigation will extend over two years. Nitrogen, which is one of the most necessary elements for the growth of plants, cannot be taken by them directly from the atmosphere. It must first be "fixed" in some compound which can then be taken up and used by plants. One of the most direct and easy means of fixing nitrogen for the use of plants is through the bacteria which grow in little nodules on the roots of certain crops, more especially clover. A crop of clover upon which these bacteria have grown if ploughed under greatly enriches the soil in nitrogen and makes it correspondingly more fertile. Many of the soils of Quebec and of eastern Canada are acid in character and when examined are found to be free from these bacteria which are of such value in soils. These soils furthermore are found to yield very poor crops. The research which Dr. Harrison is carrying on will determine whether the acidity of the soil prevents the bacteria from growing in it or whether the absence of these bacteria is due to other causes. When this is determined the way will be open to determine the cause of the barrenness of these soils and knowing their cause to provide a remedy for it. In discovering the means of enlarging the fertility of these soils an immense impetus would be given to agriculture in the two provinces in question.

Investigation into the Cause and Treatment of Soil Acidity

This investigation, for which a grant of $1,000 was made to Prof. J. F. Snell, of Macdonald College, is related to that above mentioned. It has for its object a general survey of the extent of this acidity—which may be referred to as a disease of soil—more especially in the province of Quebec. The investigation also deals with the best methods of measuring this acidity for the purpose of determining the amount of limestone which would be required to neutralize it.

The Action of Ball Mills, etc., in Grinding Ore and Other Hard Materials

Two grants of $400 and $1,100 respectively were made to Prof. H. E. T. Haultain for researches in grinding.

The first of these grants was made to Professor Haultain to enable him to purchase certain special apparatus for the purpose of continuing a research on the action of Ball Mills which he had commenced under a grant from the Council last year. Professor Haultain, employing an ingenious device designed by him, is able to photograph on a rapidly moving film the actual path of the balls in a mill when in the act of grinding at various speeds and thus obtain important information with reference to the conditions of maximum efficiency in the operation of the mill. The second grant was made for the purpose of meeting the expenses of an investigation on rock crushing by rolls to measure accurately the power required to crush different kinds of rocks at different speeds. These investigations are of great importance in connection with the development of the best and most efficient types of mills for crushing the enormous tonnages of ore which are now being raised in the great mining camps of Canada, the cost of this crushing and the condition of the crushed material yielded by the mills having a very important bearing on the question of working costs and thus on the whole development of this great and growing industry.

The Further Utilization of New Brunswick Coal

During the year a petition was addressed to His Excellency the Governor General by three hundred and thirty-eight residents of the province of New Brunswick, including six members of the provincial Cabinet and thirty-two members of the legislative assembly, asking that the Research Council be requested to make trial of various appliances and processes for the carbonization of the coals of that province and the utilization of the by-products thus obtained. This petition was forwarded by the Secretary of State to the Council.

In the petition it is stated that the coal of New Brunswick exists in large quantities, and is of a high heating value, but this value is reduced because under present conditions most of it cannot be mined without producing a large amount of slack, especially when the coal seams are as thin as two feet and under, a thickness which obtains in by far the greater part of the mining district. The thicker seams are fast being worked out. There is little or no market for the slack at any time, and when it is left in the coal and shipped as run of the mine, it restricts the uses of the coal, reducing its value and thus hampering the developing of the coal industry in New Brunswick.

The Dominion Government had already appointed the Dominion Fuel Board with Dr. Charles Camsell, Deputy Minister of Mines, as chairman, for the express purpose of investigating the general problem of the fuel supply for the Dominion and this board had already engaged the services of a fuel engineer who had paid special attention and had a wide experience in the coking of coals for domestic use. The Council therefore, after a thorough discussion of the matter with Dr. Camsell, and with his full approval, appointed an Associate Committee having Dr. Camsell as chairman, with power to nominate other members of the committee to undertake an investigation into the best methods for the economic utilization of these New Brunswick coals and to report thereon to the Research Council. A grant of fifteen hundred dollars was made to this committee for the purpose of meeting the expenses of the investigation.

The Cultivation of Drug Yielding Plants in British Columbia

The grant for this purpose made to Prof. R. H. Clark and Prof. J. Davidson, of the University of British Columbia, was mentioned in the report of last year, and the valuable results secured in this investigation were set forth. During the past year this investigation has been continued with the aid of a further grant of $1,000. Three reports embodying the final results have been received by the Council, the contents of which will probably be published by the Council during the coming year.

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Investigation of the Constitution of Caoutchouc

A small grant of $100 was made to Prof. G. S. Whitby, of McGill University, for the continuation of a research which he had commenced into the constitution of Caoutchouc. This study aimed (*a*) at securing a knowledge of the composition of this substance by studying the products of its oxidation in the presence of air, and (*b*) investigating the chemical nature of the resin occuring in raw rubber. The work is not as yet completed and is being continued, but it has already revealed the inadequacy of many of the current views regarding the chemical composition of caoutchouc, and has brought to light some interesting facts regarding the autoxidation of unsaturated hydrocarbons and has further determined the nature of the rubber resin with a completeness which has never been exceeded in the case of any other resin. It is believed that a knowledge of the exact character of the various constituents of caoutchouc will make it possible to ascertain their influence on the vulcanization of rubber and thereby, if possible, explain the variations which different samples of raw rubber show after vulcanization.

The Food Relation of Certain Minute Organisims (Entomostraca) in the Cultivation of Fresh-water Fish

It has been found that repeated attempts to stock certain fresh-water lakes with fish were unsuccessful although to all appearances these sheets of water were admirably adapted to fish life. A biological study, however, showed in these cases that the anomaly was due to the fact that the waters did not contain an adequate supply of those minute forms of life which fishes use as their food. If these could be supplied the lakes might be permanently stocked with valuable fish.

Among these minute forms the Entomostraca are of especial importance and a grant of $500, was made to Prof. A. B. Klugh, of Queen's University, to defray the cost of an investigation of this subject. The following statement is taken from a report of progress submitted by Professor Klugh:—

The object of this research is to raise Entomostraca (minute Crustacea) in quantities as the food of the young of fresh-water fishes, and thus to make a beginning in placing the practice of aquiculture on a practical basis.

Success in this undertaking demands a knowledge of many factors, each of which really constitutes a problem of considerable extent. These are as follows:—

A. Ascertaining which species of Entomostracans are most suitable for culture.
B. The nature of the food of the various species.
C. The production in quantity of this food.
D. The life histories of the various species.
E. The factors of the environment which are most favourable for the well being and rapid multiplication of those species selected for culture.

Some of these factors are:—

1. The total salt content of the water.
2. Presence or absence of certain salts.
3. The organic matter dissolved in the water.
4. Oxygen, carbon dioxide, and other gases in the water.
5. Temperature.
6. Hydrogen ion concentration.
7. Light.
8. Changes in the above factors brought about by the plants growing in the water or by the animals themselves.
9. Enemies of the Entomostracans and their control.
   (*a*) Macroscopic enemies and their control.
   (*b*) Ectoparasites and their relations to their hosts.
   (*c*) Bacteria and their relation to the health of the animals.

As the work has progressed a considerable volume of information has been obtained on many of these subjects and suggestive observations have been made on other points. A very brief statement of progress, referring to the headings above, is as follows:—

A. Considerable progress. Some species selected, many rejected. Many yet to be investigated.

B. Much work and very definite data on this point for a considerable number of species.

C. Complete success, after a large amount of experimentation, producing in any desired quantity the food suitable for a great many species.

D. Work on this phase of the problem has centred chiefly round the cause of the production of ephippial eggs, and the relation this phenomenon bears to the termination of the life-cycle. A very large amount of work done and some interesting results obtained, some definite, some suggesting future methods of investigation.

E. Large amount of work on this phase, and some definite results obtained. Methods of measuring many factors were already available, but in the case of light no suitable instrument had been developed and one had to be originated and constructed. It is still under trial but promises well. Certain results this season indicate the probable importance of bacteria and research along this line is highly desirable. At many points in the problem the need for chemical research is urgent.

The Conservation of the Sturgeon in Canadian Waters

The disappearance of sturgeon from many of the rivers and streams of Canada where formerly they were abundant is a matter of grave concern. This fish was used as food in certain parts of Canada as it still is in Russia, where there is prepared from it most of the caviar used in Europe and America. Thirty years or more ago it was expected that gradually caviar and other sturgeon products of Canadian origin would win a commanding position in the market. It is now a question whether the streams and rivers may be restocked through artificial propagation, a problem the solution of which has not hitherto been seriously sought. Mr. W. J. K. Harkness, of the Biological Department of the University of Alberta, proposed to undertake an investigation on the subject and applied to the Council for a grant to meet the expenses which would be incurred. The Biological Board of Canada reported that the investigation would yield results of great value but that it could not out of its appropriation for the year provide the grant needed, and recommended that the Research Council give favourable consideration to Professor Harkness's application. A grant of $800 was accordingly made by the Council to be used in meeting the expenses of temporary laboratory quarters on Gull river, flowing into lake Nipigon, in which stream sturgeon still abound and where they spawn in April and May. It is proposed to ascertain under what conditions artificial fertilization of the ova can be effected on a large scale and also under what conditions the resulting fry can be reared and conveyed to other streams for the purpose of stocking these.

Researches on Ultra Sonics

A grant of $2,500 was made to Prof. R. W. Boyle, of the University of Alberta, to enable him to continue important investigations which he made on this subject during the Great War for the British Admiralty. The University of Alberta will make a supplementary grant of about the same amount and the major part of the combined sum will be devoted to the purchase of apparatus required for the research.

Ultra Sonics are sound vibrations of a pitch higher than those which are audible, that is to say above 20,000 vibrations per second.

These researches will include experiments in the transmission through water of elastic (acoustic) waves of very high periodicity and short wave lengths for two primary purposes.

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(1) To signal secretly under water from boat to boat, in either surface or underwater craft.
(2) To locate submerged objects, whether fixed as rocks, or in motion like submarines, also icebergs and shores obscured by fog.

A certain amount of work has been already done on this subject, which indicates that Ultra Sonics may be used to great advantage in increasing the safety of navigation on the Atlantic coast of Canada, where accidents from icebergs, rocks, etc., have exacted a heavy toll in life and shipping.

Investigation into Certain Types of X-Ray Action

This investigation, by Prof. J. A. Gray, of McGill University, has been continued on from the past year—under the original grant of $2,000—and has resulted in certain important discoveries in this somewhat recondite field. These have been set forth in three communications, the first two published in the *Transactions of the Royal Society of Canada*, and the third in *Nature*. The titles of these communications are as follows:—

"Primary and Secondary β-Rays"—Trans. Roy. Soc. of Canada, 1922, p. 125.
"The Softening Exhibited by Secondary X-Rays"—Trans. Roy. Soc. of Canada, 1922, p. 129.
"The Transformation of Electronic into Electromagnetic Energy"—Nature, June 30, 1923.

Researches in Colour Vision

During the year 1921-22 Prof. Frank Allen, of the University of Manitoba under a grant made to him by the Research Council for researches in colour vision, discovered a new physiological principle, the principle of reflex visual sensations, and investigated in great detail its operation with numerous colours of the spectrum. He also showed how the new principle elucidated many well known facts of colour vision, of which no satisfactory explanation has been given up to that time.

During the last year—1922-23—Professor Allen, with a further grant of $195.54 for the purchase of special apparatus, continued the investigation of the application of this principle, by working out in considerable detail how light, darkness and colours, acting upon one area of a retina, affect vision in the contiguous areas around it. This investigation has shown that reflex visual sensations not only are transferred from one eye to the other, but also are transferred from one part of the retina to the adjoining regions. This application of the principle has afforded an explanation of the modification of the appearance of colours by contrast, a subject that has always remained very obscure notwithstanding the most prolonged investigation by many scientists.

Colour contrast is of immense importance in painting, decoration, and in those manufacturing arts where patterns of different colours are produced on fabrics.

These researches are not only of theoretical interest, but they have suggested practical applications to the science of artificial illumination and to the improvement of certain types of defective vision.

The grants of the Research Council are now being used in the continuance of these investigations, and especially in the application of reflex visual sensations to colour blindness, a subject little understood but of the greatest practical importance, especially in regard to safety in transportation.

The papers setting forth the results of these valuable investigations are being published in the *Journal of the Optical Society of America*.

Investigation of the Inheritance of Sugar and Starch in the Endosperm of Different Varieties of Indian Corn

A grant of $250 was made to Prof. H. F. Roberts, of the University of Manitoba, to enable him to continue an investigation into the inheritance of the capacity to form and store up sugar and starch in the endosperm of different varieties of Indian corn. This investigation, which involves a large number of chemical analyses is expected to yield results of very practical interest and value in the cultivation of Indian corn throughout Canada. Professor Roberts has been engaged upon this interesting and important work for several years and the following statement is taken from his progress report:—

This project contemplates an investigation of the mode of inheritance of sugar and starch in the endosperm of Indian corn, by means of chemical analysis. So far as the writer is aware, this method has never been pursued hitherto, the genetic analysis of corn through hybridization with respect to the distinctive characters of starchy and sugary endosperm, having been made solely by the optical division of the kernels after hybridization, according to the types, as shown in the rough by cutting the kernels. The purpose of this investigation is to determine, if possible, the exact factors concerned in the inheritance of the endosperm characters concerned in sugar and starch production, with a view to the demonstration of the more precise relations existing among these factors, the extent of linkage, where it occurs, and the exact method of "crossing-over," if possible. The breeding of corn is assuming an annually increasing importance in Canada, and precise knowledge of the mode of inheritance of the more important factors involved in inheritance in the kernel, is a prime necessity, as a foundation of knowledge for the breeder.

As will appear from the above, the experiments are in the preliminary stage. It is proposed to have analyses made of the seed of the parents, and of the first generation hybrids, of crosses between dent and flint corn on the one hand, and sugar corn on the other, and between starch or flour corn and sugar corn. The first generation (F_1) hybrids, being close-fertilized, analyses are then to be made of the F_2, or second generation seed, in order to determine the manner of the segregation of sugar and starch in this generation, which is the critical one.

The Intensity Measurements in Spectra

A grant of $300 was made to Prof. A. Ll. Hughes and Prof. J. K. Robertson, of Queen's University, to meet a part of the expense incurred in a research on the intensity measurements in spectra, more particularly of the intensity of spectrum lines in hydrogen and other gases when excited by electrons of different velocities and under different conditions of pressure, purity, etc., and also when excited by electomagnetic induction. The results which it is expected will be obtained from this research will form a contribution to our knowledge of the properties of the atom in its spectral relations.

IV.—THE STANDING ASSOCIATE COMMITTEES

The Associate Committee on Mining and Metallurgy

This committee met as usual at the same time as the annual meeting of the Canadian Institute of Mining and Metallurgy, the meeting this spring being held at Montreal. The Sub-Committee on the Utilization of Canadian Iron Ores submitted a report and the discussion at the meeting was directed chiefly to this most important question. The sub-committee reported that it had almost completed its work and the final report on this subject will be issued as a report of the Research Council during the course of the year 1923.

The Associate Committee on the Nutritional Problems of the Fox Breeding Industry

This committee continued its important investigations at the station in Hull, Quebec, being associated in this work with the Health of Animals Branch of the Department of Agriculture. The work has met with the very cordial

appreciation and support of the Fox Breeders' Association. There is a feeling on the part of the Fox Breeders' Association that the work should be extended in its scope, so that the various lines of investigation which are being followed might be pushed forward more rapidly and on a large scale with a larger plant and a greatly increased number of foxes and results thus secured more quickly. The Council believes that this is advisable and it is expected that after 1924 a special vote will be made by Parliament for this extended programme and that the work will be carried on under the direction of the Department of Agriculture. The report of this committee will be found in Appendix 'A'.

The Associate Air Research Committee

This committee has during the year given close consideration to a number of important questions which presented themselves in connection with the reconstruction of the Wind Channel at the University of Toronto, which was provided for by a grant of $5,000 made by the Government through the Research Council. This tunnel will provide the Associate Air Research Committee with means of carrying out a number of researches which they have planned.

A number of problems connected with the construction and operation of aeroplanes, more especially in the low temperatures prevailing in Canada during the winter, were studied by the committee during the year. The report of the Associate Committee will be found in Appendix 'B'.

Associate Biological Committee

In 1919-20 ship worms caused damage amounting to over fifteen million dollars to docks and wharves in the upper part of San Francisco Bay. Eminent zoologists say that this was done by the same pernicious species of shipworm, *Teredo navalis,* which for centuries has been the pest of harbours of north-western Europe. This species is especially troublesome. It can live in water carrying a heavy load of sewage in which other shipworms cannot live and as many as 50,000 to 100,000 females of this species may often be found in a single wooden pile. Each female can produce from a half million to one million young in a season. These young when in a very minute stage may float about for three or four weeks and attach themselves to any unprotected wood and piles twenty to twenty-four inches in diameter have been utterly riddled within six months.

In the summer of 1921 shipworms of this destructive species were found in Barnegat Bay, about fifty miles south of New York on the Jersey coast, and if they follow the same course as was pursued by them in San Francisco Bay, there is a possibility of their appearance in the adjacent harbours all along the Atlantic coast. If this shipworm does invade these waters, it will do its damage to the wharves in the upper parts of these harbours, where structures have been largely built upon untreated piling, because the shipworms found before this on the Atlantic coast do not thrive in such weakly brackish waters.

In spite of the fact that shipworms and other marine borers have damaged ships and wharves ever since man has first used such things, very little is known of the food habits of these animals, their breeding habits, the conditions of temperature, salinity and oxygen content of the water in which they live, and the real effect upon them of certain poisons and other means which have been used to destroy them.

In view of the already large financial losses in numerous places on the Atlantic and Pacific coasts and the possibility of the appearance of these unusually destructive borers at various points and in view of the recognition that immediate research along several lines is absolutely essential, the National Research Council of the United States organized a Committee on Marine Piling

Investigations, the purpose of which is to encourage concerted studies of the marine piling problem, including not only the use of timber and means of protecting timber from destruction by wood borers, but also the use of concrete and iron for piling purposes. A programme has been formulated for obtaining data with reference to the present occurrences of these borers and upon conditions in various ports and for conducting investigations upon practicable means for securing increased protection.

During the year under review, the Research Council of Canada was requested by the National Research Council of the United States to co-operate with them in this investigation and, after a thorough study of the situation as it affects Canada, the Research Council requested Prof. A. G. Huntsman, Director of the Atlantic Biological Station, St. Andrews, N.B., and Prof. C. McLean Fraser, Director of the Pacific Biological Station, Nanaimo, B.C., to get in touch with the American committees working on the Atlantic and Pacific coasts, respectively, and to report definitely as to how, in their opinion, the Research Council of Canada could best co-operate in this investigation.

As a result of the reports received from Dr. Huntsman and Dr. Fraser, it was agreed that the Research Council of Canada, through its Associate Biological Committee, should co-operate in this research and a grant of $2,500 was made to cover the expenses of this work for the first season. Arrangements have been made for Dr. Huntsman and Dr. Fraser to direct and supervise this investigation on the Atlantic and Pacific Coasts of Canada, respectively. The committee will co-operate in so far as possible with the Committee of the National Research Council of the United States, but it is intended under the present grant to confine attention to the biological aspect of the problem and, more particularly, to ascertain the geographical extent of the spread of these borers on the Atlantic and Pacific coasts of Canada.

The Associate Biological Committee has also had charge, during the past year, of the research carried out by Dr. F. C. Harrison on the discolouration, smut, or blackening of canned lobster, with the result that this difficulty has been solved. A full account of this investigation will be found in Appendix C of this report.

Associate Committee on Physics and Engineering Physics

The committee had one meeting at Ottawa at which Professor Eve acted as chairman and discussed the steps which should be taken to improve the teaching of physics in the Dominion. The committee also gave serious consideration to what is one of the great and pressing needs of all workers in the physical and natural sciences in Canada, namely, the provision of some adequate means of publishing the results of scientific work done in the Dominion so that these results may appear promptly and in such a manner that the credit for the work done in Canada is secured for the Dominion. There is at present apart from the Transactions of the Royal Society of Canada no adequate medium for the publication of such papers and these Transactions are much overcrowded and furthermore appear only once a year. The result is that Canadian papers now appear for the most part in periodicals which are published either in Great Britain or in the United States. The committee is of the opinion that some Canadian magazine should be established for the publication of the results of Canadian research and investigation.

The Associate Committee of Chemists

During the year this committee has had under consideration a large number of problems in industrial chemistry which were referred to it. The report of the committee appears as Appendix D.

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The Associate Food Research Committee

This committee has mapped out the following research programme: (1) to attempt to isolate water soluble vitamine in as pure a form as possible; (2) a study of the current methods of detecting and estimating the vitamine content of various materials; (3) the procuring of specimens of indigenous botanical species of northern Canada and ascertaining their values in respect to their vitamine content.

At the present time the committee is concentrating its activities in an attempt to isolate in a pure form one of the so-called vitamines. If they were isolated in a pure and active form it would be possible to ascertain their chemical composition and this would lead very probably to a more thorough knowledge of their action in the body and to their synthesis for use in foodstuffs known to be deficient in vitamines, an event that might result in recasting much of our present knowledge of a normal diet. The report of this committee will be found in Appendix E.

Nitrogen Fixation Committee

This committee reports through its chairman that it has communicated with the leading companies in Canada likely to take an interest in the fixation of nitrogen by the use of the Casale Process.

From the replies received, it is gathered that none of the companies communicated with think that the present time is opportune for the establishment of new industries for the fixation of nitrogen by any method, no matter what its advantages may be.

Statements have been secured from various authorities in the United States and in Europe regarding the position of the fixation of nitrogen problem.

A specially elaborate statement of a confidential nature has been received from Dr. H. A. Harker on the operation in Italy of the Casale process.

Miscellaneous data of a varied character on the fixation of nitrogen have also been collected since the date of submission of the committee's last report.

A concise statement summarizing present knowledge on this subject will be prepared by Dr. J. C. McLennan and will be issued shortly as a Research Council bulletin.

V. ADMINISTRATION AND FINANCE

On May 30, 1922, Dr. Frank D. Adams was appointed to succeed Dr. R. A. Ross as Honorary Chairman of the Research Council, Dr. Ross having been obliged to resign on account of pressing professional duties.

Last session Parliament voted the sum of $120,000 for the use of the Council, being the same amount as allocated to the Council annually during recent years.

During the year, the Council expended a total of $106,369.65. Three Fellowships, 22 Studentships and 14 Bursaries were awarded at an expenditure of $3,600, $22,000 and $10,500, respectively. Eighteen grants for assistance to approved researches involved an expenditure of $32,972.79. Four grants for special problems amounted to $6,538.40. Travelling expenses, including those of the members of the Council and of its eleven Associate and Advisory Committees, amounted to $6,048.72. Administration of the Associate and Advisory Committees, other than travelling expenses, amounted to $2,548.51. The sum of $1,206.30 was expended on the library of the Research Council and $16,703.76 for salaries. The administration costs of the office of the Council at Ottawa, including printing, stationery, office supplies and all other expenses, amounted to $4,251.17 during the year under review.

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APPENDIX A

THIRD REPORT OF THE ASSOCIATE COMMITTEE ON THE NUTRITIONAL PROBLEMS OF THE FOX INDUSTRY

During the past year the experimental ranch has been extended so as to contain now fourteen breeding pens and fifteen small dog pens. The necessary construction work was carried out with funds provided by the Health of Animals Branch of the Department of Agriculture.

At the end of 1922 eleven foxes that were considered of no value for experimental purposes were killed and pelted. Seven new foxes were donated by Messrs. J. Edgar Milligan, Northam, P.E.I.; B. Graham Rogers, Summerside, P.E.I.; and W. K. Rogers, D. A. McKinnon and Walter Grant, all of Charlottetown, P.E.I. To these gentlemen the committee desires here to express its indebtedness. Twenty-six pups were born during the breeding season and seventeen of these were reared. At the present time, the ranch contains a total of forty-four foxes, equally divided between the two sexes.

The committee considered that the work of the two previous seasons had shown a ration of 100 calories per kilogramme to be adequate for the requirements of the pregnant vixen. The optimum allowance of protein, on the other hand, had been only approximately fixed. The females available for the present season—sixteen in number—were accordingly divided into three groups. These were fed at three different levels of protein intake, corresponding respectively to 1·2, 1·35 and 1·5 grammes of nitrogen per kilogramme. All diets were planned to furnish about 100 calories per kilogramme; but very fat females were fed a little less than this standard allowance, while those in poor condition at the beginning of the season were fed a little more. The ten males used for breeding were grouped with respect to diet in a similar way.

Four of the females apparently did not come in heat. Of the others, eight only became pregnant, and one of these aborted about two weeks before her term. Seven litters only were therefore produced. Of these, two were from the low-protein group, three from the medium, and two from the high-protein. It cannot therefore be said that the experiments indicate any particular protein level as specially favourable. The only point which seemed to distinguish the productive from the unproductive vixens was that the former were all, at mating, in good physical condition, and relatively fat, while the latter were all below the average weight. It would appear therefore to be good practice to commence to build up the females for the breeding season not later than the 1st of September, so that, when ready to mate, they may carry as much flesh as is compatible with a state of health. If a female be in poor condition when she mates, she should probably be fed upon a fairly high level until implantation of the ovum has taken place.

Of the seven litters produced, five have been raised to maturity. These include seventeen pups. Careful observations were made of the growth curves of these pups and of the relation between growth and diet. The average data for four of the litters are shown in the appended table. Litters numbered 1 and 4 were fed on a moderately high level, litter number 5 upon a lower and litter number 6 upon a higher level. The rate of growth is seen to be dependent largely upon the food intake. With different fox pups of the same age (or perhaps rather at the same stage of growth) there is a fairly constant ratio between the caloric value of the food ingested and the gain in weight of the animal, the ratio increasing of course as growth slackens. The fox is fully grown at about five months of age.

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The foxes raised in the experimental ranch have been found to maintain a clear black colour until late in the spring, a fact which has greatly impressed many visiting fox-breeders.

During the year a bulletin written by the biochemist and fox pathologist of the Health of Animals Branch was published by the Department of Agriculture. There has been a great demand for this bulletin; the first edition of ten thousand copies was exhausted in less than six months and a second edition of ten thousand has been printed.

In November the biochemist visited a large number of the fox ranches on Prince Edward Island and arranged to have feeding experiments carried on in many ranches in order to test on a large scale the results which have been obtained in the experimental ranch. The fox breeders were requested to report the results of these experiments at the end of the year. Some of the large fox breeders have reported that this year they are feeding all their foxes according to the instructions of the biochemist and that while their feed bills have been reduced by 40 per cent they can already see a great improvement in the condition of their foxes.

TOTAL CALORIFIC VALUE OF THE DAILY RATIONS OF THE AVERAGE PUP OF THE DIFFERENT LITTERS AND THE RATIO OF THE CALORIFIC VALUE OF THE TOTAL FOOD INTAKE TO THE GAIN IN WEIGHT.

(Calories to grams)

Week	Litter No. 1			Litter No. 4			Litter No. 5			Litter No. 6		
	Cal/ KW	Cal/ Pup	Ratio	Cal/ KW	Cal/ Pup	Ratio	Cal/ KW	Cal/ Pup	Ratio	Cal/ KW	Cal/ Pup	Ratio
9	2	.....	.....	298	354	.....	280	346	.....	.....	.....	.....
10	271	420	.....	262	375	.....	246	349	.....	435	647	.....
11	282	543	12·0	287	496	12·5	265	450	12·8	411	755	17·4
12	237	553	.....	233	456	.....	230	451	.....	330	710	.....
13	243	630	.....	263	574	.....	238	525	.....	280	670	.....
14	239	668	.....	257	627	.....	214	516	.....	340	905	.....
15	198	618	19·3	237	605	20·1	227	582	21·5	303	914	19·0
16	201	697	.....	238	625	.....	241	668	.....	266	887	.....
17	182	666	.....	266	775	.....	201	605	.....	242	883	.....
18	175	666	.....	225	708	.....	174	543	.....	247	953	.....
19	152	587	42·0	214	685	42·7	220	726	24·8	230	941	42·0
20	247	965	.....	265	896	.....	190	680	.....	207	877	.....
21	225	847	.....	235	838	.....	181	673	.....	185	796	.....
22	190	847	.....	239	841	.....	191	743	.....	.....	.....	.....
23	186	862	.....	261	1,004	.....	191	770	.....	.....	.....	.....
24	175	825	55·0	259	1,028	57·2	156	640	46·5	.....	.....	.....
25	178	857	.....	226	914	.....	184	770	.....	.....	.....	.....
26	179	857	.....	199	817	.....	160	686	.....	.....	.....	.....

APPENDIX B

REPORT OF THE ASSOCIATE AIR RESEARCH COMMITTEE

During the year 1922-23, three meetings of this committee were held—May 20, 1922, September 18, 1922, and February 24, 1923.

One of the important matters engaging the attention of this committee has been the reconstruction and improvement of the four-foot wind channel at the University of Toronto. Owing to the requirements of other departments of the university, it was found necessary to dismantle this equipment during the summer of 1922, and funds for its re-erection and for a building to house it were not available. Representations having been made to the Minister of Defence, through the Research Council, a grant of $5,000 was secured, which, with the funds available in Toronto, has been sufficient to provide a separate building and pay for the re-erection of the wind channel and its accessories.

Advantage has been taken of this change to improve the design of the wind channel itself and tests recently made indicate that these modifications in design have been successful, a much higher air velocity having been obtained without the expenditure of any further power. The committee was instrumental in obtaining through Sir Richard Glazebrook, its corresponding member in England, the most recent information in regard to many points of design from the experience gained at the National Physical Laboratory and at the Royal Aircraft establishment, Farnborough. This information has been used in designing the channel.

Among the subjects on which research has been carried out during the year under the auspices of the Associate Air Research Committee, are the following:—

Use of amyl alcohol in aero engine radiators (Professor McKergow).
Accuracy and reliability of speed indicators having rubber and metallic diaphragms (Professor Bronson, Dalhousie University).
Elasticity of rubber shock absorber cord (Mr. Hughes, University of Toronto).
Strength of ply-wood (Forest Products Laboratory).
Deterioration of lubricating oils during storage at low temperatures (Professor J. Watson Bain, University of Toronto).
Strength of stream line wires at low temperatures (Mr. C. A. Hughes, University of Toronto).
Operation of aero engines at low temperatures (Professor Robb, University of Alberta).

Through the kindness of Dr. Ames, Chairman of the United States National Advisory Committee for Aeronautics, permission was granted for Dr. Eve, as Chairman of the Associate Air Research Committee, to visit the Bureau of Standards, Washington, and Langley Field, Virginia, with a view of seeing some of the important recent American developments in aeronautical work. Dr. Eve was most kindly received, and obtained a comprehensive view of the most recent American activities.

APPENDIX C

REPORT OF THE ASSOCIATE BIOLOGICAL COMMITTEE

The work on the cause of the discolouration of canned lobster carried on in 1921-22 under the auspices of this committee by Prof. F. C. Harrison and Dr. E. G. Hood, of Macdonald College, was continued during the summer and autumn of 1922 along the lines indicated in the Report of the Chairman of the Research Council for the year ending March 31, 1922. The results obtained for the succeeding year are given in the contribution by them entitled "The Discolouration, Smut, or Blackening of Canned Lobster", published in the Transactions of the Royal Society of Canada for 1923. A summary of the results by the same authors, under the same title, has also been published as Report No. 12 of the Research Council, which appeared in 1923.

The results of this investigation are of the utmost importance to the lobster canning industry.

Many explanations had been advanced amongst those interested in the industry to account for this discolouration. Of these the ones based on (1) the imperfect sterilization of the canned product, (2) the use of excessive or insufficient pickle, (3) the poor tinplate in the cans, (4) the chemical composition of the lobsters used, (5) chemical action between compounds derived from the canned meat and iron of the cans, and (6) packing lobster meat from which the

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blood has not been sufficiently washed, have each had a vogue amongst those who have given attention to the question, but, as will be shown, the majority of them at least are inadequate and based on limited experience not controlled by thorough scientific testing.

The factors in the causation of the discolouration have been determined in this investigation as (*a*) bacterial and (*b*) chemical. Both may play their part in producing discolouration in the same cans but when the bacterial factor is excluded through sterilization the chemical factor remains and is responsible for a very large part of the loss to the industry through discolouration. As will be indicated further on, this factor may be more or less neutralized without difficulty and at an almost negligible cost to the lobster packer.

The Bacterial Factor.—Drs. Harrison and Hood found micro-organisms in some of the spoiled cans, especially when the pickle was very muddy or turbid or when the meat was varicoloured or adhering to the can. These organisms are spore-forming and are found frequently in sea water and in the alimentary tract of fish, crustaceans and molluscs. A number of them are capable of producing hydrogen sulphide and if not killed by sterilization may cause blackening of the canned meat, through the hydrogen sulphide reacting with iron of the can to form sulphide of iron, which has a dark colour. The thermal death point of their spores, when in clumps, is extremely high as compared with that of the individual spores, requiring three to seven hours boiling to kill them. These spores may, when the sterilization of the canned lobster is inefficient, lead to the spoiling of it, especially if air gains entrance to the contents. Micro-organisms were also found in cans in which the contents were normal or unaffected with blackening. This is explained as due to the absence of air in the can preventing the organisms from multiplying as they belong to the aerobic class, that is, they require oxygen for their activities.

It was found that delay in packing contributes greatly to discolouration. Such delay occurs when the boiled lobster is kept over night or over the week end before it is packed. Delay in sterilization after the meat is put into the can may bring about this result. Lobster meat spoils very rapidly when left at ordinary summer temperature for a few hours, as the growth of bacteria is thus favoured and the spore-forming ones amongst them resist the heating process and produce later in the meat various kinds of discolouration. The lobster used for canning must be fresh and there must be no delay in packing and the sterilization through heating.

Complete sterilization of lobster meat containing spore-forming organisms could not be effected at boiling temperatures (212°F.) for three hours, but when the meat was subjected to 240°F. for thirty minutes complete sterilization resulted. Such a temperature is reached only by "processing," that is heating with steam under pressure. At this temperature the quality of the meat as regards taste and appearance is good but higher temperatures similarly obtained, though they may shorten the time required for thorough sterilization, affect unfavourably the taste and the colour of the meat.

The Chemical Factor.—It was shown, however, that sterilization through "processing," while it kills all the bacteria in the canned product, does not prevent discolouration developing ultimately. Lobster meat, even when washed free from blood, becomes, in the absence of bacteria, bluish-black and the pickle itself is discoloured. The factor in this discolouration is the alkalinity which, whether the pickle is sea water, a solution of pure salt, or pure water invariably characterizes the canned product as it is ordinarily made. It was found, however, that if the pickle is made acid the discolouration does not take place. The presence of the acid prevents chemical changes in the meat which obtain when the meat and pickle are alkaline in reaction, and it retards to a very consider-

able degree the growth of bacteria which may gain entrance to the canned meat after its sterilization has been effected by "processing."

To get the degree of acidity in the canned product required to prevent or delay indefinitely discolouration the pickle should be made by adding three ounces of glacial acetic acid or of citric acid, the latter in the form of crystals, to every gallon of the water used, whether the latter is sea water, a solution of salt, or pure water. The cost of glacial acetic acid is about fifty cents a pound while that of citric acid is about ninety cents. A pound, therefore, of either will acidify more than five gallons of pickle, which will serve for a large amount of the canned meat. It may be added that the colour and taste of the latter are of the best character.

APPENDIX D

REPORT OF THE ASSOCIATE COMMITTEE OF CHEMISTS

The membership of this committee is limited to twenty; five members retire each year and their places are filled by vote of the Research Council. The retiring members this year were Dr. John S. Bates, Dr. A. F. L. Lehmann, Mr. I. C. Mackie and Mr. T. H. Wardleworth. Their places were taken by Dr. F. J. Birchard, of Winnipeg, Mr. T. Linsey Crossley, of Toronto, Mr. A. Nieghorn, of Montreal, and Mr. Geo. H. Tomlinson, of Westmount.

The annual meeting of the committee was held in the Chateau Laurier, Ottawa, on May 15, 1922, every member being in attendance.

The chairman, Dr. Ruttan, gave a review of the activities of the Research Council during the preceding year, describing the work done by those who had received assistance in their researches and the research carried out by those holding Studentships and Fellowships.

Dr. Thorvaldson, of the University of Saskatchewan, gave a very full account of the chemical researches carried out in connection with the effect of alkaline soil and water upon the concrete of the northwest, accompanied by complete analyses of the waters and soils taken from various districts in Saskatchewan and Alberta. He reported that analyses had been made of the different types of cement which will serve as a useful means of reference and as a basis for proper conclusions regarding the best remedy for this very serious trouble. This paper was fully discussed by chemists who had had experience in the action of saline waters on cement.

Mr. Lesslie R. Thomson brought before the committee the question of the best binding materials to be used for lignite briquettes, with a view of obtaining suggestions from the members. He gave a history of the tests which have been made and the advantages and disadvantages of the various materials tried. Many reports were submitted by members regarding binding materials used in other countries. Mr. Thomson stated that the results of their experiments would go to show that the addition of eight parts of coal tar pitch and about four and a half parts of waste flour screenings to one hundred parts of lignite gave the best economic results. Many suggestions for possible binding materials were offered by various members.

The committee had under consideration the utilization of the screenings of other forms of refuse from coal mines. It was pointed out that the use of these as colloidal fuel had not been tried out in Canada and its advantage over briquettes was very thoroughly discussed. It was observed that most excellent results had been obtained in British Columbia through concentrating low grade coal by the process of flotation.

Dr. John S. Bates presented a number of outstanding problems awaiting solution in the pulp and paper industry, and remarked that while most of these could be efficiently studied in a Research Institute, others must be solved in

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the industry itself. He pointed out that our knowledge of the composition and typical reactions of the constituents of wood was very unsatisfactory and a thorough investigation along this line would be of fundamental value to all wood industries. He called attention to the fact that the chemistry of pulp has been very incompletely worked out and that most of the methods of determining its value are empirical. The same could be said of the fundamental conditions of the cooking process. There is very much to learn regarding the course of reaction in the various processes for the manufacture of pulp; investigation might lead to radical improvements. Standardization of methods for determining strength, freeness, bleaching and beating qualities would be of great value to the whole industry and would be a field of investigation particularly adapted to a Research Institute. A Research Institute would also be well adapted for the standardization of methods of testing paper for strength, colour, finish, etc. The suitability of new pulpwoods, such as jack pine, hardwoods, etc., for pulp and paper has been attracting attention in many mills but very little of practical value has been accomplished. The seventh problem to which Dr. Bates called attention was the conditions of growth and nature of infection of the various fungi which attack wood and pulp. While this problem is already receiving attention from the Research Council, who have a number of workers engaged on it, it is so large that several years of investigation will be required not only to determine the forms and the effect of environment on their action, but also the value of infected wood in the manufacture of pulp. The eighth problem was the methods of utilization of waste sulphite liquor. A systematic study of this problem is needed to show how the enormous waste can be converted into an economic saving. In the discussion which took place, on the last problem submitted by Dr. Bates, it was found that many members had experience in this investigation, which is an outstanding one in connection with the sulphite pulp process. Special attention was called to the recent investigation by Mr. Tomlinson on the production of sulphite liquor waste yielding a very high percentage of fermentable sugar.

A discussion regarding the manufacture of cyanogen compounds in Canada was introduced by Mr. Horace Freeman, who pointed out that a large amount of cyanogen compounds required for the mining industry in Canada was produced during the war, but that the defects in the patent laws prevented Canada and Canadians from obtaining the benefit of their research in this and other investigations. The Research Council was asked to appoint a special committee to investigate the application of patent laws to chemical patents. In the future the question will be a very acute one in connection with patents held by the Research Council itself.

A very full discussion of the danger to the public from carbon monoxide poisoning was introduced by Mr. Hambly. It was decided to recommend strongly to the Department of Health at Ottawa that a bulletin be prepared and widely distributed, as it was felt that the danger to life and health was a very real one and one of which the general public was quite ignorant.

Attention was directed to the difficulty experienced by chemists in outlying towns and villages in obtaining access to chemical literature. It was decided to recommend to the Research Council that a catalogue of the chemical and physical journals of the various libraries in Canada be prepared and distributed, so that chemists would know where they could obtain any particular reference on a chemical or physical problem. This resolution was subsequently brought before the Research Council and investigation showed that a complete catalogue of journals and periodicals in the various fields of science was being prepared by the librarian of McGill University, but it would take two or three years to finish it. The Research Council then voted $3,500 to enable this work to be carried out within a year and the catalogue, at the time of writing, is about complete.

During the year, the chairman submitted to the various members of the committee a large number of problems of a chemical nature which came before the Research Council. The committee was also circularized regarding the amendment to the Patent Law which came before the House during the session. Many of the suggestions made by the chemists were incorporated in the amended Act.

APPENDIX E

REPORT OF THE ASSOCIATE COMMITTEE ON FOOD RESEARCH

The study on the preparation of the " B " vitamin undertaken by the committee has been in progress for its second year. At the outset the committee was faced with the problem of finding a satisfactory method for ascertaining the presence and potency of this compound, as the only one available, the antineuritic action on pigeons in which polyneuritis had been experimentally produced, was tedious, time consuming, and often unsatisfactory. Several authorities had used the rate of multiplication of yeast cells as an indication of the antineuritic substance. While these looked promising at first, various factors were found to interfere with the validity of these methods as promoted by their initiators and their value, as an implement of research, was, at the time the committee started work, seriously questioned.

A comparative study of the various methods of employing the yeast cell as an indicator of vitamin activity was undertaken and occupied several months' time. The various factors which vitiated these methods were investigated and traced to their sources. As a result of this preliminary study the method of growing pure strains of "Saccharomyces Cereviseae" on artificial culture media, to which minute quantities of vitamin solutions can be added and their effect observed on yeast cells, has been developed, which is free from the objection inherent in the previous methods. The method is not entirely novel but has incorporated the best features of all the previous methods in use and may be said to be a composite, and subsequent experience has shown it to be satisfactory for the purpose in view.

The next step was to take up the separation of the crude vitamin preparations from rice millings. Previously the usual technique employed large quantities of ether and ethyl alcohol. In view of the difficulty of obtaining cheap alcohol by the committee it was found advisable to develop an alternative method dispensing with the use of alcohol. Dilute acetic acid solutions were found to be effective for this purpose and the factors governing the optimum extraction of the crude preparations were discovered by subsequent research so that small scale quantities of the crude concentrates can be readily prepared in an active condition.

For the more complete separation of the active portion of the crude concentrates various metallic salts of inorganic acids and reagents used in preparation of alkaloids have been previously used. A recent method published by Osborne and Mendel employing a series of extractions with alcohol of various strengths indicated a possible solution. All the organic solvents then available were employed in an effort to find a specific solvent for separating the active principle. The result of this feature of the work showed that ethyl alcohol up to 85 of strength was the only effective solvent and that the other solvents, even when saturated with water, had no capacity to remove the antineuritic compound. Subsequently several other organic solvent liquors have become available in commercial quantities and these will be employed to ascertain their value in this respect.

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A preliminary study of the crude preparations was undertaken to ascertain a suitable colour test for the antineuritic substance. Various dyestuff intermediates are now available which can be coupled with various diazo compounds, giving a series of dyestuffs whose constitution is known. It was considered possible that these intermediates when coupled to a diazotysed vitamin solution might give a coloured dye, whose constitution, since one compound is known, could be determined, thus giving a clue to the chemical identity of the vitamin. The crude preparations, in the case of a few of these intermediates, do give a colour which is masked more or less, and it is hoped that in the case of the purer preparations to be obtained later on that this feature will be more successful.

The chemical separation of the active portion of the crude extract has been undertaken on a small scale by means of metallic reagents and especially phosphotungstic acid. Hitherto this latter compound has been the commercial article. These are prepared by empirical methods and different manufacturers prepare a reagent having in each case a different constitution.

Such reagents, even from the same manufacturer, often contain considerable quantities of impurities and inert matter and all vary considerably in their precipitating power. Our experience has shown that phosphotungstic acid is a fairly effective separating agent but a synthesis and study of the various combinations of phosphoric acid and tungstate radicles will be necessary for the preparation of a reagent which is pure and possessing a uniform precipitating capacity, before much progress can be made along these lines.

In so far as the work has progressed, the general properties of the substance in the crude extracts of the rice millings agree with those previously associated with the active antineuritic compound. Various authors have expressed doubt as to this substance being identical with the yeast cell activator. Experiments with polyneuritic pigeons are now in progress to determine this point, and the results so far obtained appear to indicate that the antineuritic compound has no yeast-activating properties.

The committee in course of the work has accumulated a voluminous series of protocols and experimental data which will be assembled and edited. The most serious problem the committee has to face is that of securing a requisite supply of technical assistance. The assistants in Professor Benson's laboratory, where the work is being carried on under her supervision, have been devoting all their spare time to this problem, but owing to ill health she has had to relinquish direction of it for the last six months and turn over her departmental work to her assistants, whose time for research has been considerably curtailed as a result.

APPENDIX F

The following is a complete list of persons who have been enabled to secure special post-graduate training in science under Research Council Fellowships, Studentships, or Bursaries and, who having completed their work under these awards, now occupy the positions indicated in each case.

Name	Present Occupation
Miss M. Anderson, B.A., M.Sc.	No information.
F. M. Archibald, B.Sc.	Chemist, Imperial Oil Refineries, Ltd., Sarnia, Ont.
H. C. Bates, B.A., M.A.	Instructor in Physics, Lafayette Collegc, Easton, Pa.
A. H. Bell, B.A.	Fellow in Geology, University of Chicago, Chicago, Ill.
H. P. Bell, B.Sc., M.Sc., M.A., Ph.D.	Assistant Professor of Biology, Dalhousie University, Halifax, N.S.
G. H. Berkeley, B.A., M.A., Ph.D.	Pathologist in charge, Dominion Field Laboratory of Plant Pathology, St. Catharines, Ont.
Miss E. L. Bishop, B.A., M.A.	Teacher of Mathematics, Collegiate Institute, Picton, Ont.
H. A. Braendle, B.A., M.A.	Physicist, Ames-Holden-McCready System, Montreal, Que.
O. C. Bridgeman, B.A., M.A.	Assistant Professor of Chemistry, University of Alberta, Edmonton, Alta.
J. W. Burns, B.Sc., M.Sc.	Instructor in Chemistry, University of Western Ontario, London, Ont.
Miss F. M. Cale, B.A., M.A.	Demonstrator, Dept. of Physics, University of Toronto, Toronto, Ont.
Miss M. L. Clark, B.A., M.A.	Teacher of Mathematics, Collegiate Institute, Sarnia, Ont.
R. J. Clark, B.A.	Demonstrator, Department of Physics, McGill University, Montreal, Que.
Miss L. Corbett, B.A., M.A. (Mrs. H. Rowley)	Head of Analytical Dept., Abitibi Pulp and Paper Co., Iroquois Falls, Ont.
Miss A. E. Dempsey, B.A., M.A.	Assistant Chemist, Maple Leaf Milling Co., Port Colborne, Ont.
E. P. Dolan, B.Sc., M.A.	Deccased.
V. H. Emory, B.A.Sc.	Research, Abitibi Pulp and Paper Co., Iroquois Falls, Ont.
T. S. C. Fawcett, B.A.Sc., M.A.Sc.	No information.
R. E. Foerster, B.A., M.A.	Biological Board of Canada, B.C.
H. R. Foreman, B.A., M.A.	Assistant Manager, Keith's Electric Refrigeration Co., Ltd., Toronto, Ont.
Miss C. W. Fritz, B.A., M.Sc.	Research, University of Toronto, Toronto, Ont.
W. A. Gale, B.A.Sc., M.A.Sc.	No information.
B. E. Gilbert, B.A., M.A.	Student at Botany Graduate School, University of Chicago, Chicago, Ill.
Miss K. F. Godwin, B.A., M.Sc. (Mrs. J. W. Pinhey)	Holding Philip Carpenter Fellowship in Zoology, McGill University, Montreal, Que.
C. Greaves, B.Sc., M.Sc., Ph.D.	Research, McGill University, Montreal, Que.
R. Hamer, B.A., M.A., Ph.D.	Instructor in Physics, University of Wisconsin, Madison, Wis.
R. H. Harris, B.A., M.A.	Chemist, Quaker Oats Company, Saskatoon, Sask.
W. H. Hatcher, B.A., M.Sc., Ph.D.	Assistant Professor of Chemistry, McGill University, Montreal, Que.
E. Hearle, B.S.A.	In charge of mosquito investigation, Entomological Laboratory, Banff, Alta.
G. H. Henderson, B.A., B.Sc., M.A., Ph.D.	Professor of Physics, University of Saskatchewan, Saskatoon, Sask.
Miss E. M. Hill, B.A., M.Sc.	No information.
A. D. Hone, B.A., M.A.	Headmaster, London Technical High School, London, Ont.
H. J. C. Ireton, B.A., M.A.	Demonstrator and Research in Physies, University of Toronto, Toronto, Ont.
A. B. Jackson, B.S.A.	Assistant Plant Pathologist, Dominion Laboratory of Plant Pathology, St. Catharines, Ont.
W. F. James, B.A., M.Sc., Ph.D.	Assistant Geologist, Geological Survey, Ottawa, Ont.
Miss M. B. Kearney, B.A., M.A.	Teacher, 88 W. College Ave., Tallahassee, Florida.
K. H. Kingdon, B.A., M.A., Ph.D.	Physicist, Research Laboratory, General Electric Co., Schenectady, N.Y.
W. A. Lawrance, B.A., M.A., Ph.D.	Stanley Professor of Chemistry, Bates College, Lewiston, Me.
J. F. Lehmann, B.Sc., M.Sc.	Holding 1851 Exhibition Scholarship in Cambridge, England.
A. H. Leim, B.A.	Research, Department of Biology, University of Toronto, Toronto, Ont.
G. H. W. Lucas, B.A., M.A., Ph.D.	Research Department of Chemistry, University of Toronto, Toronto, Ont.
D. G. MacGregor, B.A.	Professor of Physics, Mount Allison University, Sackville, N.B.
C. A. Mackay, B.A., M.A.	Instructor and research in Physics, Princeton University, Princeton, N.J.
A. W. McCallum, B.Sc.F., M.A.	Division of Botany, Department of Agriculture, Experimental Farm, Ottawa, Ont.
W. H. McCurdy, B.A., M.A.	Holding 1851 Exhibition Scholarship, Princeton University, Princeton, N.J.
J. L. McDonald, B.A.	Harvard Medical School, Cambridge, Mass.
J. W. McKinney, B.Sc., M.Sc., Ph.D.	Special work for Dominion Fuel Board, Ottawa, Ont.
H. R. McLarty, B.A., M.A.	Pathologist in charge, Dominion Laboratory of Plant Pathology, Summerland, B.C.

LIST OF FELLOWSHIPS, ETC.—*Concluded*

Name	Present Occupation
Stuart McLean, B.A., M.A.	Research, Lamp Development Laboratory, Nela Park, Cleveland, Ohio.
T. C. McMullen, B.A., M.A., Ph.D.	Dean, Albert College, Belleville, Ont.
W. C. McQuarrie, B.A., M.A.	Instructor in Physics, Lafayette College, Easton, Pa.
J. A. McRae, M.A., Ph.D., F.I.C.	Professor of Chemistry, Queen's University, Kingston, Ont.
John Melville, B.A.Sc., M.A.Sc.	With Whalen Pulp and Paper Mills, Ltd., Swanson Bay, B.C.
Miss B. K. E. Mossop, B.A., M.A., A.A.A.S.	No information.
Miss D. E. Newton, B.S.A., M.Sc.	Hudson's Bay Fellowship, University of Manitoba, Winnipeg, Man.
Miss M. Newton, B.S.A., M.Sc., Ph.D.	Associate Professor of Biology, University of Saskatchewan, Saskatoon, Sask.
H. G. Oddy, B.A., M.A., Ph.D.	Instructor in Chemistry, University of Alberta, Edmonton, Alta.
Miss M. E. M. Olding, B.A.	Teacher of English and Botany, New Glasgow High School, New Glasgow, N.S.
J. F. Phillips, B.A.Sc., M.A.	Research in Department of Zymology, University of Toronto, Toronto, Ont.
H. N. Racicot, B.A.	Pathologist in charge, Dominion Laboratory of Plant Pathology, Ste. Anne de la Pocatiere, Que.
P. V. Rosewarne, B.A., M.A.	Chemist in charge, Oil Laboratory, Fuel Testing Station Department of Mines, Ottawa, Ont.
W. W. E. Ross, B.A.	Assistant Magnetician, Meteorological Service, Toronto, Ont.
J. E. Saunders, B.Sc., M.Sc.	Mining Engineer, South America Gold Areas Ltd., Sao Bento, E.F.C.B. Minas Geraes, Brazil.
D. A. Scott, B.A., M.A.	Associate Director, Insulin Division, Connaught Laboratory, University of Toronto, Toronto, Ont.
W. F. Seyer, B.A., M.Sc., Ph.D.	Associate Professor of Physical Chemistry, University of British Columbia, Vancouver, B.C.
Miss E. Shanley, B.A., M.Sc.	Research in Department of Pathology, McGill University, Montreal, Que.
W. W. Shaver, B.A., M.A., Ph.D.	No information.
Miss J. D. Spier, B.A., M.Sc.	No information.
H. N. Stephens, B.A., M.A., Ph.D.	No information.
O. J. Walker, B.A., M.A., Ph.D.	Assistant Professor of Chemistry, University of Alberta, Edmonton, Alta.
E. F. Whyte, B.A., M.A., Ph.D.	Lecturer in Chemistry, Queen's University, Kingston, Ont.
D. Wolochow, B.A., M.A.	Research, Department of Chemistry, University of Saskatchewan, Saskatoon, Sask.
C. A. H. Wright, B.Sc., M.Sc., Ph.D.	A. D. Little Inc., Charles River Road, Kendall Square, Cambridge, Mass.
E. G. Young, B.A., M.Sc., Ph.D.	Professor of Biochemistry, Univ. of Western Ont. Medical School, London, Ont.
J. F. T. Young, B.A., M.A., Ph.D.	Demonstrator and Research Assistant, Department of Physics, University of Toronto, Toronto, Ont.

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APPENDIX G

LIST OF FELLOWSHIPS, STUDENTSHIPS AND BURSARIES, 1922-23

FELLOWSHIPS

Name	Where held	Subject of Research
E. H. Boomer, B.Sc., (Univ. of B.C.) M.Sc. (McGill).	Department of Chemistry, McGill University.	An investigation on vapour densities, molecular compound formation and the physical properties of certain organic compounds and their correlation in terms of molecular forces.
W. W. Shaver, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Field spectroscopy. The extreme ultra violet spectra of the alkali metals.
G. M. Shrum, B.A., M.A., (Toronto).	Department of Physics, University of Toronto.	Liquefaction of helium and an investigation of the structure of the Balmer lines of hydrogen.

STUDENTSHIPS

F. B. Adamstone, B.A., M.A. (Toronto).	Department of Biology, University of Toronto.	Investigation on the organisms constituting the bottom fauna of Lake Nipigon.
D. S. Ainslie, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Investigation on extending the spectrum into the extreme ultra violet for caesium, sulphur and other elements.
H. C. Bates, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Investigation on the interferometer and other methods of investigating the compressibility of crystals together with an investigation of the bearing of the results on atomic structure.
R. E. Foerster, B.A., M.A. (Univ. of B.C.).	Department of Zoology, University of British Columbia.	Investigation on the food, and the enemies of the young Pacific salmon in fresh water.
J. C. Forbes, B.A., M.A. (Univ. of Sask.).	Department of Biochemistry, McGill University.	Investigation on the chemical constitution of pepsin.
C. Greaves, B.Sc., M.Sc. (McGill).	Department of Chemistry, McGill University.	Investigation on the chemistry of beryllium.
W. V. Howard, B.A., M.Sc. (McGill).	Department of Geology, McGill University.	Investigation on the granitization of the Temiskaming series in northern Quebec.
A. H. Leim, B.A. (Toronto).	Department of Biology, University of Toronto.	Investigation on the life history of the shad.
Miss Mattie Levi, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Investigation on the properties of the characteristic X-radiation from light elements.
A. D. Macallum, B.A., (Toronto), M.Sc. (McGill).	Department of Chemistry, McGill University.	Preparation of caoutchouc.
D. J. MacLeod, B.A., M.A., (Queen's).	Department of Bacteriology, Queen's University.	The discolouration of canned lobster.
W. C. McQuarrie, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Investigation on the recoil phenomena in helium and other gases bombarded by alpha rays.
John Melville, B.Sc. (Univ. of B.C.).	Department of Chemistry, University of British Columbia.	Investigation on the vapour pressure of carbon dioxide in equilibrium with mixtures of solutions of potassium carbonate and potassium bicarbonate.
D. M. Morrison, B.Sc. (Univ. of B.C.), M.Sc. (McGill).	Department of Chemistry, McGill University.	Study of molecular compound formation.
Miss Irene Mounce, B.A., M.A. (Univ. of B.C.), M. Sc. (Univ. of Man.).	Department of Botany, University of Toronto.	Investigation on the biology of timber-destroying fungi.
H. G. Oddy, B.A., M.A. (McMaster), M.A., Ph.D. (Toronto).	Department of Chemistry, University of Toronto.	Friedel and Craft's reaction in some preparations from maleic and fumaric acids.
H. N. Racicot, B.A. (McMaster).	Department of Botany, University of Toronto.	Investigation on the normal growth of the bean plant and the correlation between various organs and the effect of disturbing the correlation by removing part of one of the organs, namely the leaves.
J. E. Saunders, B.Sc. (McGill).	Department of Mining Engineering, McGill University.	Investigation of the differential flotation of the copper nickel iron sulphide ores of the Sudbury district.
H. G. Smith, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Investigation on radiation potentials for the spectrum of ionized potassium and the relation of the spectrum of ionized potassium to that of argon.
H. N. Stephens, B.A. (McMaster), M.A. (Toronto).	Department of Chemistry, McGill University.	Constitution of caoutchouc.
Miss E. M. Taylor, B.A., M.A. (Toronto).	Department of Chemistry, University of Toronto.	Effect of acid on the growth rate of yeast.
Miss Mollie Weinberg, B.A., M.A. (Univ. of Man.).	Department of Physics, University of Manitoba.	Study of experimental acoustics.
A. G. Dustan, B.A.Sc. (Toronto).	Department of Botany, McGill University.	Resigned.
M. Gêrin, B.A.Sc. (Montreal)	Department of Engineering, McGill University.	Resigned.
D. R. Harrison, B.Sc., M.Sc. (McGill).	Department of Chemistry,McGill University.	Resigned.
G. H. W. Lucas, B.A., M.A., Ph.D. (Toronto).	Department of Chemistry, University of Toronto.	Resigned.
W. H. McCurdy, B.A. (Dalhousie).	Department of Physics, University of Toronto.	Resigned.

BURSARIES

Name	Where held	Subject of Research
E. P. Dolan, B.Sc., M.A. (St. Francis Xavier's).	Department of Geology, McGill University.	Study of the contact phenomena in connection with the intrusives of Mount Royal and Metamorphic zones of Mt. Royal.
T. S. C. Fawcett, B.A.Sc., M.A.Sc. (Toronto).	Department of Mining Engineering, University of Toronto.	A study of rock crushing with rolls.
Miss M. A. Fritz, B.A. (McGill).	Department of Geology, University of Toronto.	The stratigraphy and palaeontology of Toronto and vicinity.
W. A. Gale, B.A.Sc. (Univ. of B.C.).	Department of Chemistry, University of British Columbia.	The phase relationships of sodium sulphate and magnesium sulphate; a commercial method of separation.
J. L. F. Germain, B.A. (Univ. of Montreal).	Department of Chemistry, Royal College of Science, London, England.	Study in advanced analytical chemistry.
Miss K. F. Godwin, B.A., M.Sc. (McGill).	Department of Botany, McGill University.	The causes and prevention of the deterioration of groundwood pulp.
P. G. Hiebert, B.A. (Univ. of Man.), M.A. (Toronto), M.Sc. (McGill).	Department of Chemistry, McGill University.	The action of the halogen hydrides upon pure hydrogen peroxide.
Miss M. B. Kearney, B.A. (Toronto).	Department of Physics, University of Toronto.	The destruction for fluorescence of various solutions on exposure to ultra violet light.
S. Lehrman, B.A., M.A. (Toronto).	Department of Chemistry, University of Toronto.	The scattering of light by dust free liquids.
Miss A. I. McPherson, B.A. (McGill).	Department of Physics, McGill University.	The effect of X-rays and radium rays on hydrogen ion concentration and electrical conductivity of solutions.
L. A. Munro, B.A., M.A. (Dalhousie).	Department of Chemistry, McGill University.	The variation in apparent volume with degree of subdivisions and the absorption of vapors by alumina.
J. F. Phillips, B.A.Sc., M.A. (Toronto).	Department of Zymology, University of Toronto.	Study of the chemistry of: (a) Bacterial association of bacillus granulobactor pectinovorum and bacterium volutani, (b) Bacillus aceto-ethylicum.
Miss J. D. Spier, B.A. (Mc- (McGill).	Department of Botany, McGill University.	The cause and prevention of fungus decay of chemical pulps during storage.
Miss M. L. Clark, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Resigned.
C. L. Dewar, B.Sc. (McGill)	Department of Mining, McGill University.	Resigned.
D. M. Findlay, B.A. (Toronto).	Department of Chemistry, University of Toronto.	Resigned.
C. H. McLeod, B.A. (Toronto).	Department of Botany, University of Toronto.	Resigned.
D. McNeil, B.A. (St. Francis Xavier).	Department of Chemistry, McGill University.	Resigned.
D. O. Notman, B.Sc. (Queen's).	Department of Chemistry, Queen's University.	Resigned.
H. E. Searle, B.Sc. (Queen's)	Department of Metallurgy, Queen's University.	Resigned.

APPENDIX H

LIST OF ASSISTED RESEARCHES, 1922-23

Grantee	Where carried on	Subject of Research	Amount awarded
			$ cts.
Prof. Frank Allen.....	Department of Physics, University of Manitoba, Winnipeg, Man.	To continue investigation on colour vision.....	195 54
Associate Biological Committee.	Atlantic Biological Station, St. Andrews, N.B.	To investigate certain phases of the destruction of piling by marine boring animals.	2,500 00
Associate Committee on Accurate Methods for determining Yield of Grain.	Dominion Experimental Farms.	Investigation of best methods for obtaining accurate results in testing varieties, strains, and treatments of grains.	15,000 00
Associate Committee on the Nutritional Problems of the Fox Industry.	Experimental Station, Department of Agriculture, Hull, Que.	Investigation of the problems affecting the fox industry of Canada.	5,000 00
Prof. R. W. Boyle.....	Department of Physics, University of Alberta, Edmonton, Alta.	Investigation on Ultra Sonics.....	2,500 00
Prof. R. H. Clark and..... Professor J. Davidson	Departments of Chemistry, and Botany, University of British Columbia, Vancouver, B.C.	Investigation on economically cultivating a number of essential oil and drug yielding plants in British Columbia.	1,000 00
Prof. P. Gillespie.....	Department of Civil Engineering, McGill University, Montreal, Que.	Investigation of the causation of cracks in concrete protective coatings on steel to protect against corrosion.	500 00
Dr. F. C. Harrison.....	Macdonald College, Macdonald College, Que.	Investigation on the relation of soil acidity to Nitrogen Fixing Bacteria.	1,000 00
Prof. H. E. T. Haultain.....	Department of Mining Engineering, University of Toronto, Toronto, Ont.	Investigation on rock crushing with rolls.....	1,100 00
Prof. H. E. T. Haultain.....	Department of Mining Engineering, University of Toronto, Toronto, Ont.	To continue study of the action of ball mills.....	400 00
Prof. A. Ll. Hughes and Prof. J. K. Robertson.	Department of Physics, Queen's University, Kingston, Ont.	Investigation on the intensity measurements in spectra.	300 00
Prof. A. B. Klugh.....	Department of Biology, Queen's University, Kingston, Ont.	To ascertain the food relations of certain minute organisms (Entomostraca) in the cultivation of fresh water fishes.	500 00
Prof. J. J. R. Macleod.....	Department of Physiology, University of Toronto, Toronto, Ont.	Investigation on the action of the blood towards toxines in conditions of fatigue.	1,500 00
Prof. G. W. Scarth.....	Department of Biology, McGill University, Montreal, Que.	Investigation on the action of pure salts on structure and growth of vegetable cells.	250 00
Prof. J. W. Shipley.....	Department of Chemistry, University of Manitoba, Winnipeg, Man.	To continue investigation on the soil corrosion of steel and iron piping.	300 00
Prof. J. F. Snell.....	Macdonald College, Macdonald College, Que.	Investigation into the cause and treatment of soil acidity.	1,000 00
Prof. G. S. Whitby.....	Department of Chemistry, McGill University, Montreal, Que.	Investigation on the Constitution of Caoutchouc...	100 00

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ADDITIONAL RESEARCHES IN PROGRESS 1922-23

Grantee	Where carried on	Subject of Research
Associate Biological Committee.	Macdonald College, Que.....	Investigation on Chemistry and Bacteriology of Fish Curing.
Associate Committee on Industrial Fatigue.	Department of Physiology, University of Toronto, Toronto, Ont.	Problems in Industrial Fatigue.
Associate Food Research Committee.	Laboratory of Food Chemistry, University of Toronto, Toronto, Ont.	Investigation on Vitamines.
Committee of the Engineering Institute of Canada. (Prof. C. J. Mackenzie.)	University of Saskatchewan, Saskatoon, Sask.	Investigation of the causes of the deterioration of concrete in the Provinces of Manitoba, Saskatchewan, and Alberta, through the actions of alkali waters of the soils.
Horace Freeman.....	567 Hornby Street, Vancouver, B.C.....	Investigation into the new processes in the treatment of the separation of silver, lead and zinc in the concentrates of complex ores of British Columbia.
Dr. J. A. Gray.....	Department of Physics, McGill University, Montreal, Que.	Investigation on Röntgen Rays.
Prof. A. Ll. Hughes.....	Department of Physics, Queen's University, Kingston, Ont.	To purchase a specially designed motor generator set for giving up to 1,500 volts with a current up to 0·2 amperes, with necessary accessories to study the bridging of the gap in the ether waves between those produced by Ultra-Violet Light and the so-called X-Rays.
Prof. F. M. G. Johnson.....	Department of Chemistry, McGill University, Montreal, Que.	Investigation of surface energy of solids.
Prof. L. V. King.....	Department of Physics, McGill University, Montreal, Que.	Investigation on Fog Signalling.
Dr. J. C. McLennan.....	Department of Physics, University of Toronto, Toronto, Ont.	Investigation on the properties of Helium.
Dr. J. C. McLennan.....	Department of Physics, University of Toronto, Toronto, Ont.	Investigation on Explosive pressures which require a high voltage current apparatus. (Piezo-Electric Experimental research.)
Dr. J. C. McLennan.....	Department of Physics, University of Toronto, Toronto, Ont.	Investigation on the spectrum of the Infra Red Rays.
Prof. H. F. Roberts.....	Department of Botany, University of Manitoba, Winnipeg, Man.	Investigation of the inheritance of sugar and starch in the endosperm of different varieties of Indian Corn.
Dr. A. N. Shaw.....	Department of Physics, McGill University, Montreal, Que.	Investigation on Conductivity and Vapour Pressure of Salt Solutions.
Special Committee on Iron Ores of the Mining and Metallurgy Committee (J. G. Morrow.)	Hamilton, Ont.....	Utilization of the low grade iron ores of Canada.

APPENDIX I

In view of the great importance of the subject of the action of the alkaline waters of the Prairie Provinces in attacking and disintegrating concrete foundations and other structures, to which reference has been made in the present report, it has been thought advisable to publish the following paper by Professor Thorvaldson, of the University of Saskatchewan, which was read at the Fifth Annual Meeting of the Research Council's Associate Committee of Chemists, held in May, 1922. This paper contains an admirable presentation of the information available on the chemical aspects of the distintegration of concrete by alkaline waters.

THE CHEMICAL ACTION OF ALKALINE WATER ON CONCRETE

The problem of the so-called "Action of alkali on concrete" is generally considered to be peculiar to the Prairie Provinces of Canada and the corresponding states south of the international boundary. There is no doubt that those regions of the prairies, having a low rainfall, present extraordinary conditions in respect to the amount of soluble salts present in the soil. The experiences of engineers in the dry belt of Western Canada and the Western States have indeed brought this problem very forcibly to the attention of scientists and the general public.

During the summer of 1918 the writer, while searching for potash, analyzed nearly a hundred samples of water collected from various salt lakes and marshes of Saskatchewan, and found that all of these contained from one per cent to thirty-six per cent of total solids. In 1919 his attention was drawn to repeated failures of concrete foundations of various buildings in the central portion of the city of Saskatoon. These had been at first attributed to defective concrete, and even in some cases had been replaced free of charge by the original builder, but later suspicion was thrown on the ground waters as being responsible for the failures. Analysis of the waters from these foundations showed in all cases the total solids to be above one per cent and in some cases above five per cent.

An analysis of water taken from the basement of one of these buildings may be taken as typical. Large quantities of this water were pumped out each day.

	Parts per million
Sulphate (SO_4)	10326
Chloride (Cl)	131
Carbonate (CO_3 present as HCO_3)	196
Calcium (Ca)	410
Magnesium (Mg)	153
Sodium (calculated)	4420

Calculated in hypothetical combinations this gives:—

	Parts per million	Percentage of total solids
Sodium chloride (NaCl)	216.6	1.37
Sodium sulphate (Na_2SO_4)	13398.0	84.52
Magnesium sulphate ($MgSO_4$)	757.8	4.78
Calcium sulphate ($CaSO_4$)	947.2	5.98
Calcium carbonate (as bicarbonate)	530.6	3.35
Total solids	15850.2	100.00

The outer layer of the concrete which had been in contact with these waters was found to be soft. All cohesion between the cement and the aggregate had disappeared, so that it could be scraped off with a dull knife. The depth to which the action had proceeded varied, but in some cases it seemed to have proceeded throughout the whole thickness of the wall. Sometimes there is a thin blistered shell of calcium carbonate on the outside, while the damage has proceeded to some depth inside. On drying cracks form in the damaged concrete, and incrustations on the surface are often found. These are composed mainly of sodium sulphate with small quantities of calcium and magnesium salts.

As waters comparable to the one of which analysis is given above are widely distributed throughout the western provinces, it is evident that any deleterious action of these on concrete would present a serious and a widespread problem for the engineer, in the building of foundations, irrigation structures and aqueducts. But while we have conditions here which are extreme, and where the damage has been very marked, the problem is far from being confined to the western prairies. Typical cases of the destruction of concrete by waters containing these same salts have been observed and described on the continent of Europe and in Great Britain and Ireland. The problem had been studied there, mainly in relation to sea-water which contains high concentrations of sulphates, long before attention was drawn to the matter in the West.

The use of concrete for structures built under water became general between 1865 and 1886. Five years after the latter date (1891) a paper was published in the Proceedings of the Institution of Civil Engineers, on " The Influence of Sea-water upon Portland Cement and Concrete." The author describes very fully

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the deterioration of concrete work of the dock at Aberdeen which was built in 1875 and which failed badly. Dr. Michaelis, of Berlin, published in the same year a paper on "The Behaviour of Portland Cement in Sea-water," in which he states that the "aluminate and ferrate of lime are not only decomposed and rapidly softened by sea-water, but they also give rise to the formation of double compounds, which in their turn destroy the cohesion of the mass by producing fissures and bulges. The salts contained in sea-water, especially the sulphates, are the most dangerous enemies of hydraulic cements." He also observed that the hydrate of magnesia is formed during the deterioration of the concrete.

The writers of both papers recommend the use of mixtures rich in cement (not less than one part of cement to four of aggregate) in order to produce a dense impervious concrete.

Engineers did not agree as to the cause of the Aberdeen failure. Some claimed that the difficulty lay with the use of a cement too high in lime, others thought that the failure was due to the presence of magnesia in the cement. Actual tests did not favour these views. Another view was that wherever failures occurred they must be due to defective or improperly handled cement. The last view has been held by some engineers up to the present time.

Cases of deterioration of concrete in sea-water were from time to time observed. Concrete docks at Sunderland, Hartlepool and Belfast failed to stand up and the action of the magnesium chloride in sea-water on the uncombined lime was generally blamed for the failure as the magnesium in the sea-water seemed to replace the calcium in the cement.

Two methods were introduced for protection of the concrete. One was to construct large blocks of dense concrete, season these on land and air-dry them thoroughly, thus carbonising the outside. These were then placed in position in the sea. The other was to produce concrete impervious to water by depositing a layer of asphalt either on the outside of the structure or in the concrete near the outer edge of it.

Concrete structures at Scarborough were supposed to have been damaged by sea-water. An investigation was made by B. D. Butler, who came to the conclusion that the damage was due to land water containing sulphates. He says: "Waters containing calcium or other sulphates are a serious source of danger to cement concrete exposed to their action, and they are very liable to attack the cement, and to cause deterioration, with, in extreme cases, disintegration of the mass."

The evidence as to damage by sea-water is very conflicting. This may be due to a number of causes such as modification of the conditions by land water, by the flora and fauna which attach themselves to concrete structures in the sea and the failure to discriminate between the action of the sea-water itself and the seepage water in the soil in which the foundations are embedded. Exposure between tides and evaporation may cause great changes in the concentration of the salts in the water which adheres to the structure thus producing conditions in some places favourable to damage.

In 1916 the Council of the Institution of Civil Engineers in Great Britain appointed a committee to collect information as to the deterioration of structures of timber, metal and concrete, when exposed to the action of sea-water. The British Department of Scientific and Industrial Research has supported and co-operated with the Institution of Civil Engineers in this matter and a lengthy report was published in 1920. This report deals with the available information about existing structures in various parts of the British Empire. Arrangements, it is said, are being made for further investigation. While the report relates many instances of damage due to sea-water, it maintains that generally speaking damage can be prevented by the use of dense concrete.

In 1912 Bates, Phillips and Wig, of the United States Bureau of Standards, published a paper on the "Action of Alkali Water and Sea Water on Cements."

Most of their field tests covered a period of only about one year for the same specimen, although some tests covered about three and a half years. They found that properly made Portland cement concrete when totally immersed in sea-water did not show decomposition in that time. They are not certain that the same can be said about structures exposed between high and low tide. However if the sea-water is brought into intimate contact with the cement in the laboratory they found that marked chemical action took place, the following changes being the most important:—

(1) The magnesia is precipitated from the sea-water and the calcium of the cement goes into solution.

(2) The sulphates of the sea-water are taken up by the cement.

No evidence of the formation of tricalcium sulphoaluminate was found although this had been supposed by many, and especially by Le Chatelier, to be responsible for the damage to concrete in sulphate solutions. The magnesium in the cement they found to be practically inert, and the quantity of alumina, iron and silica did not seem to affect the action of the sea water on the cement. Up to 1·75 per cent the quantity of sulphur trioxide in the cement did not have an effect. Chlorine and sodium were not taken up by the cement in appreciable quantities. Test pieces in laboratory (cylinders made of mortar) showed rapid deterioration when exposed to solutions of sulphates or of mixtures of sulphates and chlorides.

In 1910 Burke and Pinckney, of the Montana State Agricultural College, published a paper on the "Destruction of Hydraulic Cements by the Action of Alkali Salts." The work reported had been carried out during the three years 1907-10, and was begun because of the opinion that many failures of concrete structures in the state and especially those at Great Falls, Montana, were in some way connected with the alkali in the soil. The procedure in the laboratory experiments was to set cement with water, cure same for a few weeks and then to grind the set cement. The ground material was then extracted with various solutions of salts.

The authors came to the conclusion that the sodium and magnesium sulphates in the waters of the dry belt are responsible for the disintegration of concrete. These salts they say react with the free lime in the cement forming products which occupy from two to three times as much space as the original substance. The mechanical force thus exerted disrupts the cement.

Papers by Dr. Carl Steik published by the Wyoming Agricultural Experiment Station in 1917 and 1919 gave a large amount of experimental work on this problem. Dr. Steik opposed the theory that the damage is due to the formation of gypsum and the corresponding increase in volume, as he found that gypsum acts as a cementing material. Dr. Steik found solutions of magnesium chloride to be the most active disintegrating agents, the sulphates of sodium and magnesium being next in order. Sodium chloride was found to accelerate the sulphate action while sodium carbonate retards it. Solutions of calcium sulphate were found to have no bad effects.

Presence of sulphuric acid, disodium hydrogen phosphate, magnesium fluoride and oxalic acid was found to increase the resistance of cement to the alkalies.

A very thorough field investigation was carried out by Wig, Williams, Finn, etc., of the United States Bureau of Standards, and the results published in 1917. Specimens of concrete of varying composition and preparation were placed in test plots in several states of the union. Disintegration was found to take place in regions where any one of the sulphates, sodium, magnesium or calcium predominate. While the porous tile and lean mixtures were affected first and disintegrated, the less porous test pieces were also affected. The damage was found to increase with increasing concentration of sulphates, but low grade cement tile made in the usual way was found to be subject to disintegration of the soil water contains one-tenth of one per cent of alkali sulphates.

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The authors considered the disintegration to be due both to chemical action causing a softening of the set cement and to physical disruption due to expansion from the crystallization of salts in the pores of the concrete. They recommend a mixture not leaner than 1 to 3 in order to produce a dense concrete.

Experience in the Canadian West in the experimental plot in Saskatoon, now operating for three years, and at Brooks, Alberta, operated by A. S. Dawson, of the Canadian Pacific Railway, is that while porous concrete disintegrates very quickly and dense test pieces disintegrate slowly even the densest mixtures made with the greatest of care are affected by the concentrations of sulphates commonly found in the soil waters of the prairies. Further that while many preventative measures have been tried none of these are very satisfactory, since the best that can be done is to slow down the action. Waterproofing by means of a layer of asphalt gives protection as long as this layer is unbroken, but weak spots in this layer may destroy the advantages of such treatment.

It is therefore most desirable to obtain such an understanding of the nature of the action of these salt solutions on cement and concrete, as will enable us to predict whether Portland cement of the composition at present specified can be modified so as to prevent the damage, or we have to look for different building materials to avoid the difficulty.

In our work at Saskatoon the first year and a half were spent on obtaining data on the soil conditions in a district where the action was very marked. Then we began the study of the chemical action of the salts found in the soil water of the district, on the various chemical compounds present in cement, beginning with the simplest of these. For this work the excellent researches on the constitution and hydration of cements which have been carried out at the Bureau of Standards in Washington and the Geophysical Laboratory of the Carnegie Institution serve as the starting point. It is therefore perhaps worth while to summarize very briefly some of the work to date on the constitution of cement.

Perhaps the first definitely planned research on cement was carried out by John Smeaton in 1756, when he determined to attempt to find the most perfect cement possible for the building of the Eddystone Lighthouse. He found that for mortar, to be used in water, the purest lime was not the best, but that the lime giving the best results was really chalk impregnated with clay. Pure lime would not harden under water while burnt clayey lime did harden. Thus he obtained a hydraulic lime mortar which when mixed with pozzolana—a pumice-like material of volcanic origin—produced a satisfactory mortar for the lighthouse. While this may be considered the beginning of the cement industry, the material was not constitutionally, except in a slight degree, like Portland cement of to-day. The name Portland cement appeared first in 1824 when Joseph Aspdin, a bricklayer of Leeds, took out a patent for making a cement from limestone and clay, the name being taken because the set product resembled the stone quarried at Portland, England. This cement was burned at a low temperature without the formation of clinker which is formed by partial fusion. The hard product when formed by "overburning" was generally rejected, although it was more like the Portland cement of to-day. Later the value of the hard-burned product was recognized, and the production of Portland cement as we know it to-day began shortly after the middle of the 19th century.

The pioneer work on the constitution of cement was done by a number of men, of whom one might mention Bergman of Sweden, Saussure of Switzerland, and Vicat of France. The last named explained the hardening of hydraulic lime by chemical action of the lime on the alumina and silica, while ordinary mortar made of rich lime and sand required carbon dioxide for hardening, and if excluded from carbon dioxide remained soft for a number of years. On the other hand rich lime mixed with finely ground pozzolana hardens in a short time in water, the lime and the pozzolana combining chemically.

In 1887 Le Chatelier published a paper which is now a classic on the constitution of cement. The microscope and chemical analysis supplemented each other in his research. He concluded that Portland cement contains tricalcium silicate, tricalcium aluminate, "calcium ferrate" and "multiple silicates."

The work at the Geophysical Laboratory and the Bureau of Standards indicates that the chief constituents of well burnt clinker of Portland cement are tricalcium silicate, dicalcium silicate, tricalcium aluminate and clay or glass high in oxide of iron, with 5·3 calcium aluminate (5 $CaO \cdot 3\ Al_2O_3$) and calcium oxide as minor constituents. These conclusions have now been generally accepted, although there was some opposition, especially among the Germans, to accepting tricalcium silicate as one of the chief constituents, the claim being made that what was considered to be this substance always contained aluminium oxide. Bates and Klein, of the Bureau of Standards, prepared tricalcium silicate almost free from aluminium oxide and showed that this substance had all the properties of Portland cement except that it is somewhat less plastic. On the other hand dicalcium silicate in the pure state sets very slowly —too slowly for practice—but if left in contact with water hardens in three or four months to the strength attained by the tricalcium silicate. Bates found that tricalcium aluminate hydrates almost instantly, giving out heat but does not set or harden. Others claim that it sets and hardens rapidly. The suggestion has been made that the confusion is due to the fact that the tricalcium aluminate decomposes at its melting point (1535° C.) producing 5·3 calcium aluminate (5 $CaO \cdot 3\ Al_2O_3$) and calcium oxide, and that this mixture sets and hardens rapidly. This mixture may be used as a quicksetting cement.

For burning a cement from the pure oxides of calcium, aluminium and silicon a temperature of 1650° C. is required. At this temperature tricalcium silicate forms fairly rapidly from dicalcium silicate and lime. If iron oxide and magnesium oxide are present the melting point is lowered, so that the necessary reactions take place at a lower temperature (about 1425° C.). From burning the mixture of pure oxides at 1650° C. a mass is obtained containing about 30 per cent liquid and 70 per cent solid crystalline material. On cooling, the clinker is of the following composition:—

45 per cent $3\ CaO\ SiO_2$ —tricalcium silicate.
35 per cent $2\ CaO\ SiO_2$ —dicalcium silicate.
20 per cent $3\ CaO\ Al_2O_3$—tricalcium aluminate.

At 1900° C. the tricalcium silicate decomposes again into dicalcium silicate and lime.

The most valuable properties of Portland cement are conferred on it by the tricalcium silicate which it contains, and one should adjust the conditions so as to favour the production of this substance during the manufacture of the cement.

Klein and Phillips, of the United States Bureau of Standards, made extended study of the hydration of the constituents of Portland cement and summarize their results as follows:—

> The hydration of cements is brought about by the formation of amorphous hydrated tricalcium aluminate with or without amorphous alumina, the aluminate later crystallizing. At the same time sulphoaluminate crystals are formed, and low-burned or finely ground lime is hydrated. The formation of the above compounds begins within a short time after the cement is gauged. The next compound to react is tricalcium silicate. Its hydration may begin within twenty-four hours, and it is generally completed within seven days. Between seven and twenty-eight days the amorphous aluminate commences to crystallize and betaorthosilicate (dicalcium silicate) begins to hydrate. Although the latter is the chief constituent of the American Portland cements, it is the least reactive compound. The early strength (twenty-four hours) of cements is probably due to the hydration of free lime and the aluminates. The increase in strength between twenty-four hours and seven days

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depends upon the hydration of tricalcium silicate, although the further hydration of aluminates may contribute somewhat. The increase between seven and twenty-eight days is due to the hydration of beta-calcium orthosilicate (dicalcium silicate) but here are encountered opposing forces, in the hydration of any high-burned free lime present and in the crystallization of the aluminate. It is to this hydration that the falling off in strength between seven and twenty-eight days of very high-burned high limed cements is due, whereas the decrease shown by the high alumina cements is due to the crystallization of the aluminate. Finally, the iron in the cement is resistive to hydration and does not form any definite crystalline hydration products, but occurs as a rust-like material.

When one considers the disintegration of concrete in sulphate solutions in relation to these facts, it seems likely that the cement is not greatly acted on during the period of hydration. Cement briquettes will develop nearly full strength when cured in sulphate solutions of a concentration which later cause disintegration. This would, however, probably not be true of very porous concrete. The action is therefore probably mainly one between the salts and the products of hydration of cement. Calcium goes into solution as calcium hydroxide and if magnesium salts are present, magnesium hydroxide is precipitated on account of its lower solubility. The absorption of the sulphate ion by the hydrated cement, and the great difficulty which is experienced in freeing disintegrated cement from sulphates suggests that at least one step in the action may be typically colloidal.

As to the investigation which we are carrying on at the University of Saskatchewan, with financial aid from the Research Council, the western provinces and some public service corporations the time has not come to make any statements as to results. Field work is being carried on in selected plots one in each of the provinces of Manitoba, Saskatchewan and Alberta. The effects of variations in the manufacture of concrete are being studied, as well as the efficiency of various methods of waterproofing. In the laboratory we are preparing the various substances present in cement and studying their actions with water and the solutions of salts, using analytical and physico-chemical methods of measurement as well as the petrographical microscope to follow the changes taking place. A study is also being made of cements during the progress of disintegration as well as on disintegrated cement obtained from concrete which has failed in the field. Several different types of cement are being used in this work."

APPENDIX J

COMMUNICATIONS WITH REFERENCE TO DR. HARRISON'S RESEARCHES ON THE BLACKENING OF CANNED LOBSTER

Editorial from "Canadian Fisherman" by Jas. H. Conlon, Editor

Has science shown the way to overcome the smut or blackening in canned lobster? A report recently made by Dr. F. C. Harrison and Dr. E. G. Hood, as a result of protracted investigation and experiment, a summary of which appears in this issue of the *Canadian Fisherman,* would seem to so indicate. If the recommendations laid down in the report are faithfully applied by lobster canners there is every reason to expect that the smut will cease to be a problem to the industry and a serious annual economic loss will be avoided.

It is estimated that the lobster pack of any year is totally consumed within eighteen months, so it is essential for the successful marketing of the commodity that it remain in good condition for a year and a half. By applying sanitary canning methods and by adding acetic or citric acid to the pickle in fixed proportion, the experimenters have been able to can lobster that is per-

fectly marketable in eighteen months' time. As an indication of the improvement in the pack that may be effected hereafter, the investigators compared the regular factory pack with their own experimental pack and at the end of eighteen months results were as follows:—

Factory pack—cans: very bald, black all over top; general appearance of meat: slight to bad discolouration, meat unmarketable; pickle: slight discolouration; linings: badly discoloured.

Experimental acid pack—cans: 75 per cent free, and 25 per cent with a "trace" of discolouration on cap; general appearance of meat: clean and marketable; pickle: clear; linings: free from discolouration.

These results were typical of all intermediate monthly inspections and show conclusively the beneficial results obtained by using acid in the pickle.

The acid tins, from the commercial point of view, gave marketable lobster in all cases where sterilization had been effected, whereas in the normal factory pack, the lobster was not marketable, except as second grade and in many cases was unfit for food.

Combined with the acid addition to the pickle, it is pointed out as essential that complete sterilization is effected, and the report urges the substitution of the present boiling vat in favour of the pressure cooker. It relieves the erroneous impression that the retort is an expensive piece of equipment. It is not. It may be had in all sizes, suitable for any conditions, and may be operated without increased cost.

The report is of extreme economic value and we hope it will be distributed widespread before the spring canning season opens. It is trusted, too, that canners will see the wisdom of adopting suggestions voluntarily. The improvement of the pack is to their obvious advantage. One packer recently made the statement that the smut trouble at the present time occasions a loss, conservatively estimated, at 50 cents per case, or about $75,000 on the yearly output. It was stated, too, that if methods were devised which would render it possible to can lobsters so that they would keep their colour, flavour and texture for a year or eighteen months, it would increase the value by at least $4 per case, or $600,000 on an annual output of 150,000 cases. Thus one may estimate that the total annual loss to the lobster industry comes to approximately $700,000. And this is no mean item when one considers that the lobster pack yielded in 1921, $3,107,426 on an output of 137,607 cases.

As we have said, the report gives promise of eliminating what has been a menace to the lobster industry. There is nothing in the series of recommendations which does not seem practical of adoption. In other words, it would seem just as easy and little more costly to can in the ideal fashion on a scientific basis than to pursue less sanitary and slovenly methods. Where it means $700,000 to the canners, there is logical ground for assuming that they will fall in line.

OPINIONS EXPRESSED BY PROMINENT FISH PACKERS AS TO THE PRACTICAL VALUE OF DR. HARRISON'S INVESTIGATION ON "THE DISCOLOURATION, SMUT, OR BLACKENING OF CANNED LOBSTER"

W. H. Tidmarsh, Exporter of Canned Lobsters, Charlottetown, P.E.I.:

"The good work done by yourself has been productive of excellent results. I have handled a large quantity of this year's pack of lobsters on Prince Edward Island, and I never would have believed that there could have been, in so short a space of time, such a marked improvement in quality."

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Chambers & McKay, New Glasgow, N.S.:

"Kindly accept our congratulations on the splendid results shown by your research, which is not only of much benefit to us personally, but of untold value to our fishing industry."

Wm. A. Found, Assistant Deputy Minister of Fisheries, Department of Marine and Fisheries, Ottawa.

"While a copy of this report has been sent to every lobster canner, it appears likely that there is going to be a continuous demand for it, and the desirability of obtaining a reprint for future use is submitted for your consideration."

(It is worth while noting that the first edition of 1,000 copies of the printed report was completely exhausted within a couple of weeks. The above request was received about three weeks after the first edition of the report was received from the printer and is typical of a great many similar requests which were received, and as a result of which a second edition was printed).

A. B. Fisher, Vice-President, J. W. Windsor, Limited, Canned Fish, Vegetables, Fruit, Etc., Montreal, Que.

"The writer was almost going to say that he felt this was the first and only report ever put out that was of real practical value to the packers, as it appears to us to be brim full of good sense from start to finish. If it is possible to send us even one more copy, we would appreciate it very much, and, in the interest of the business in general, we would strongly urge that the department get further copies printed."

A. & R. Loggie Company, Limited, Loggieville, N.B.

"We did not have the pleasure of listening to your report at Moncton this fall in connection with the lobster industry. We have been endeavouring to get your ideas as outlined at that meeting through various channels. We understood it was to be published, and the only reasonable and practical report, in connection with the lobster industry that many of the packers, that were there, have heard yet. If you have this report in pamphlet form, would like very much to get it."

Peerless Packers, Limited, Lobster Packers, Fish Products and Other Sea Foods, Commission Merchants, Wolfville, N.S.

"Dear Sirs,—I attended the meeting of the Canadian Manufacturers' Association, Fishery Branch, at Moncton during December and I heard the address and the outline of your Dr. Harrison, his conclusions arrived at through his experiments in connection with lobster packing during the past three years. It was very instructive and will doubtless do a vast amount of good among the various canners engaged in this business. I was particularly impressed with his recommendations and conclusions and I would like to have, in printed form, his report and his methods of packing. Will you please have several copies of this report mailed to us and should you not have these reports ready, we think that it would be a very wise method and an urgent matter for the Advisory Board to have this report put in the hands of the Canners of Lobsters at an early date so that it would become effective for the spring packing and be of some use to those engaged in the business.

"Kindly have our address as one of the first on this list for a report, and oblige,

Yours truly,

PEERLESS PACKERS, LIMITED,
(Sgd.) J. Wm. Smith, Mgr.

APPENDIX K

THE NATIONAL RESEARCH INSTITUTE

In the spring of 1921 the Government introduced into the House of Commons a Bill—on the lines of a draft Bill proposed by the Research Council—for the establishment of a National Research Institute. This Bill passed the House by an almost unanimous vote, receiving the third reading on May 10, but was rejected by the Senate. The House of Commons then passed a vote of $100,000 for the purpose of preparing the necessary plans and commencing the erection of the Institute, but under the circumstances of the case the Research Council was not able to avail itself of the grant in question.

In the fall of the year that Government was defeated and it was judged inadvisable for the Research Council to press for the reintroduction of the Bill in the session of Parliament which followed almost immediately upon the new Government taking office, but rather that the Bill for the establishment of the National Research Institute with such alterations, if any, as were deemed advisable, should be introduced in the following session, that of 1922-23, when it could receive the full consideration which it deserved.

As has been already stated, the Research Council considers the erection of a National Research Institute to be necessary to the further progress of the work for which the Government brought the Council into existence, namely, the furtherance of scientific and industrial research in the Dominion of Canada.

Having developed its work on the lines set forth in the preceding pages, the next step which the Council should take is to organize in the various industries of Canada Guilds of Research, as has been done so successfully in no less than twenty-four industries by the Research Council of Great Britain. The Research Council in the Mother Country, having received a grant of £2,000,000 and dealing with industries which are developed on a much larger scale than in Canada, has arranged for the creation of a separate research laboratory for each industry, in which the special problems facing that industry may be studied and solved, and has assisted these separate laboratories by special grants of money supplementary to those provided by the respective industries themselves. In Canada, this is impossible since the funds at the disposal of the Research Council are insufficient and the industries are not as a general rule in a position to provide such laboratories without direction and assistance.

The establishment of a National Research Institute would, it is believed, meet Canadian conditions. In it the Government could make its contribution, in co-operation with the several industries of the Dominion, by providing ample laboratory accommodation for all investigations and two or three highly trained research workers of wide knowledge and experience, under whom investigations for all the industries might be carried out by chemists, physicists, etc., whose salaries would be defrayed by the several industries by whom they were engaged for the solution of their special problems. Thus the Government would co-operate with the industries—supplying the laboratories or workshops, with their equipment and the necessary direction—while the several industries would provide for the payment of the investigators and a portion of the expenses of conducting their respective researches. This plan presents some features of that adopted by the Mellon Institute of Pittsburg and others which are found in the work of the Bureau of Standards at Washington, or in the National Physical Laboratory in London. In this National Research Institution provision might also be made for research in pure science and for any other work which might be assigned to it by the Government.

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As has been stated in the Report of the Administrative Chairman of the Research Council for the year ending March 31, 1921:—

Elsewhere Research Institutes have been or are being founded. Of those already in operation there are the National Physical Laboratory of Great Britain, the Bureau of Standards with its Industrial Research Institute at Washington, the Commonwealth Institute of Science and Industry for Australia, the Cawthron Institute for New Zealand, the National Institute of Japan, the Physikalische-Technische Reichs Anstalt of Charlottenburg, and the Chemical Institute at Dahlem, Germany, and the Research Institute at Brussels for Belgium.

Besides the Central Research Institute at Dehra Dun, India, which is to be enlarged to cover industrial research on a semi-commercial scale, the Government of India has accepted the proposal to found another central Research Institute advanced by the Chemical Services Committee of the Government. Further, the establishment of a Research Institute for Burmah is now under consideration.

The National Physical Laboratory of Great Britain, as its name implies, concerns itself with research in physical, electrical and engineering problems of all kinds and with the standardization of technical instruments and apparatus, of measurements of length, volume, weight, capacity and energy in its different forms. It, however, also undertakes research on metallurgical problems in co-operation with the Iron and Steel Institute, the Institution of Mechanical Engineers, and other technical organizations. It performs a very great service in the development of many technical processes of the industries.

The function of the Bureau of Standards was until 1919 indicated by its name. Since then it has taken on industrial research work. A building of a very large capacity and of the most solid construction, erected in the immediate vicinity of the laboratories of the bureau and designed for engineering problems for war service, but completed only in November, 1919, was given to the bureau by President Wilson and is devoted to industrial research which will be carried on on a large scale. In it can be located a large number of industrial plants on a semi-commercial scale and some are installed therein already. All these will be engaged on problems of special importance to various lines of industry as the need for the investigation of these arises.

The lesson for Canada is an obvious one. Almost everywhere there is a recognition of the value of scientific research as a factor in the promotion of national prosperity, scientific research, not casually pursued as was the case in the past, but organized and directed to the economic utilization of the natural resources of each country and the promotion of human welfare.

In the United States, research, especially in connection with industry, is now being carried on on an enormous scale. There are, it has been claimed, more than 2,000 firms which maintain laboratories specially equipped and staffed to carry on research each in its own line. The Dupont Company, the Western Electric, the General Electric, the Nela Company and a number of other firms spend annually huge amounts to this end. Further it is estimated that about $30,000,000 will have been spent in 1921 for research of which amount one-third is voted by Federal and State Governments, the remainder being derived from private sources. Research is fostered there as it is nowhere else to-day.

The people, the Parliament, and the Government of Canada cannot be and ought not to be indifferent to this situation. The nation must not be forced in the matter of new knowledge to live on the crumbs that fall from a wealthy neighbour's table. The establishment of a National Research Institute is the first and the earliest measure that should be taken to put Canada in a position to hold her own, to develop her natural resources and thereby to permit a great increase in her population.

The Research Institute should, as advocated by the Research Council, be under its control, subject of course to the approval of the sub-committee of the Privy Council for Scientific and Industrial Research in such matters as the appointments to and the salaries of the staff of the Institute, and the acceptance of grants, donations or bequests given under conditions by private individuals or companies to support special lines of research. The Council should be made a body corporate to administer such and other funds and to acquire and hold property of all kinds necessary for the carrying on of the work of the Institute.

The establishment of a National Research Institute in Canada has, furthermore, been very strongly advocated by no less than seventy-two of the most important and influential public bodies representing the industries of the Dominion, including the Canadian Council of Agriculture, the Canadian Manufacturers' Association, the Trades and Labour Congress, Boards of Trade all over the Dominion, as well as the Canadian Clubs of our leading cities, the scientific and technical societies including the Royal Canadian Institute, the Canadian Branch of the Society of Chemical Industry, and by every important newspaper in the Dominion from the Atlantic to the Pacific.

APPENDIX L

REPORT OF THE COMMITTEE OF THE HOUSE OF COMMONS, APPOINTED TO CONSIDER THE MATTER OF THE DEVELOPMENT IN CANADA OF SCIENTIFIC RESEARCH, PRESENTED TO THE HOUSE OF COMMONS ON APRIL 27, 1920.

The Special Committee appointed last year to consider the above question presented their report thereon to this House on the 2nd day of July, 1919. In that report the establishment of a Bureau of Standards was recommended, but while a generous national support for scientific research was unanimously favoured, for the reasons then stated no decision was reached as to the precise method whereby that support could be most effectively applied.

Your committee, the majority of whom served in a similar capacity last year, having further considered the whole matter in the light of the evidence and material already adduced, have no hesitation in stating that the urgency of action to be taken to establish a National Research Institute to promote scientific and industrial research in Canada is patent to all who know what is being done abroad in this line.

There is in Canada no organization which even distantly approaches the character of any of the research institutes abroad or now being established.

Great Britain has the National Physical Laboratory at Teddington, near London. Germany has two research institutes, one physical and the other chemical. In France and Italy measures are being taken to organize research institutes. The United States has a National Bureau of Standards at Washington, to which is now attached a laboratory building of exceedingly ample accommodation to be devoted to industrial research. The amount spent by the bureau exceeds two millions a year. The Commonwealth Government of Australia is establishing an Institute of Science and Industry. An institute for research known as the Cawthron Institute is being established at Nelson, New Zealand, by private benefaction. Japan is founding a National Research Institute, for which already ample funds have been obtained from the Emperor, the Government and from private sources.

It is evident, therefore, that Canada, to meet the international competition which the work of these laboratories will serve to accentuate very greatly, must have a National Research Institute, which will place at the command of the country all the resources of science and further the development of the natural wealth of the country to meet the huge burden of debt imposed by the war. The developed wealth of Canada as compared with that of the United States is small. If the natural resources of the Dominion were appropriately utilized, its developed wealth might readily be as much as ten times what it is now. The conversion of our natural resources into developed wealth, however, can only be accomplished through the application to them of science of the most highly advanced type.

To take one instance only, to show how vital research is to Canada, it may be pointed out that the high grade iron ores of the world are being exhausted, and, in consequence, the lower grades must in the very near future be alone available. Of these Canada has an enormous supply in areas distributed from the Atlantic to the Pacific. We are to-day importing annually at least $150,000,000 worth of ore, iron, steel and their products. If research could show us how to utilize commercially our own low grade iron ores in competition with foreign high grade ores we would not only build up important mining and manufacturing industries throughout Canada, but as well avoid remitting vast sums abroad.

It may be pointed out, also, that in Great Britain the industrial firms in a large number of lines of industry are now being organized under the auspices of the Department of Scientific and Industrial Research into Trade Associations for Research. These industries will thereby be put in a position of enormous advantage as regards production. The National Research Council of the United States is organizing similar associations in the United States to meet competition from abroad. In Canada the organization of similar bodies, "Guilds for Research," must be encouraged by being associated with a National Research Institute.

Your committee believe the first step towards providing for the research required is the establishment of a National Research Institute whose functions will be to carry on researches, not only parallel to those of the Bureau of Standards at Washington, but such also as will assist in the development of the natural resources of the country and will promote the application of the most advanced scientific knowledge to all lines of industrial production in Canada.

In this connection your committee have considered the following matters:—

1. The scope of the work of the proposed Research Institute and the form of its government.
2. The site of the Institute and the character of the buildings which should first be erected.
3. The appropriation that should be made by Parliament during this session for the purchase of a site. The erection of the buildings and the maintenance of the Institute.

1. The work of the Institute should include the following:—

(*a*) The investigation and determination of standards and methods of measurements including length, volume, weight, mass, capacity, time and heat, light, electricity, magnetism and other forms of energy; and the determination of physical constants and the fundamental properties of matter.

(*b*) The standardization of the scientific and technical apparatus and instruments for Government service and for use in the industries of Canada; and the determination of the standards of quality of the materials used in the construction of public works and of the supplies used in the various branches of the Government service.

(*c*) The investigation and standardization upon request of the materials which are or may be used in the industries, and of the products thereof.

(*d*) Researches undertaken with the object of improving the technical processes and methods used in the industries and of discovering new processes and methods which may promote the expansion of the existing industries or the development of new Canadian industries.

(*e*) Researches undertaken to assist in the development of the natural resources of Canada.

(*f*) Researches undertaken to promote the utilization of the waste products of industries.

2. The Institute should have charge, direction, or supervision under conditions to be determined in each case of the researches which may be undertaken by or for individuals or industrial firms or by such organizations, to be known as Trade Guilds for Research, as may desire to avail themselves of the facilities offered for this purpose by the Institute.

Your committee strongly recommend:—

1. That a National Research Institute for Canada endowed with the functions and of the character indicated in the foregoing be established in the vicinity of Ottawa, on a site fifty acres in area, of easy access and conveniently located for water, gas and electric power supply.

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2. That the first building to be erected for the Institute should be of the best modern construction suitable for laboratory work and of such dimensions as to provide accommodation for some years to come.

3. That there be appropriated by Parliament $500,000 for the purchase of the site and the construction of the building, $100,000 for the scientific equipment of the Institute, and $50,000 for salaries and maintenance during the first year of its operation.

4. That legislation be enacted at this session to provide for the establishment of this National Research Institute and the government of the same.

APPENDIX M

PUBLICATIONS OF THE HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH OF CANADA

Annual Reports for the Years 1917-18, 1918-19, 1919-1920, 1920-21, 1921-22

GENERAL REPORTS

1. The Briquetting of Lignites, by R. A. Ross, E.E., D.Sc.
2. The Recovery of Vapours from Gases, by Harold S. Davis, M.A., Ph.D., and Mary Davidson Davis, B.A.
3. The De-tarring of Gas by Electrical Precipitation, by J. G. Davidson, Ph.D.
4. Nicotine and Tobacco Waste, by A. D. Hone, M.A.
5. Canadian Waste Sulphite Liquor as a Source of Alcohol, by Vernon K. Krieble, Ph.D.
6. An Investigation into the Question of Early Putrefaction of Eviscerated Fish in which the Gills have been left, by Louis Gross, M.D.
7. Survey of General Conditions of Industrial Hygiene in Toronto, by Associate Committee on Industrial Fatigue of the Research Council.
8. A Method of Smelting Titaniferous Iron Ore, by W. M. Goodwin, B.A., B.Sc.
9. Food Requirements of the Ranch Fox, by G. Ennis Smith, B.A.Sc.
10. Fuel Saving Possibilities in House Heating, by L. M. Arkley, M.Sc., and James Govan.
11. Red Discoloration of Cured Codfish, by F. C. Harrison, D.Sc., and Miss Margaret E. Kennedy, B.A., M.Sc.
12. The Discolouration, Smut or Blackening of Canned Lobster, by F. C. Harrison, D.Sc., and E. G. Hood, Ph.D.

BULLETINS

1. The Need for Industrial Research in Canada, by Frank D. Adams, Sc.D., LL.D., F.R.S.
2. Researches on Sound Measurement, by Louis V. King, M.A., D.Sc., F.R.S.C.
3. How to Handle Frozen Fish, by E. E. Prince, D.Sc., LL.D.
4. Hints on Frozen Fish, by E. E. Prince, D.Sc., LL.D.
5. Science and Industry, by Prof. J. C. Fields, Ph.D., F.R.S.
6. The Heating of Houses, Coal and Electricity Compared, by A. S. L. Barnes.
7. The Manufacture of Ethyl Alcohol from Wood Waste, by G. H. Tomlinson, B.A.
8. Some Problems of the Fox-Raising Industry, by Andrew Hunter, M.A., B.Sc., M.B., Ch.B. (Edin).
9. The Honorary Advisory Council of Scientific and Industrial Research and its Work, by Frank D. Adams, Sc.D., LL.D., F.R.S.
10. A Plan for the Development of Industrial Research in Canada, by R. F. Ruttan, B.A., M.D., D.Sc., F.R.S.C.

Page 371 (Report for 1923-4) comes after p. 512.

OTTAWA, February 19, 1926.

The Hon. JAMES A. ROBB,
Acting Chairman, Sub-Committee of the Privy Council on
Scientific and Industrial Research,
Ottawa.

SIR,—I have the honour of presenting to you the Report of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1925.

In accordance with the requirements of the Research Council Act, this report consists of two parts—the report of the President and a statement of the receipts and expenditures of the Council during the year under review.

Your obedient servant,

H. M. TORY,
President of the Honorary Advisory Council
for Scientific and Industrial Research.

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THE SUB-COMMITTEE OF THE PRIVY COUNCIL ON SCIENTIFIC AND INDUSTRIAL RESEARCH, 1924-25

The Hon. THOMAS A. LOW, *Chairman, Minister of Trade and Commerce.*

The Hon. CHARLES STEWART, *Minister of the Interior and of Mines.*

The Hon. WILLIAM R. MOTHERWELL, *Minister of Agriculture.*

The Hon. JACQUES BUREAU, *Minister of Customs and Excise.*

The Hon. JAMES MURDOCK, *Minister of Labour.*

NATIONAL RESEARCH COUNCIL, 1924-25

President: H. M. TORY, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S., President, University of Alberta, Edmonton, Alta.

Members: *Retire*

FRANK D. ADAMS, Sc.D., LL.D., F.R.S., Hon. M.E.I.C., Hon. M.I.M.M., Hon. M.A.I.M.M.E., Emeritus Vice-Principal, Emeritus Dean of the Faculty of Graduate Studies and of the Faculty of Applied Science and Logan Professor of Geology and Palaeontology, McGill University, Montreal, P.Q..... 1927

CHAS. CAMSELL, B.Sc., LL.D., F.R.S.C., Deputy Minister, Department of Mines, Ottawa, Ont..... 1927

A. L. CLARK, B.Sc., Ph.D., Dean, Faculty of Applied Science and Professor of Physics, Queen's University, Kingston, Ont..... 1927

HUME CRONYN, B.A., LL.B., London, Ont..... 1925

A. FRIGON, B.Sc., D.Sc., A.M.E.I.C., A.M.A.I.E.E., Dean, Ecole Polytechnique, 1430 St. Denis Street, Montreal, P.Q..... 1927

Sir GEORGE GARNEAU, B.A.Sc., LL.D., 71 St. Peter Street, Quebec, P.Q. 1926

J. H. GRISDALE, B.Agr., D.Sc.A., Deputy Minister, Department of Agriculture, Ottawa, Ont..... 1926

A. B. MACALLUM, Ph.D., Sc.D., LL.D., F.R.S., Professor of Biochemistry, McGill University, Montreal, P.Q..... 1926

A. S. MACKENZIE, Ph.D., D.C.L., LL.D., F.R.S.C., President, Dalhousie University, Halifax, N.S..... 1925

J. A. MCCLELLAND, Vice-President in Canada, International Association of Machinists, 113 Coronation Bldg., Montreal, P.Q.... 1926

J. C. MCLENNAN, O.B.E., Ph.D., D.Sc., LL.D., F.R.S., Professor of Physics and Director of the Physics Laboratory, University of Toronto, Toronto, Ont. 1925

W. C. MURRAY, M.A., LL.D., F.R.S.C., President, University of Saskatchewan, Saskatoon, Sask. 1925

R. F. RUTTAN, B.A., M.D., D.Sc., F.R.S.C., Dean of the Faculty of Graduate Studies and Research, Macdonald Professor of Chemistry and Director of the Department of Chemistry, McGill University, Montreal, P.Q. 1926

Secretary: S. P. Eagleson, Esq., West Block, Ottawa, Ont.

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NATIONAL RESEARCH COUNCIL

REPORT OF THE PRESIDENT, 1924-25

I. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL

Five meetings of the National Research Council were held during the year under review. On May 23, 1924, a meeting of the Council was held in the city of Quebec, and four other meetings were held in the offices of the Council at Ottawa. On two occasions during the year, the volume of business to be dealt with required that the meetings be extended over two days. Consequently, the Council was actually in session seven days during the year, with an average of nine members attending each of these meetings.

Members of the National Research Council are appointed for a term of three years, a certain number retiring from membership each year. The term of appointment of the following members of the Council expired on April 1, 1924; Sir George Garneau, Dr. W. L. Goodwin, Dr. A. B. Macallum and Mr. Arthur Surveyer. Dr. Goodwin had previously tendered his resignation, owing to the fact that the nature of the work on which he was then engaged rendered it extremely difficult for him to attend the meetings of the Council or take an active interest in its work. Mr. Surveyer also expressed the desire that he should be permitted to retire from membership, owing to the pressure of private business affairs.

The four vacancies on the membership of the Council at the beginning of the year under review were consequently filled by the appointment of Dr. A. L. Clark, Dean of the Faculty of Applied Science, Queen's University, Kingston, to succeed Dr. Goodwin, and of Dr. Augustin Frigon, Dean, Ecole Polytechnique, Montreal, and General Director for Technical Education in the province of Quebec, to succeed Mr. Surveyer, and by the reappointment as members of the Council of Sir George Garneau and Dr. A. B. Macallum, all four appointments being for a period of three years, terminating March 31, 1927.

The Research Council Act, 1924, which is dealt with in detail in a later section of this report, came into effect on July 19, 1924. Under this Act the maximum membership of the Council was increased from eleven, as heretofore, to fifteen. In accordance with past practice, the new Act also provided for the establishment of a system of rotation in membership, whereby approximately one-third of the members of the Council will retire each year. In order to facilitate the appointment of members to the Council in accordance with the provisions of the new Act, all of the members of the Council placed their resignations in the hands of the Government. Under the provisions of an Order in Council dated December 9, 1924, the eleven gentlemen who composed the Council when the new Act came into effect were reappointed to the Council for varying terms of office, in order to provide for the retirement of the required number of members each year, and the membership of the Council was increased by the appointment, thereto, of Dr. Charles Camsell, Deputy Minister of the Federal Department of Mines, and of Dr. J. H. Grisdale, Deputy Minister of the Federal Department of Agriculture. In March, 1925, the membership of the Council was further increased by the appointment of Mr. J. A. McClelland, Vice-President in Canada of the International Association of Machinists, which association is affiliated with the Trades and Labour Congress of Canada.

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At the close of the year under review, therefore, fourteen gentlemen had been appointed members of the National Research Council, leaving one vacancy still to be filled, in order to bring the membership up to the maximum number authorized under the provisions of the new Act.

A complete list of the membership of the National Research Council as it stood at the close of the year under review, showing in each case the date of retirement, will be found on page 4 of this report. It is perhaps of interest to note that six of the fourteen members who composed the Council on March 31, 1925, had been appointed for the first time within the previous two years.

Organization and Research Facilities

The National Research Council has, up to the present time, maintained only a comparatively small administrative staff in its offices at Ottawa. The Council is unanimously of the opinion that until such time as laboratory facilities are provided for its work, it would not be justified in building up a costly technical staff. It has therefore been the fixed policy of the Council to devote its entire financial resources to the co-ordination, stimulation and prosecution of research work in Canada and to the training of research workers for service in Canadian institutions and industries.

At the close of the year under review there had been organized under the auspices of the Council, fifteen Associate Committees, having a total membership of 178 eminent scientists and business men who, without remuneration give of their time and experience in furthering the work of the Council. A detailed explanation of the functions of these committees, together with a review of the work which engaged their attention during the year 1924-25, will be found beginning at page 17 of this report.

In addition to the work carried on by these Associate Committees, there were during the past year fifty-four definite researches in progress, under the auspices of the Council, in various Canadian laboratories. Each of these investigations was directed, without remuneration, by a Canadian scientist specially qualified to undertake the particular research work entrusted to him. A summary of the work carried out under these awards will be found beginning at the bottom of this page.

During the same period, forty-six persons who had graduated from a university with distinction in science, and many of whom had had several years' post-graduate experience in scientific research, were at work in the laboratories of various Canadian universities under National Research Council Scholarships. The work carried on by each of these forty-six scholarship grantees was carefully supervised by a university professor whose co-operation to this end had been enlisted by the Council. In addition there were fifteen research assistants at work under expert direction endeavouring to solve problems toward which the Council had granted financial assistance.

The total research organization actively at work under the auspices of the National Research Council during the year under review numbered 352, of which number 291 persons served without remuneration. Through its policy of enlisting the co-operation of existing research organizations and highly trained scientific investigators in the prosecution of co-ordinated researches and through the granting of partial assistance to ensure the prosecution of necessary work, it has been possible for the Council, at a comparatively small cost, to so stimulate research work in Canada as to enable it to build up an active and effective voluntary research organization.

Assisted Researches

During the past eight years the National Research Council has granted financial assistance to eighty distinct researches and of these investigations twenty-six were completed before April 1, 1924. During the year under review

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there were in progress, in nineteen departments of science at fourteen Canadian universities, fifty-four researches to which financial assistance had been granted by the Council.

The number of these investigations carried out in each of the major departments of science was as follows: Department of Physics, 10; Department of Chemistry, 8; Department of Biology, Botany and Biochemistry, 5 each; Field Husbandry, 4; Department of Bacteriology and Mining Engineering, 3 each; Department of Chemical Engineering and Zoology, 2 each; and one research was carried out in each of the following departments: Forestry, Plant Breeding, Entomology, Physiology, Pathology, Geology, Metallurgy, Mechanical Engineering and General Engineering.

These investigations were carried out in the following fourteen Canadian universities: University of British Columbia, University of Alberta, University of Saskatchewan, University of Manitoba, University of Toronto, Queen's University, University of Western Ontario, Ontario Agricultural College, McGill University, University of Montreal, Macdonald College, University of New Brunswick, Mount Allison University, and Nova Scotia Technical College. It should perhaps be noted that some of the more important investigations, such as those on grain rust and tuberculosis, involve research in more than one department of science, and were carried on simultaneously in various laboratories. Furthermore, six investigations were conducted in commercial laboratories or in the laboratories of the Federal and Provincial Governments.

Since the establishment of the Council in 1916 the total amount expended in the assistance of research work in Canada is $304,668.77 and of this sum $154,424.96 was awarded by the Council to assist investigations which were in progress during the year 1924-25. A considerable part of this total had of course, been expended before the year under review in connection with researches which extended over more than one year, but $50,972.25 was actually expended in this service during the year ending March 31, 1925, which amount is more than 42 per cent of the total appropriation provided for all phases of the work of the Council.

All financial assistance granted by the National Research Council in aid of research work must be used exclusively to meet the actual expenses of approved scientific investigations. The grantee does not himself derive any financial benefit from an award but in every case must agree with the Council to undertake, without emolument, responsibility for the supervision of the investigation and for the presentation to the Council of a complete report thereon.

It will be noted that investigations were carried out during the year under review in university laboratories situated in every province in Canada, save one, and even in that case the Council directly assisted an important provincial industry in the solution of some of its technical problems (by an investigation carried out in another province where there were adequate laboratory facilities.) The Council has therefore succeeded during the year under review, notwithstanding the comparatively small financial resources at its disposal, in carrying out researches of interest and importance to every province in the Dominion.

It is obvious that there are a great many important and pressing Canadian problems which it has not been possible for the Council to attempt to solve under its assisted researches program. This applies with particular force to problems of an industrial nature. Universities and colleges are primarily institutions for the dissemination of knowledge, and the members of their staffs cannot be expected to undertake investigations which are not closely allied to the particular subjects on which they must be thoroughly informed in connection with their academic work. It follows therefore that university laboratories are peculiarly adapted for the conduct of researches of a purely scientific nature.

But what of industrial researches? Even if the universities possessed the special equipment for such work, it would be a fatal mistake to turn them from their primary purpose of teaching into semi-commercial organizations for the

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solution of industrial problems. It is true that in some countries, notably in the United States and in Great Britain and Germany, where large industries are firmly established, the industries are carrying on considerable research work in laboratories which they themselves have established. Canadian industries, however, with very few exceptions, have not yet reached that stage of development where it is possible for them to provide or maintain such laboratories unassisted. They are, however, in constant competition with firms in foreign countries which enjoy the benefit of such facilities and not infrequently with disastrous results. The National Research Council has been struggling along endeavouring to do what little it can to assist this situation, but until the Council is provided with adequate laboratory accommodation, it is obviously impossible to make any material progress toward the solution of Canadian industrial problems. The Council is convinced that this is a question of such national importance as to demand suitable action in the immediate future along the general lines recommended in the final report of the Special Committee appointed by the House of Commons to study this question.

Complete lists of the grants awarded during the year under review and of grants which were continued in 1924-25 with the aid of assistance awarded in a previous year, and of researches completed prior to April 1, 1924, will be found on pages 64-66 of this report.

A brief synopsis of reports received covering research work carried on under these grants during the year under review is given, beginning at page 41 of this report.

It is quite impossible to form an accurate opinion as to the value of scientific research by selecting an individual problem and demanding an accounting as to what has been accomplished in connection with that research within a stated period of time. Some problems will be solved quickly, while others will require long and arduous toil before they can be brought to a successful conclusion. There will even be problems which it will be considered expedient to abandon without tangible result, but all searching after the hidden facts of nature is of value, if properly directed and if the results be properly recorded. Such knowledge is the bed-rock upon which all important discoveries are founded.

History is replete with examples in which the full economic significance of a scientific investigation was not realized until many years had elapsed after the completion of the investigation. Faraday's discovery of the principle upon which the entire modern electrical industry has been built is but one outstanding example of this fact. His work was little appreciated in his day but it is now recognized to be of such importance that an outstanding American statesman recently stated in a public address: "Our whole banking community does not do the public service in a year that Faraday's discoveries do us daily." The absolute truth of this statement is indicated by the fact that the value of electrical power generated in Canada to-day exceeds $100,000,000 annually, and more than $600,000,000 is invested in Canadian electrical plants alone.

During recent years public opinion in all progressive countries throughout the civilized world has come to realize with increasing clearness that scientific research properly directed always pays even from a dollars and cents point of view, and that in many cases it is the deciding factor between success and failure in industry. It frequently scales apparently insurmountable barriers, it turns into profitable use hitherto unused resources and industrial by-products, and it invariably shows on the credit side of the ledger at the end of the year. Many astounding specific examples might be cited in illustration of this fact, but it will be sufficient for the present purpose to merely observe that its continued use by large industrial organizations is self-evident proof of its economic soundness.

In the United States industrial research has in recent years been developed on a scale unparalleled in history. Japan also is making enormous strides in

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this direction, while the activities in this respect in European countries of importance from a commercial point of view, such as Great Britain, France and Germany, is a matter of common knowledge.

It does not require any stretching of the imagination to understand that industries which engage in scientific research are in a commanding position over industries which do not enjoy such benefits. It therefore behooves those in charge of Canadian industrial enterprises to study this question much more carefully than they have in the past. The more seriously they investigate all phases of the problem the more firmly will they become convinced that the question which they must decide is not whether Canadian industries can afford to engage in scientific research but whether they can afford to be indifferent to its advantages.

Training Research Workers

It is now universally recognized that a country which does not produce a steady stream of research workers, highly trained in various departments of science, is labouring under a very serious handicap. On consideration of the returns received in connection with the research inventory taken by the Council in 1917, it was evident that there was a great dearth of such men in Canada, and in order to improve the situation in this respect the Council established a series of scholarships to be held in Canadian universities, which are awarded annually for post-graduate research work in science.

Scholarships of this nature are now awarded in practically every country of industrial importance throughout the civilized world and the number is constantly increasing. For example, it has been estimated that there are now more than two thousand (2,000) such scholarships available to promising graduate students each year in the United States alone and since Canadian students rank second to none in mental capacity, many of the scholarships available in the United States are awarded to Canadians. Unfortunately, however, the great majority of these most promising Canadians, having completed their academic training at American universities, remain in that country and their services are consequently lost to Canada.

It is the purpose of the National Research Council in establishing a system of scholarships to develop, in Canada, a corps of highly trained research men for service not only in Canadian universities and technical schools, but also in the industries, in the technical service of the Federal and Provincial Governments and in agriculture.

Three classes of scholarships are awarded by the Council, namely, Bursaries, Studentships and Fellowships, having an annual value of $750, $1,000 and $1,200, respectively. These awards are intended to enable students who have graduated with distinction from a university to continue their training in science until they have qualified for a Ph.D. degree, three years being the maximum assistance granted to an individual candidate under any combination of awards.

These scholarships are awarded to the best qualified applicants therefor. The minimum qualification for a Bursary is graduation with distinction from an approved university. An applicant for a Studentship must have had at least one year of post-graduate research experience, while Fellowships are awarded only to persons who possess very high qualifications and who have demonstrated beyond question their ability to carry on independent research.

During the eight years ending March 31, 1925, the National Research Council awarded one hundred and nine Bursaries, eighty-six Studentships, and forty-two Fellowships. These two hundred and thirty-seven awards were held by one hundred and fifty-one persons in thirteen departments of science, at sixteen Canadian universities. Each award was held under the direction of a member of the staff of the university where the award was held, who had agreed

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to co-operate with the Council in the careful supervision of this work. According to the latest returns which it has been possible for the Council to secure, two hundred and ninety-five scientific papers have been published by these grantees, of whom one hundred and thirty-four have secured the degree of M.A. or M.Sc., and forty-one the degree of Ph.D.

At the end of the year under review one hundred and thirty-one persons had completed their training in science under these awards. The Council has, therefore, during the past eight years increased to this extent the number of research workers available for service in Canadian industries and universities or in the Government service. Of these, eighty-nine persons held a Bursary, Studentship or Fellowship for one year, twenty-three persons held awards for two years and only nineteen persons took advantage of the maximum assistance available and held awards for three years.

It will perhaps be of interest to note the present occupation of the one hundred and thirty-one persons who have completed their training under these awards. Of these, fifteen persons are continuing their post-graduate studies, some under scholarships from other sources and some having gone to foreign universities for special instruction or in order to continue their training in some particular branch of science; thirty-four persons are enaged in the teaching profession, thirty of these having received appointments to the staffs of Canadian universities, where the great majority of them will have an opportunity of continuing their scientific training and of engaging in research work. Twenty-four persons are employed in the industries and twenty-two have accepted positions in the technical branches of the Federal and Provincial Governments. One grantee has died and the balance have failed to furnish the Council with information regarding their present occupation.

It is especially gratifying to note that of the one hundred and thirty-one grantees, only seventeen persons have accepted positions in foreign countries; all of the others, so far as it has been possible to ascertain, are at work in Canada with the exception of eight persons, who are continuing their post-graduate studies in the United States or in England.

A complete list of the persons who held National Research Council scholarships during the past year, showing in each case the university from which they graduated, the laboratory in which the award was held and the research work carried on by the student, will be found beginning at page 67 of this report. In addition, a list of persons who have been enabled to secure special graduate training in science under these scholarships and who completed their work prior to the year under review will be found on page 69 of this report.

A statement showing the number of Fellowships, Studentships and Bursaries and the expenditure incurred by the Council in connection therewith, in each of the eight years since these awards were instituted, is given below in a form convenient for reference purposes.

Year	Fellowships	Studentships	Bursaries	Expenditure
				$ cts
1917–18	3	4	.....	5,550 00
1918–19	3	5	.....	7,150 00
1919–20	5	16	5	20,100 00
1920–21	5	10	8	16,925 00
1921–22	7	9	28	37,725 00
1922–23	3	22	13	34,975 00
1923–24	12	8	25	37,548 89
1924–25	4	12	30	39,201 66
	42	86	109	199,175 55

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International Activities

The National Research Council of Canada is an important link in an Empire and an international organization for the co-ordination and development of scientific research throughout the civilized world. The Council was established in 1916 by the Canadian Government acting on the request of the British Government, which, having read the handwriting on the wall, had not only established a similar organization in Great Britain, but had also petitioned each of the British dominions to take like action, with the object of developing an empire scheme for scientific and industrial research.

In Great Britain this work has grown to such magnitude and is recognized to be of such importance that a separate Government Department of Scientific and Industrial Research was created several years ago, while organizations similar to the National Research Council of Canada have been established in practically every important unit of the Empire. The National Research Council of Canada keeps in close touch with the activities carried on by each of these organizations and particularly with the Department of Scientific and Industrial Research in Great Britain.

It will of course be recognized that the national problems peculiar to any unit of the Empire depend to a large extent on geographical location. The problems of major importance to Canada are not, as a general rule, the problems which are most pressing in South Africa, India, or Australia, for example, and consequently each country must make up its mind that unless it tackles its own national scientific problems in a businesslike way, most of them are likely to remain unsolved. Nevertheless, there are many important problems in which several units of the Empire have a joint interest and a considerable volume of scientific work has already been carried out, especially in Great Britain, which is of very definite value to Canada. The development of an effective organization through which all scientific research carried on throughout the British Empire can be closely co-ordinated is therefore a duty of very great importance.

The Council is also the official Canadian representative in the International Research Council, of which organization practically every important commercial country in the world is a member. The International Research Council constitutes a focal point through which the views, on important scientific questions of general interest, of the most important scientific organizations and of the leading men of science throughout the civilized world can be reviewed and disseminated.

Under the International Research Council, there have been organized a number of International Scientific Unions, each of which confines its activities to questions relating to some particular department of science. Up to the present time the National Research Council of Canada has organized Canadian committees in five of these International Scientific Unions, as follows: —

International Union of Pure and Applied Chemistry.
International Union of Pure and Applied Physics.
International Mathematical Union.
International Union of Geodesy and Geophysics.
International Astronomical Union.

Through the International Research Council and its various Unions, the National Research Council of Canada is enabled to keep in close touch with the development of scientific thought and progress throughout the civilized world.

Since the National Research Council is the official adviser to the Federal Government on scientific questions, the Council is frequently called upon through the Department of External Affairs to pass judgment on important

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international questions of a scientific nature. During the year under review, the Council dealt with questions such as the following:—

(*a*) A communication from the League of Nations asking for an opinion on a Draft Convention on the Protection of Scientific Property, providing that work which has resulted in valuable scientific discovery should be recognized by an adequate share in the financial returns arising from the discovery.

(*b*) A resolution passed by the League of Nations recommending that students should be provided with special travelling facilities, in order to encourage interchanges of post-graduate students among nations.

(*c*) A communication from the World's Metric Standardization Council, requesting comment on their scheme for world metric standardization.

(*d*) A report from the Imperial Economic Conference regarding research.

(*e*) A report from the Colonial Research Committee of Great Britain.

(*f*) A request for financial assistance toward the publication of the International Tables of Constants and Numerical Data of Chemistry, Physics and Technology.

(*g*) The finding of the best qualified candidates available in Canada and the awarding of two post-graduate scholarships in science offered to Canadian students by the Imperial College of Science and Technology of London, to be held at that institution.

(*h*) The selection of a suitable candidate for the British Empire Exhibition Scholarship, open to Canadian post-graduate students for research in science and tenable at a university in Great Britain.

In connection with questions such as the two last mentioned the Council was able, by means of the machinery already established in connection with its own scholarships, to secure the best candidates available in Canada for these awards. The students finally selected possessed such qualifications as ensured beyond question that they would creditably represent Canada at British universities.

Research Council Act, 1924

In July, 1924, a revised Research Council Act (14-15 George V, chapter 64) was passed by the Canadian parliament under which the Council is constituted a corporate body and given charge of all matters affecting scientific and industrial research in Canada, which may be assigned to it, and, is also charged with the duty of advising the Dominion Government on questions of scientific and technological methods affecting the expansion of Canadian industries or the utilization of the natural resources of the country.

Under the new Act the Council shall consist of not more than fifteen members, who, with the exception of the president, shall hold office for a period of three years, one-third of the membership retiring each year.

The Act provides that the Council shall meet at least four times a year in the city of Ottawa and may also meet at such other times and places as the Council may deem necessary. No member of the Council, with the exception of the president, may receive any payment or emolument for his services other than to be reimbursed for the approved expenditure actually incurred in connection with the work of the Council.

In addition to the above-mentioned general powers the Council is charged under the Act with the following specific duties:—

To promote the utilization of the natural resources of Canada;

To undertake researches with the object of improving the technical processes and methods used in the industries of Canada, and of discovering processes and methods which may promote the expansion of existing or the development of new industries;

To undertake researches with the view of utilizing the waste products of said industries;

The investigation and determination of standards and methods of measurements, including length, volume, weight, mass, capacity, time, heat, light, electricity, magnetism and other forms of energy; and the determination of physical constants and the fundamental properties of matter;

The standardization and certification of the scientific and technical apparatus and instruments for the Government service and for use in the industries of Canada; and the determination of the standards of quality of the materials used in the construction of public works and of the supplies used in the various branches of the Government service;

The investigation and standardization, at the request of any of the industries of Canada, of the materials which are or may be used in, or of the products of, the industries making such a request;

To undertake researches, the object of which is to improve conditions in agriculture.

The Act also provides that the Research Council shall have charge of, and direction or supervision over, the researches which may be undertaken, under conditions to be determined in each case, by or for single industrial firms, or by such organizations or persons, as may desire to avail themselves of the facilities offered for this purpose. The Council is also empowered to publish from time to time such scientific and technical information as it may deem necessary.

Under the Act all discoveries, inventions, etc., made by members of the technical staff of the Council are vested in the Council and shall be made available to the public under such conditions as the Council may determine.

A complete copy of the Act will be found in Appendix "A" of this report.

It is evident that it will be quite impossible for the Council to carry out many of the duties which have been assigned to it under the above Act until such time as a National Research Institute, containing the necessary laboratory facilities has been established in Canada.

Publications

In addition to its annual report, two series of publications are issued by the National Research Council. These are numbered in sequence according to date of publication and are known under the general titles of "Reports" and "Bulletins."

The reports of the Council cover work which has been carried out under the auspices of the Council. This series is for the most part, of a technical nature. On the other hand the bulletins issued by the Council contain important information which has been compiled by the Council and is presented in non-technical language in so far as this may be possible. Bulletins are designed to furnish authentic information on important scientific questions in a manner which can be readily understood by a person without scientific training.

At the close of the year under review fifteen reports and eleven bulletins had been published by the Council. A list of the titles of these publications will be found on page 73 of this report.

Finance

During the year under review the National Research Council received, from all sources, a total revenue of $124,797.10. Of this amount $120,000 was voted by parliament for the work of the Council, $900 was received from the Imperial College of Science and Technology, London, England, to cover *inter alia* the travelling expenses of the students who had won the two post-graduate scholarships offered in Canada for 1924-25 by the Imperial College and which were tenable at that institution. The balance of the income of the Council

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during the year under review was derived from refunds from various sources but principally from balances remaining unexpended upon the completion of research work.

The total expenditure of the Council during the year amounted to $121,010.76. Of this sum $50,972.25 was expended on grants in aid of research and $40,101.66 was expended on the post-graduate training of research workers. The amount expended by the Council for all other purposes including the payment of fees necessary to maintain Canadian membership in the International Research Council and its Scientific Unions, the administration and travelling expenses of Associate Committees, travelling expenses of members of the National Research Council and its staff, salaries of staff, honoraria, library, printing, and general administration totalled only $29,936.85.

It will therefore be seen that although the Council had only a comparatively small sum of money at its disposal and notwithstanding the fact that there is a very definite limit beyond which it is impossible to reduce overhead expense without sacrificing efficiency and that this minimum must be expended regardless of whether the total expenditure be large or small, the Council succeeded during the year under review in so organizing its work as to enable it to devote more than 75 per cent of its entire expenditure directly to the prosecution of research work in Canada.

Perhaps the outstanding fact which is to be deduced from the above figures, is that the financial transactions of the Council fail entirely to afford any accurate conception of the volume or the importance of the work carried on by the National Research Council. If it were necessary for the Council to pay the full cost of all investigations carried out under its auspices and to provide salaries in lieu of the service now so effectively rendered by the many leaders in science and industry, who co-operate with the Council on a voluntary basis the present expenditure would be hopelessly inadequate to meet the situation. This fact will be obvious to all who compare the figures quoted above with the activities of the Council as described in other sections of this report.

A detailed statement of the receipts and expenditures of the Council during 1924-25 is given on page 60 of this report, and Appendix "G" contains a classified statement of the expenditures incurred by the Council during each of the past nine years.

II. SUMMARY OF THE ACTIVITIES OF ASSOCIATE COMMITTEES

Foreword

The Associate Committees which have been appointed by the National Research Council may, broadly speaking, be divided into two classes. In the first place there are the committees which have been appointed, one in each of the major departments of science, with the main purpose in view, of keeping the Council constantly in touch with important research problems requiring attention and with advances made from time to time in the particular departments of science which they represent and also in order that the Council may have the benefit of extensive scientific advice in each of these sciences in connection with any problem which may arise during the progress of its work. Research work may of course in some cases be carried on under the auspices of these committees, but their main function is as stated above.

The other group of Associate Committees has been appointed for the specific purpose of undertaking the co-ordination, organization and prosecution of research work on some main problem or group of problems. These committees may, of course, serve also in an advisory capacity, but differ from the first group in that their first duty is to undertake some specific research work assigned to them.

At the close of the year under review there were fifteen Associate Committees of the National Research Council in operation. Of these the following seven might be said to be Advisory Committees: Associate Committee of Chemists, Associate Committee on Mining and Metallurgy, Associate Committee on Physics and Engineering Physics, Associate Biological Committee, British Columbia Advisory Committee, Associate Committee on Pacific Problems, and the Associate Library Committee. It is customary for these committees to meet once a year at a time and place most convenient to the majority of the members concerned, to discuss the work of the Council, the manner in which the committee can most effectively co-operate therein and to make such recommendations to the Council as may be deemed necessary or advisable. A brief account of the annual meetings held during 1924-25 by the committees named above will be found beginning at page 34 of this report.

In addition to the seven Associate Committees of an advisory nature, there were in existence at the close of the year under review eight Associate Research Committees, as follows: Associate Committee on Tuberculosis, Associate Committee on Cereal Grain Rust, Associate Committee on Helium, Associate Committee on the Nutritional Problems of the Fox Industry, Associate Committee on New Brunswick Forest Investigations, Associate Committee on Accurate Plot Work, Associate Committee on Food Research, Associate Committee on Aeronautics.

A synopsis of the activities carried on by each of the above committees during the year ending March 31, 1925, is given hereafter and careful perusal of this section will afford a general idea of the nature and extent of the research work which it was possible for the National Research Council to organize and carry on during the year under review because of the unselfish co-operation of the members of the above committees, all of whom serve without remuneration of any kind and give freely of their time and experience. There is obviously no other way in which it would be possible for the Council, with its limited financial resources, to carry out a programme of such magnitude.

A complete list of all Associate Committees which were in existence at the close of the year under review together with the names of the members of each committee will be found on pages 74-81 of this report.

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Associate Committee on Cereal Grain Rust

It has been estimated that in the year 1916 wheat rust caused a loss in Canada and the northern States amounting to $250,000,000. It has also been estimated that in that year Canada's loss alone was approximately 100,000,000 bushels of wheat irrespective of all other grains.

Very serious losses are incurred every year through this disease and although the damage is less in some years than in others, depending largely upon weather conditions, wheat rust is a constant menace, as it may become epidemic at any time when conditions are favourable for its development. When it is considered that the average annual loss in Canada through cereal grain rust has been estimated, by those competent to judge, to be not less than $25,000,000, it will immediately be obvious that this is a national problem of such magnitude as to demand prompt and aggressive action and the question naturally arises as to what has been done in Canada toward eliminating, or at least greatly reducing, the enormous annual loss caused by this disease.

In answer to this question it is necessary to admit that until very recently nothing in any way comparable to the economic importance of the problem has been done in Canada to combat grain rust. It is true that the Federal Department of Agriculture has done some work on this disease and since 1917 has had at least one man at work endeavouring to solve some of the problems involved. It is also true that in Canadian universities and agricultural colleges, particularly in those situated in the prairie provinces, various scattered investigations have been undertaken on various phases of the question. It is also true that the National Research Council has subsidized certain researches carried out on this subject in the laboratories of the above universities and through its scholarships has endeavoured to develop a corps of research workers competent to undertake research work of this nature. It is however only necessary to consider some of the facts relating to this disease to thoroughly appreciate that it is not likely to be wiped out or even materially checked by any such isolated investigations, for if the economic importance of this question is enormous, the scientific difficulties to be overcome are of equal magnitude.

It would be well, perhaps, to give some slight idea of the difficulties confronting research workers engaged in grain rust investigation. In the first place, the problem is seriously complicated by the fact that there are many different rust fungi, that they are sub-divided into many biologic forms or parasitic strains and that the disposition of these strains varies considerably. For instance, in dealing with the black stem rust of wheat, we must consider not one single variety of *Puccinia graminis*, but thirty-nine or forty distinct strains within that variety. Wheat which is immune from one, two or a dozen strains of black stem rust may be quite susceptible to the rest of the forty strains known to exist.

This explains why reports are occasionally broadcast that some individual has developed a variety of wheat which is entirely rust resistant. It is invariably taken for granted in such cases that no scientific proof is necessary. There is the plot of wheat growing without the slightest trace of rust in the midst of other plots which have been badly affected by the disease. On the surface the evidence would seem to be conclusive. Unfortunately, however, the fact is that the wheat which is apparently immune from rust, is immune only to the particular strains of rust which happened to be present that year in the locality where the wheat was grown. The following year, or the year after, some other of the forty strains of black stem rust will be present in that locality and it will then invariably be found that the wheat which was supposed to be immune is badly affected by rust. It has fallen a prey to other strains.

But even if it were possible to develop a variety of wheat which is immune to all varieties of rust existing in Canada, it would still be essential that that variety should also possess suitable milling and baking qualities. This imposes further difficulties on the research worker.

The intricacies which have been outlined relate only to the plant breeding phases of the problem. It would, however, be futile to expect to find a solution for the grain rust scourge through any one channel. Several different departments of science are involved and it is essential that research work should be carried out simultaneously in each. For example, in addition to researches on plant breeding, physiological and ecological studies should be carried on to solve questions such as the effect of fertilizers and soil fertility, etc., on the prevalence and destructiveness of rust; that biochemical studies be carried on to determine the fundamental nature of resistance to rust; that biologic studies should be carried on to determine the number and distribution of the various forms of rust which it is necessary to combat. It is also essential that epidemiology researches should be undertaken to determine the manner in which rust spores are perpetuated and spread and the conditions, meteorological and otherwise, most favourable for its development and under which it may become epidemic.

Research work on cereal grain rust, in each of the above departments of science presents its own peculiar difficulties, such as those indicated. Further, since the problems which must be solved in all of these departments closely interlock, the progress which it is possible to make in connection with this problem in any one department of science is very definitely restricted by the extent of the progress which has been achieved in connection with other phases of the work. It is therefore obvious that progress toward the solution of cereal grain rust can only be accomplished through the close co-ordination and careful direction of all researches carried out in Canada on this subject and through the initiation of new work where and when necessary.

The National Research Council, on consideration of the foregoing facts, was unanimously of the opinion that the time had arrived for the pooling of all resources existing in Canada, in a concerted attack on all phases of this disease, in order that as rapid progress as may be possible may be made toward the solution of the problem.

The Council has adopted a fixed procedure for dealing with all problems of such major importance whereby it is possible to secure prompt and effective results. The first step taken was to enlist the co-operation of every organization in Canada known to engage in research work on cereal grain rust and of all the leading scientific authorities in Canada on various phases of this problem. The Federal Department of Agriculture was, of course, the first organization to be approached and readily agreed to join with the Council in a co-ordinated and concentrated attack on all the problems of this disease. The Council next enlisted the co-operation of the chief scientific workers who had carried on rust researches in various departments of science at the universities of Manitoba, Saskatchewan and Alberta. All individuals and organizations approached by the Council were agreed that the only hope of finding any real solution of the cereal rust problem lay through a concentrated, co-ordinated plan of attack such as was proposed by the Council.

The next step taken was to organize the chief scientific experts on rust, representing the various organizations and institutions named, into an Associate Committee on Cereal Grain Rust of the National Research Council. This committee, a complete list of which will be found on page 74 of this report, was appointed under the joint chairmanship of the President of the National Research Council and the Deputy Minister of the Federal Department of Agriculture.

The Council decided that immediately preceding the first meeting of the Associate Committee, a general conference of all persons interested in rust research should be held. To this conference, which was held in Winnipeg on September 9 and 10, 1924, were invited not only all Canadian research workers on rust, but also leading rust experts from the United States, where a considerable volume of work has been done on this problem. Twenty-six delegates

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attended this conference, eleven of whom represented the Department of Agriculture, the same number represented the National Research Council and the universities of Manitoba, Saskatchewan and Alberta. Four delegates were present from the United States, including Dr. E. C. Stakman, who is probably the foremost authority on grain rust problems on this continent.

The conference continued in session for two days. The first day was devoted to the presentation of the following twelve papers and reports, which constituted a thorough survey of the grain rust problem and the present situation in Canada and the United States:—

REVIEW OF THE PRESENT STATUS OF THE CEREAL RUST SITUATION IN THE DOMINION OF CANADA AND THE UNITED STATES OF AMERICA.

Review of the Situation in the Dominion of Canada—Professor W. P. Fraser.

Review of the Situation in the United States—Dr. E. C. Stakman.

INVESTIGATIONS UNDER WAY AND REVIEW OF RESULTS.

(a) Canada

Bionomics of Oat Rust—Dr. D. L. Bailey.
Stem Rust of Wheat Studies—Professor W. P. Fraser.
Mycological Aspects—Dr. G. R. Bisby.
Resistance Studies—Professor W. T. G. Wiener.
Cytological Aspects—Dr. W. P. Thompson.
Biochemical Aspects—Dr. R. Newton.

(b) United States

Cereal Rust Investigations in the United States—Dr. E. C. Stakman.
Plant Breeding Aspects of the Rust Problem—Dr. H. K. Hayes.
The Relation of the Common Barberry to the Rust Problem—Dr. I. G. Dickson.
Barberry Eradication in America—Dr. H. L. Bolley.

The following day was given over to the thorough discussion of all phases of the problem as presented in the above papers. When the conference was satisfied that the situation had been thoroughly canvassed, a small special committee was delegated to draft a definite programme of researches on cereal grain rust, which in the opinion of the conference should be undertaken in Canada and the United States, with the fullest co-operation. The report of this committee which was then carefully reviewed by the conference and finally adopted as an international programme on this question, reads as follows:—

REPORT OF THE COMMITTEE ON INTERNATIONAL CO-OPERATION IN CONNECTION WITH CEREAL RUST RESEARCHES

The committee recommend that the following phases of the Cereal Rust problem be investigated co-operatively by investigators in Canada and the United States.

EPIDEMIOLOGY STUDIES

1. That the work on overwintering of the summer stage of rust in the Mississippi valley of the United States be extended to include stations in Canada under different environmental conditions, and that two types of stations be established: (*a*) Those at which germination tests will be made at frequent intervals throughout the fall, winter and spring; (*b*) Those at which observations will be made to determine whether the rust appears earlier in the spring than in other locations.

2. It is recommended that numerous logically located spore trap stations be established in the United States and Canada to determine the degree to which cluster cup spores and summer spores are carried by the wind. Uniform system of spore trapping is to be used, and viability studies are to be made.

3. Aeroplanes should be used to determine the spore content of the upper air.

4. Meteorological data should be accumulated on the direction of air currents and precipitation, temperature and moisture, in order to correlate the movement of spores with the appearance of rust.

5. Meteorological data should be taken to ascertain under which condition the rust develops more abundantly after inoculation has taken place.

6. The number and distribution of barberries and buckthorns, and their responsibility in the development and spread of rust should be determined. Ecological studies should also be made to ascertain to what degree these shrubs are likely to become established in Western Canada.

BIOLOGIC SPECIALIZATION

7. It is recommended that the number and distribution of biologic forms of cereal rust fungi of economic importance be determined; special emphasis is to be placed on black stem rust. The facts should be ascertained by means of (*a*) greenhouse studies; (*b*) field studies in uniform rust nurseries.

PHYSIOLOGICAL AND ECOLOGICAL STUDIES

8. It is recommended that a project list be made of the fundamental researches now under way in Canada and the United States, and that this list be presented to the next Cereal Rust Conference, in order that necessary correlation of investigations may be made.

9. Standard manurial experiments are to be made at various stations in order to determine the effect of soil fertility on the prevalence and destructiveness of rust.

BREEDING FOR RUST RESISTANCE

The prosecution of the following projects is desirable:—

10. The collection of those biologic forms which occur in the hard red spring wheat region.

11. The establishment of greenhouse facilities for studying the resistance of varieties in the seedling condition.

12. The establishment of field rust nurseries for studying resistance of varieties and hybrids under artificially created epidemics, using all biologic forms occurring in the spring wheat area.

13. Genetic studies should be made of the material in the rust nurseries.

14. Cytological and histological studies are to be made of the material in the nurseries.

15. Field tests of purified hybrids should be made at various field stations under conditions providing adequate replication of rod rows and in fortieth acre plots.

16. Short rows of each of the purified hybrids should be made at as many places as possible.

17. Milling and baking tests should be made of all promising hybrids as soon as they are available.

(Signed) E. C. STAKMAN, *Chairman.*

G. R. BISBY, *Secretary;* H. L. BOLLEY, I. G. DICKSON, W. P. FRASER, H. T. GUSSOW, H. K. HAYES, R. J. NEWTON, W. P. THOMPSON.

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Immediately following the general conference, the Associate Committee on Cereal Grain Rust held its first meeting. The report of the Committee on International Co-operation in Cereal Grain Rust was adopted as a foundation upon which to build a co-ordinated programme of rust research work to be immediately and aggressively undertaken in Canada, and the facilities and personnel available at various centres in Canada for the prosecution of the different phases of this work were carefully reviewed.

When the committee had thoroughly canvassed the situation in a preliminary way and had reached a general decision as to the work which should be undertaken in Canada, the centres at which it could be carried out most effectively and as to the research directors under whose supervision the various researches should be placed, it was agreed that an adjournment should be taken until these tentative plans had crystallized sufficiently to enable the Committee to formulate a definite research programme for the ensuing year and to allocate the work to the best possible advantage.

At the second meeting of the committee, held on January 26, 1925, tentative research programs, which had been drafted in the interval between the first and second meetings of the committee, covering the major departments of science affected, were presented for consideration and discussion. These were all carefully reviewed item by item, with the result that the following program for cereal grain rust research in Canada was finally adopted by the committee:—

Grain Rust Research Program for Canada

Biochemical Studies.

1. The fundamental nature of resistance to stem rust.

Plant Breeding.

2. The crossing of common wheats known to possess some resistance, with the hope of building up a hybrid in which several genetic factors, governing resistance to at least a majority of the biologic forms of rust, would be present.

3. The interspecific crosses between emer and durum varieties of adequate resistance and desirable common types.

4. Cytological investigations to determine the chromosome conditions in the hybrids resulting from various crosses with a view to determining the underlying causes of sterility and linkage.

Plant Pathology.

5. Epidemiology studies involving investigation on

(*a*) Overwintering;
(*b*) Spread;
(*c*) Viability of various spore forms of Puccinia graminis;
(*d*) Conditions governing infection.

6. Epidemiology studies involving a study of the spore content of the air with particular reference to the origin and spread of black stem rust. This project also includes the accumulation of meteorological data and the correlation of this with rust development.

7. Biological Specialization. The culture and determination of biologic forms of P. Graminis tritici with particular relation to

(*a*) What forms are present in Western Canada.
(*b*) Their relative frequency.
(*c*) Their distribution.
(*d*) Seasonal variation in occurrence and distribution.

8. Biological Specialization. The origin and constancy of biologic forms. To determine if possible whether biologic forms of the stem rust organism arise by hybridization on the barberry and to investigate the stability of forms.

9. Stem Rust of Oats. To study further the nature and distribution of biologic forms of the oat rust organism, to make epidemiology studies and to determine varietal resistance in oats with a view to developing resistant varieties of oats.

10. Crown Rust of Oats. A parallel study with stem rust of oats with especial emphasis on the relation of the buckthorn to crown rust in Western Canada.

11. Barberry Eradication. An intensive survey of specially selected areas was proposed with a view of obtaining conclusive data on the probability of the barberry becoming established as a native shrub under western Canadian conditions. The desirability of eradicating whatever barberries that still remain in western Canada was emphasized.

12. Buckthorn Survey. Continuous with barberry eradication, to locate buckthorn and get rid of it wherever possible.

The allocation of this work was the next item of business dealt with. It was unanimously agreed that the laboratory work should be centred at the Universities of Manitoba, Saskatchewan and Alberta. It was also the concensus of opinion that all of the biochemical studies should be carried on at the University of Alberta under the direction of Dr. Robert Newton.

With reference to the Plant Breeding program, the following conclusions were reached by the committee:—

(1) Cytological investigations should be largely confined to the University of Saskatchewan and should be under the direction of Dr. W. P. Thompson.

(2) Some phase of the crossing work should be handled by Dr. Harrington at the University of Saskatchewan.

(3) The majority of the crosses should be made and the hybrids tested at Winnipeg. The work carried on by Professor W. T. G. Wiener at the Manitoba Agricultural College should be correlated with this work and the program enlarged, if possible.

The committee also decided that the work on the Plant Pathological phases should be allocated as follows: Projects (5, 6, 7, 11, and 12) as stated in the foregoing research program should be carried on jointly at both Saskatoon and Winnipeg, and Projects (8, 9, and 10) should be undertaken at Winnipeg only. This program is now in active operation and will be pressed forward with the utmost possible dispatch.

Summary

The results which have been achieved in connection with this problem during the year under review may therefore be very briefly summarized as follows:—

1st. The Council has secured the co-operation of all organizations in Canada which engage in cereal rust research and, through the welding of these into an Associate Committee of the Council, has ensured a concentrated co-ordinated attack on all phases of the problem.

2nd. An International Conference of all research workers and others interested in this problem has been held and complete information obtained as to the exact situation in Canada and the United States, at the present time, with respect to Cereal Grain Rust.

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3rd. An international program of researches on this subject has been established and arrangements made for the closest co-operation in all future work with investigators in the United States. This is of particular importance since epidemics recognize no international boundary and especially since grain rust infection largely originates in the United States and spreads up into Canada.

4th. A specific grain rust research program for Canada has been drawn up and adopted.

5th. Plans have been perfected whereby all facilities existing in Canada for research work on grain rust are being fully utilized in putting the Canadian program into effective operation.

It would, of course, have been quite impossible for the Council to accomplish the above results, had it not been for the whole-hearted and unselfish co-operation which has so readily been given by the Federal Department of Agriculture, the Universities of Manitoba, Saskatchewan and Alberta, and the many highly trained research directors at these institutions who, without any personal financial return, are giving of their time and experience in the direction of this important work.

It is a fortunate thing for Canada that men who have made a heavy investment to provide themselves with very specialized training, are willing to devote their talents to the solution of important national problems without any bickering as to the financial return which they will personally derive from such work. Unfortunately there is sometimes a tendency to depreciate the very real service rendered by such men simply because of the conviction which lies dormant in the back of the minds of a great many people that no person gives any material service, especially to a Government, without being paid therefor in some manner, and if perusal of the foregoing statement were to accomplish no other purpose than to dispel this entirely erroneous conviction and to convince the reader that there are many scientific men in Canada who are big enough to serve their country without selfish motives, it will have served at least one very useful and very much needed purpose.

Associate Committee on Tuberculosis

For several years past there has been a steadily growing growing conviction that sufficient attention has not been paid, in Canada, to the solution of tuberculosis problems through research. To put the matter on no higher plane than that of financial values, it is obvious that bovine and avian tuberculosis are responsible for an enormous annual loss in the live stock and dairy industries and apart altogether from the untold suffering and misery directly attributable to the ravages of this disease among humans, there is each year an appalling economic loss rising from the illness of those suffering from it and through the premature death of thousands of the most desirable type of citizens.

In the past, researches on tuberculosis have been carried out at various centres in Canada. Scattered investigations relating to human tuberculosis have been undertaken principally in university and sanitarium laboratories, while the most important Canadian researches to date on bovine tuberculosis are those undertaken by the Federal Department of Agriculture at Ottawa and by a committee appointed by the Department of Health of the province of Alberta from the officers of that department and from the scientific staff of the University of Alberta.

Recognizing the importance of this problem and the necessity for the co-ordination and stimulation of all tuberculosis research work which is carried out in Canada, the National Research Council appointed a small committee of gentlemen, who in the past have taken a keen interest in this subject and who are eminently qualified to express an opinion thereon, to consider and

report as to the manner in which the Council could co-operate in the solution of problems arising from tuberculosis. This committee met at Ottawa on March 18, 1925, and its deliberations were crystallized in the following report to the National Research Council:—

> "1st. The committee wishes to highly commend and strongly endorse the work which has for several years been conducted in the Biological Laboratory of the Health of Animals Branch of the Department of Agriculture in research in the problem of bovine tuberculosis under the direction of Dr. E. A. Watson.
>
> "2nd. Because of the essential unity of the problem of tuberculosis, whether affecting man or lower animals, it will be necessary to broaden the scope of the enquiry to include a study of certain phases of human tuberculosis.
>
> "3rd. It is the judgment of the committee that the present plan of research in tuberculosis should be greatly expanded and additional financial support be made available at the earliest possible moment for increasing the facilities for such research and enlarging the personnel necessary for the work.
>
> 4th. It is therefore recommended that the National Research Council appoint a representative committee to consider this matter and evolve a plan which will give effect to the proposals contained herein."

This report was approved by the National Research Council and steps were immediately taken to give effect to its recommendations. In accordance with its fixed policy in dealing with such major problems, the Council appointed an Associate Committee on Tuberculosis Research, representative of all organizations known to be actively working on, or which are directly interested in, the problems of this disease, such as the Federal Departments of Agriculture and Health, the universities and agricultural colleges, the Canadian Tuberculosis Association and the sanitaria, the stock breeders, etc. The personnel of this committee will be found on page 74 of this report.

The National Research Council has assigned to the committee the duty of thoroughly canvassing the situation in connection with all phases of this disease, of evolving a detailed research program and of taking such steps as may be considered necessary by the Committee, and approved by the Council, to ensure the active prosecution of that program. In connection with this work the Council has carefully followed a definite plan of action as a result of which it will be possible during the coming year to properly organize the work and to initiate scientific investigations on the problems of this disease with the greatest possible efficiency and expedition.

Report of the Associate Committee on Helium for the Year ending March 31, 1925

In January, 1924, the National Research Council instituted a Special Committee on Helium, with a membership consisting of Professor J. C. McLennan, Chairman, Dr. A. S. Mackenzie, Dr. R. F. Ruttan and Dr. H. M. Tory. This action was taken by the Council on consideration of representations received from the Department of National Defence, suggesting the continuation of the investigations on the extraction of helium from the natural gases of Canada that were initiated and partly carried through by Professor McLennan in the years 1917 to 1920 at Calgary.

The committee was authorized by the National Research Council to make a preliminary survey of the helium situation in Canada and the Council also provided a grant of $5,000 for this work on condition that the Department of National Defence and the British Air Ministry each contributed an equal

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amount. At the same time the Council took preliminary steps to have representations made to the Government that suitable action should be taken to ensure the conservation of the sources of helium in Canada.

At a meeting of the National Research Council held in May, 1924, Dr. McLennan, Chairman of the Helium Committee, reported progress and informed the Council that the Federal Department of Mines was reinvestigating the natural gases of Canada with a view to ascertaining their helium content at the present time. In November, 1924, the chairman of the committee roported to the Council that at a meeting of the committee held on the previous evening, the whole situation relating to the supply of helium available in Canada was considered both from the standpoint of the possibility of utilizing the helium content of Canadian gas for industrial or for military, naval and aeronautical purposes and from the point of view of the practicability of ensuring a supply of helium for scientific purposes in Canada and possibly also in Great Britain. It was also reported that the investigation of the helium content of the natural gases of Canada was being pressed forward by the Federal Department of Mines.

The committee strongly recommended close co-operation in this work with the Federal Department of Mines and with the Ontario Department of Mines and, in order to give effect to this recommendation, the Council added the following persons to the Special Committee on Helium:—

Mr. J. McLeish, Director, Mines Branch, Federal Department of Mines, Ottawa.

Mr. R. T. Elworthy, Chemist, Mines Branch, Federal Department of Mines, Ottawa.

Mr. R. B. Harkness, Commissioner of Gas, Department of Mines, Toronto.

Mr. J. Patterson, Assistant Director, Meteorological Service, Toronto.

The addition of these gentlemen automatically changed the committee from a Special Committee, consisting of members of the National Research Council only, to an Associate Committee on Helium.

In order to enable the committee to take without delay such action as it might consider advisable, the Council also rescinded the conditions originally attached to the grant of $5,000 provided for the work of the committee and authorized such expenditure from the above grant as the committee might consider necessary in connection with the preliminary survey.

Further meetings were held by the committee during the year under review, at which all phases of the question were thoroughly canvassed. The conclusions of the committee, as a result of these meetings, were crystallized in the following report, which was presented to the National Research Council in March, 1925.

Progress Report of the Associate Committee on Helium

It would appear that Canada is developing large resources of natural gas for which an immediate market as a domestic fuel may not for a long time be available, but which may be utilized, provided suitable processes are developed and their economic feasibility demonstrated, for the production of important and valuable by-products.

Some of the natural gases in Canada also contain sufficient quantities of helium to justify the re-establishment in a natural gas station at Inglewood of the helium recovery plant formerly built and operated at Calgary, in order that helium may be made available for scientific and industrial research within the Empire, and that an improved and cheapened process of recovery may be developed should larger supplies of helium be required for national or commercial purposes.

I. Canada contains the only important supplies of helium, as far as is known, in the British Empire. Small wells have recently been found at Inglewood, Ont., the gas from which contains 0.8 per cent helium. This compares favourably with the gas used in the United States plant at Fort Worth.

II. An experimental plant was erected at Hamilton and later at Calgary for the recovery of helium from natural gas. The essential parts of this plant are still at Calgary and would cost about $25,000 to replace at the present time.

III. The men who acquired the necessary training and knowledge for the running of this plant are available to assist in training a new set of men in the technical details of the process. If advantage is not taken of this now, it may not be possible to obtain their services later.

IV. The British Admiralty furnished all the money for erection, equipment and operation of the plant at Hamilton and later at Calgary and it would only be fitting that Canada should complete the work begun, and perfect the process.

V. There are already known large resources of natural gas in Canada carrying from 0.2 per cent to 0.4 per cent helium. A process perfected for one gas could be used with slight modification for others.

VI. The United States at present hold the only large supply of helium available, and they are not disposed either to part with the gas or with their knowledge of their methods for extraction. They spend annually on their research laboratory alone more than the amount required to put the Canadian plant in operation and run it for some years.

VII. While carrying on experimental work on the separation of helium, a knowledge of the processes involved would be gained that might prove useful in connection with refrigerating processes generally.

VIII. While perfecting the process, a good supply of helium would be obtained which could be furnished to laboratories for experimental research, from which results of industrial importance might be obtained and uses found for helium which would make it worth while to extract it from even low-grade natural gas.

IX. If advantage is not taken of our present opportunity, and the supply of helium now available for scientific laboratories in the Empire becomes exhausted, it may not be possible to get a new supply.

Recovery of Formaldehyde and Other Products

The Mines Branch of the Department of Mines has had under way for several years a small laboratory investigation on the recovery of formaldehyde from natural gas.

Preliminary work on the production of formaldehyde by the partial oxidotion of methane, the main constituent of natural gas, suggests the possibility of a successful industrial process. This particular problem is of great interest to the British Government, and unofficial suggestions for co-operation and financial assistance have already been made by officials of the British Scientific and Industrial Research Department.

The establishment of an experimental helium plant at Inglewood would provide an ideal opportunity for the prosecution of this further investigation on a semi-commercial scale, as large supplies of practically pure methane could be made available without additional cost, and without using gas which is at present required and utilized for domestic consumption.

It may be found feasible in this laboratory also to conduct experiments having in view improvements in methods of manufacturing carbon black from natural gas.

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The use of industrial gases, such as natural gas and coke oven gas for the manufacture of chemical products will, probably in a few years, assume great importance. Already, the Germans are producing on a manufacturing scale a substitute for gasoline, called "synthol," from carbon monoxide and hydrogen. The British Department of Scientific and Industrial Research in their new chemical research station are taking up the study of gas reactions at high temperatures and pressures. It seems desirable to have in Canada an experimental station where the necessary knowledge and experience in the special technique of industrial gas reactions could be obtained.

In connection with the statement above the following suggestions are made:—

(i) That action be taken to secure control of the gas area at Inglewood.

(ii) That consideration be given to a geologic study of the field and its further development by drilling.

(iii) That an experimental station be erected at some suitable location near Inglewood:—

(*a*) to perfect the helium separation process,

(*b*) to obtain a good supply of helium,

(*c*) to determine the commercial cost of separation,

(*d*) to investigate the possible commercial manufacture of formaldehyde and other synthetic products from methane.

(*e*) to investigate other uses of natural gas including the fixation of the contained nitrogen which in the case of the Inglewood gas is 12 per cent. This is with an eye to the economic production of fertilizers,

(*f*) to conserve the knowledge of processes already gained and to train future workers in this field of research.

ESTIMATE OF COSTS

(*a*)	Acquiring gas rights		$ 5,000
(*b*)	Removal of plant from Calgary		1,200
(*c*)	Reconstruction of Plant:		
	Remodelling column	$ 2,500	
	Engines and compressors, etc.	11,200	
	Building, 30 ft. x 60 ft. and installation	4,000	
	Pipe lines	3,000	
	2 Gasometers	4,000	24,700
(*d*)	Drilling two new wells		5,000
			$35,900

Operating Costs: $1,500 a month.
(No cost for power).

J. C. McLENNAN,
Chairman.

March 19, 1925.

Dr. McLennan, Chairman of the committee, in presenting the foregoing report, informed the Council that the control of the Canadian Western Natural Gas Company at Calgary had been transferred to new interests and that as gases richer in helium than those of the Calgary field were known to exist in Canada, the committee was strongly of the opinion that action such as that suggested by the committee should be taken immediately to move the helium plant from the property of the above company in Calgary and to restore the building to its original condition according to the agreement between the company and the British Admiralty. A communication was read from the general manager of the above company indicating that the company desired that action such as that suggested should be taken, as they wished to make other use of the building.

After considering the above report, the National Research Council decided to authorize Dr. McLennan, as Chairman of the Associate Committee on Helium, to remove the helium plant from its present location at Calgary and to place it in suitable storage, pending decision as to its final disposition. The Council also authorized the expenditure from the grant placed at the disposal of the committee of such sums as were required for this purpose.

Dr. McLennan, on behalf of the committee, explained the necessity of securing an option on the gas rights of certain properties in Ontario in order that the plans of the Helium Committee might be protected, pending final decision as to the action which should be taken in connection therewith.

The Council gave approval to the proposal and authorized the Committee to expend from the grant already placed at its disposal a sum not exceeding $500 to secure a six months' option on the property concerned.

It should be stated that subsequent activities of the Committee embraced the securing of the option on the Inglewood gas wells and on the gas rights over some 1,600 acres in the neighbourhood as well as the transference of these rights to the Government of the province of Ontario, which body now holds them for the benefit and use of the Crown. Further negotiations are in progress with the object of setting up a Helium Extraction and Gas Research Station at Inglewood.

Associate Committee on the Nutritional Problems of the Fox Industry

Canada's possibilities as a fur-growing country are almost limitless. For this purpose her climate is practically ideal and in her vast stretches of territory it is easy to find those conditions peculiarly suited to the growth of almost any fur-bearing animal. Of those which have been raised in captivity on a commercial scale the fox is the most important and Canada has become known all over the world not only as a source of the finest fox furs, but also for the excellence of the animals available for breeding purposes.

In order to realize that fox ranching is now an important Canadian industry it is only necessary to consider the fact in the year 1923, the latest for which figures are available, there were 1,240 fur farms in Canada, the lands and buildings of which were valued at more than two million dollars. The value of the foxes contained on these farms, apart from all other fur bearing animals, was approximately six and a quarter million dollars, and the value of the fox pelts and animals sold during the same year amounted to two million one hundred and sixty thousand dollars.

Recognizing the importance of this industry and the necessity for the solution of some of the many special problems arising from the fact that the animals are bred and raised in captivity, the National Research Council several years ago undertook and has since carried on in co-operation with the Federal Department of Agriculture a thorough investigation of the nutritional problems of captive foxes. The fox breeders themselves donated to the Council all of the foxes required in connection with this research.

Until recently the factors affecting the quality of the fur have not been well understood. This investigation has established the fact, however, that the character of the food consumed by foxes is one of the greatest influences on the colour, length and thickness of the fur and therefore of its commercial value. Important results of this work were given in the last annual report of the National Research Council. In the year just ended a new series of experiments has confirmed the favourable effects of feeding captive foxes approximately 100 calories per kilogram of bodilyweight during the major portion of the year and there remains no doubt that the value of the pelt is largely determined by the diet of the fox.

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Further study has been made of the special requirements of the breeding female. Although the results obtained cannot yet be regarded as final, they suggest the following tentative conclusions:—

(1) Females should be so fed as to reach a minimum weight during the summer months, and to gain from 35 to 40 per cent during the fall.

(2) Females in good condition for breeding show a pronounced development of adipose tissue in the posterior medial line of the abdomen, and have large deposits of fat in the abdominal cavity.

(3) Overfeeding should be avoided during later pregnancy and during lactation.

As a result of the researches which have been carried out in connection with the problems of this industry both the National Research Council and the Department of Agriculture are convinced of the necessity of continuing the investigation on a permanent basis, and since the above department is now in a position to undertake entire responsibility for this work and to place a qualified officer permanently in charge of an experimental fox ranch to be erected in the Province of Prince Edward Island, the National Research Council relinquished to the Department of Agriculture, at the close of the year under review, all connection with this work. The action taken by the Council in this respect is but one more example of the fact that the National Research Council is always more anxious to co-operate in every possible way with the government departments and other existing research agencies in the co-ordinated prosecution of researches than to build up any big organization under its own auspices.

In relinquishing its conduct of the research the committee desires to express its gratitude to all those who, by the gift or loan of foxes, or in any other way, have assisted it in its labours; and also its satisfaction that the work which it had the honour of initiating is to be continued under such favourable conditions as those afforded by the Department of Agriculture. It is also a matter of satisfaction to know at the conclusion of this work that in the opinion of the fox ranchers themselves the researches which have been carried on to date under the auspices of the Council are of great importance and have furnished valuable assistance at a critical stage of the development of this growing industry.

Associate Committee on New Brunswick Forest Problems

Reforestation

In February, 1925, for the first time in the history of Canada, our monthly production of newsprint was greater than that of any other country in the world. In view of the new paper mills now being installed here it is comparatively safe to predict that in a very short time Canada will have acquired in newsprint production a safe lead over all competitors. The pulp and paper industry is one of which Canadians may well be proud, but if its development and that of lumbering and other related industries are to continue it is essential that we give early and serious attention to replenishing the supplies of timber which are being utilized for those purposes, as well as to making good the ravages by fire and insects. If we wait until there is an actual shortage it will be too late, for to grow timber of merchantable size requires from fifty to one hundred years.

Realizing the importance of forest renewal in Canada, the National Research Council has from the time of its inception taken steps to investigate the question of reforestation. In connection with this work it has always been the policy of the Council to co-operate in the closest possible manner with the Forestry Branch of the Department of the Interior and a record of the past

activities of the Council on this question will be found in previous annual reports. At the present time the Council is engaged in a research on reseeding burnt-over and cut-over forest areas in the province of New Brunswick. This work is being carried on by the Associate Committee on New Brunswick Forest Problems acting in closest co-operation with the Federal Forestry Branch and the Department of Lands and Mines of the province of New Brunswick.

The main problem under investigation is the determination of the cheapest practical method of restocking such areas with the more valuable commercial soft woods. The planting of trees is, under present economic conditions, so costly as to be prohibitive, but the success so far achieved in reseeding is such as to encourage the hope that the reforestation problem may eventually be solved in this way.

During 1923 about sixty acres were seeded, the test areas being in two different districts and covering a variety of conditions. These were examined in 1924 and found to be doing well, with promise of a good stand of timber under reasonably favourable conditions. New areas were seeded in the autumn of 1924, those being selected in the more accessible districts, adjacent to railways and highways where possible. An effort was also made to choose land burnt with different intensity, and in different years. White pine and white spruce were the species seeded and a large quantity of white spruce seed was collected for future work.

It is important that this investigation be continued, both to determine accurately the best conditions for seeding in different districts, and to provide for a careful study of the growth and mortality of trees already springing up. Much interest in this work has been shown and if it can be proved that reseeding is commercially profitable, reforestation should be made a part of our national policy.

Associate Committee on Food Research

Vitamines

For some years medical men were greatly puzzled by a group of diseases, including amongst others beri-beri, rickets and scurvy. These were generally supposed to be caused by germs or by minute quantities of some obscure poison in various kinds of food. Then the theory was put forward that they might be due to deficiencies in the diet, and, while not generally accepted for a long time, this has proved to be correct. "Deficiency diseases," as we now call them, are in reality due to the lack in our food of one or more substances known as vitamines. These long-unsuspected and even now little-understood compounds are not only necessary to the preservation of health, by preventing beri-beri, rickets, scurvy and other diseases, but also control in some mysterious way the processes of growth and reproduction. The study already made of their properties has resulted in a general revaluation of foods, new classifications being based not only on their chemical analysis and calorific value, but also on vitamine content.

The Associate Committee on Food Research was engaged during the year under review in carrying out, in the Food Chemistry Laboratory at the University of Toronto, and in the Biochemical Laboratory of the University of Western Ontario, a research on the isolation of a pure vitamine, an extremely difficult task. The present investigation has been confined to a study of vitamine B, that member of the group possessing anti-neuritic properties. It has been found that phosphotungstic acid prepared in a certain way precipitates vitamine B from its solutions free from the growth and anti-scorbutic vitamines. This preparation of phosphotungstic acid is therefore being used to precipitate vitamine B in its purest form. When a considerable quantity has been obtained an effort will be made to determine the exact nature of the vitamine. Several papers will shortly be published giving in detail the results so far obtained.

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Associate Committee on Aeronautical Research

An account was given in the Annual Report of the National Research Council for the year 1923-24 (page 21) of the manner in which the Council carries out its definite policy for the closest co-operation with all departments of the Federal Government. The committee under review is one example of such co-operation. Several years ago the Council was informed that there were many important scientific problems which in the opinion of the technical officers of the Air Services, Department of National Defence, urgently demanded investigation.

The Council consequently appointed an Associate Committee on Air Research comprised of representatives of the Department of National Defence and other eminently qualified persons, and assigned to this committee the duty of advising as to aeronautical researches which should be undertaken in Canada and the prosecution of such investigations as were finally approved.

In most cases it is necessary for the Council to provide financial assistance for the carrying out of such work but it is only fair to record that in this instance the Air Services of the Department of National Defence have furnished from funds at their disposal, practically all of the assistance required by this Committee up to the present time in connection with the prosecution of its research work.

Four meetings of the Associate Committee on Air Research were held during the year under review and following is given a brief outline of various investigations which are being carried out under the direction of the committee.

Variable Pitch Air Propeller

Under the auspices of the committee, Mr. W. A. Turnbull has been engaged in experimental work on a variable pitch air propeller. During the war Mr. Turnbull had constructed a propeller in England, which was shipped to Canada in an incomplete condition, had then been finished, sent to Camp Borden for test, and unfortunately destroyed. As a result a new arrangement has been made, and a grant of $1,500 obtained through the National Research Council, from the Royal Canadian Air Force, to enable Mr. Turnbull to carry on his work.

Toronto Wind Channel

Progress has been made by Professor Parkin in work carried on in connection with the Toronto Wind Channel, with a view of eliminating difficulties arising from the irregular distribution of return air currents in the new Aerodynamic building, and some preliminary results of the experiments on the image effect of the Wind Channel walls have also been reported to the committee.

Oiling Radial Engines in Winter

This subject was brought to the attention of the committee, but, although necessary and of great importance, has had to be left over for the present as it has been found impossible to secure a radial engine for the experimental work.

Oleo Landing Gear Oils

Professor C. M. McKergow, of McGill University, has been conducting an investigation on the viscosity, freezing point, etc., of oils for use in oleo shock absorbers in cold weather. This investigation, it is hoped, will throw light on the rate of change of viscosity with temperature.

Behaviour of Rubber Shock Absorbers at Low Temperatures

Professor Wilson, of the University of Alberta, and Professor Finlayson, of the University of Manitoba, are carrying on this experimental work, and a grant of $50 has been recommended for materials and apparatus.

Magneto Noises in Radio Reception Equipment

An investigation regarding the elimination of magneto noises in radio reception equipment carried in aeroplanes, has been undertaken by Professor Vickers of the University of British Columbia. An application has been made to the National Research Council for a grant to cover the cost of assistance.

Wing Commander E. W. Stedman, Assistant Director of Air Services, Department of National Defence, on returning from a journey of inspection in the United States, gave some valuable information to the committee on recent developments in that country in aircraft work, some of the most important being:—

> The use of tetra-ethyl lead in the proportion of 3 cc. per gallon, replacing alcohol or benzol as an addition to motor fuel for the purpose of preventing knock. The use of this substance has been developed in the laboratories of General Motors, and it seems likely that its use, when further developed, may render it possible to use gasoline of ordinary quality in the high compression engines of aeroplanes.
>
> Porous metal bushings composed of a zinc copper alloy, formed by pressure into a porous mass capable of containing 25 per cent by volume of oil, and therefore lasting a long time without lubrication.
>
> Further work on the avoidance of corrosion of spark plugs and deposit in the engine cylinders by the use of chemical substances such as dibrom-ethylene.
>
> Researches regarding super chargers of the turbine type, driven either by direct connection to the engine, or by a separate turbine operated by the exhaust gases.

Colonel Stedman drew the committee's attention to the intensive research on aeronautical matters which has been prosecuted in the United States, the result being that the performance of the most recent types of the American Aeroplanes is far in advance of anything done in Europe.

Colonel Stedman also furnished a very interesting report on his observations at Farnborough and other stations in England, and also in France, during his recent visit to Europe.

A complete list of the members of the committee will be found on page 77 of this report.

Associate Committee on Accurate Plot Work

Determination of Accurate Methods of Testing Varieties of Cereals

The development of new varieties of cereals is one of the most important tasks in agricultural research. Extensive work of this nature has been carried out on all the Government Experimental Farms, in the University Departments of Agriculture and by a large number of private investigators. The results to date have been worth untold millions to Canada. New varieties of cereals are continually being tested, giving promise of still further advances.

When new varieties have been developed it is of great importance to secure at an early date a fair comparison between these and standard varieties, to determine the yield, quality, earliness, susceptibility to disease, character of the soil best adapted to their growth, effect of climate, and many other factors. This problem is on the face of it a complex one, and it is not strange that so far no standard methods of testing have been adopted in this country.

To develop such standard methods of testing varieties of cereals there has been formed an Associate Committee of the National Research Council under the Chairmanship of Dr. J. H. Grisdale, Federal Deputy Minister of Agriculture. This committee includes in its membership representatives of the Federal

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and Provincial Departments of Agriculture, superintendents of the Experimental Farms, university and agricultural college professors, and other specialists in the growing or testing of cereals. There has been outlined a program of work which will require at least three years to complete, and experiments will be carried out under agreed conditions at a number of different centres, among them the Experimental Farm at Ottawa; Experimental Stations at Charlottetown, P.E.I., Cap Rouge, P.Q., and Scott, Sask., MacDonald College, P.Q., and the Universities of Manitoba, Alberta and British Columbia.

The work of one season has already been completed and results of value have been secured but it is deemed wise to defer publication of details until a later date, when it will be possible to make a critical analysis of all the data obtained.

Associate Committee of Chemists

The annual meeting of the committee was held in Kingston at Queen's University on the 26th of May, 1924, seventeen members of the committee being present, as follows: Dr. R. F. Ruttan, Chairman of the committee; Dr. H. M. Tory, President of the National Research Council; Dr. E. H. Archibald, Dr. F. J. Birchard, Mr. Alfred Burton, Dr. Paul Cardinaux, Mr. T. Linsey Crossley, Mr. J. R. Donald, Mr. A. G. Fleming, Mr. H. Freeman, Mr. R. E. Gilmore, Dr. N. Macallum, Dr. A. E. Macintyre, Dr. D. McIntosh, Mr. G. H. Tomlinson, Dr. G. S. Whitby, and Mr. R. A. Witherspoon. A complete list of the members of the committee will be found on page 78 of this report.

Dean Ruttan, of McGill, occupied the chair and made a full report of the activities of the National Research Council for the year 1923-24, making special reference to those subjects which are of interest to the chemists. He pointed out that during the seven years' existence of the National Research Council, thirty-eight (38) Fellowships, seventy-four (74) Studentships and seventy-nine (79) Bursaries had been awarded at an expenditure of $159,973.89.

One hundred and nineteen (119) scientific papers had been published, twenty-eight (28) grantees had been awarded M.Sc., and nineteen (19) the Ph.D. The majority of these were in physics or chemistry. About half of those who had completed their graduate courses were engaged in teaching and the other half were engaged in industries, or are continuing their research work. Only ten (10) have accepted positions in foreign countries and sixty-five (65) have remained in Canada.

Dr. Ruttan called attention to the new catalogue of scientific periodicals which was about to be issued. The first suggestion regarding this publication came from the Associate Committee of Chemists in 1921.

The question of publication of scientific literature in Canada, specially chemical literature, was fully discussed and the National Research Council was asked to take an active part in devising some method by which Canadian researches could be published in Canada. Increasing the number of bulletins and reprints by the Council was recommended.

A number of papers were read pointing out the necessity for chemical research in connection with many industries in Canada.

(1) Dr. Neil Macallum read a paper on the "Pitting of Cans used for Canned Fruit, etc." It was pointed out that the loss from this source was very heavy and that the Associate Committee of Biologists was investigating the loss due to the defective canning of lobsters; the value of different varieties of tin plate was discussed, as well as the method of sterilizing, etc.

(2) A paper was submitted by Prof. H. E. Bigelow on "The Industries of New Brunswick," and the necessity for research to their development. The basic industries of that province were agriculture, lumbering, and fishing, each of these can be developed by organized research.

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Dr. Tory called attention to the importance of investigating the problems of the Maritime fishermen, and Dr. Ruttan called attention to the utilization of waste fish and fish waste.

Mr. Gilmore reported that the results of the investigation of New Brunswick coals by the Mining and Metallurgical Department would be published in a short time.

Dr. Birchard gave a paper on "Laboratory Investigations on the Grain Industry in Canada." Among the points investigated by the Laboratory in Winnipeg, special attention was devoted to the determination of moisture in the different grades of grain in storage and elevators, as well as in cars and boats; the comparative milling and baking values of different grades of wheat and the effect on the baking value of rust, frost, sprouting, etc. A large number of experiments were made on the effect of artificial drying. Dr. Birchard was asked by the committee to submit to the National Research Council a series of statements showing the possibilities of laboratory investigations in connection with the wheat crop of the northwest.

Mr. Alfred Burton read a paper on "Textile Research of the Woollen Industry." After calling attention to the bonuses given by the English Government to aid in the textile industries of Great Britain, Mr. Burton asked that the National Research Council meet a deputation from the woollen industries with a view to discussing the best methods of development.

Mr. Burton was asked by the chairman to state clearly the problems of the woollen industry and to send a report to the National Research Council, so it might receive careful consideration.

Mr. Crossley discussed the question of the manufacture of pulp and paper from straw. He pointed out that there were some forty million tons of straw available annually which contains fifty per cent (50%) cellulose. The difficulty of transportation had not yet been overcome. Although he did not consider the manufacture of paper from straw to be economical at present, it was something that should not be forgotten. A very powerful press, such as one recently devised in England, might reduce the bulk of the straw to such a degree as to make transportation possible.

The question of "standardizing household coal" was brought up by Mr. J. R. Donald, who pointed out the necessity of protecting the householder by fixing the standard for ash in anthracite and other domestic coals. American anthracite contains about twenty per cent (20%) ash, Welsh coal about eight per cent (8%). If the health authorities make tests of foodstuffs in view of protecting the public, he claimed that similar tests might be made of domestic fuels. The committee agreed that this question should receive the consideration of the National Research Council. It was agreed to send a memorandum to the Dominion Fuel Board.

The chairman announced that the following members, having served for a period of four years, retire automatically from the committee: Dr. H. E. Bigelow, Mr. J. R. Donald, Mr. R. E. Gilmore, Dr. Neil Macallum, and Mr. R. A. Witherspoon.

The following gentlemen were recommended by the committee to the National Research Council to fill the vacancies: Dr. John S. Bates, Bathurst Co., Bathurst, N.B.; Harold G. Girvin, Chief Chemist, Steel Co. of Canada; Dr. L. F. Goodwin, Queen's University, Kingston; Dr. R. M. MacLean, McGill University, Montreal; Dr. F. W. Skirrow, Electro Products Company, Shawinigan, P.Q.; and Mr. J. A. Wales, Superintendent of the Chemical Alcohols, Limited, Montreal, P.Q.

Associate Committee on Physics and Engineering Physics

The seventh annual meeting of the Associate Committee on Physics and Engineering Physics was held in the city of Quebec on May 19, 1924. Eleven members of the committee were present at the meeting.

The committee had under consideration difficulties which had arisen in connection with the annual contribution required for Canadian membership in the various Scientific Unions of the International Research Council, this committee being specially interested in the International Unions on Physics and Engineering Physics, Geodesy and Geophysics and on Astronomy.

After carefully canvassing the situation the committee was unanimously agreed that as practically all countries of importance, from a trade point of view, have joined these Unions and as membership therein is recognized to be a national asset and as the National Research Council is the official representative in Canada of the International Research Council and has organized all of the Committees which have been established in Canada in connection with the above Scientific Unions, therefore, the National Research Council of Canada should make arrangements for the payment, from government funds, of the fees necessary to maintain Canadian membership in the above named International Scientific Unions.

The question of the best means for the publication of scientific papers in Canada was also carefully discussed, attention being called to the fact that physicists have for some time past been seriously handicapped because of the lack of facilities in Canada for the prompt publication of scientific papers. Certain definite recommendations, on this question, were made to the National Research Council by the committee.

The committee discussed the question as to the steps which should be taken to retain, for service in Canada, the most promising graduates of Canadian universities. The problem of ensuring adequate training in Physics of students entering on a medical course was also dealt with. It was the consensus of opinion of the committee that there should be closer co-operation between the Physics departments of the various universities in the distribution of information as to vacancies in the field of Physics and as to qualified physicists, who are available for appointment to such vacancies. The committee was also of the opinion that medical students should receive training in Physics in both pre-medical years of their course.

The question of the distribution of the scholarships awarded annually by the National Research Council was under consideration with the result that the committee approved of the policy adopted by the Council that such awards should be held at Canadian universities, but that a limited number of Fellows, who had obtained their Ph.D., should be permitted to proceed overseas for special training. In this connection the committee were also of the opinion that a limited number of Fellows should be brought to Canadian universities from Great Britain or from other parts of the Empire.

A general resolution was passed by the committee recommending that the National Research Council take steps to ascertain what products are imported into Canada which might with the assistance of suitable technical knowledge be advantageously manufactured in Canada either for home consumption or for export.

A report was presented to the committee by Dr. A. S. Eve, Chairman of the Sub-Committee on Radio, which committee was appointed during the previous year, to inquire into the possibility of undertaking research and observational work in Canada, connected with the following groups of investigations:—

Group I.—Atmospheric Electricity.

(*a*) Ionization.
(*b*) Potential Gradient.
(*c*) Penetrating Radiation.
(*d*) Air Earth Currents.
(*e*) Auroræ.
(*f*) Magnetic Storms.

Group II.—Radio Signals.

(*a*) Strength, Fading, Deviation in Direction Finding.
(*b*) Interference with Signals (distant and local).

The committee approved this report after it had been thoroughly discussed and decided that the sub-committee should be continued for another year and that Dr. A. Frigon should be added thereto. It was agreed that the sub-committee collect from various sources such information as is available in Canada relative to radio problems.

An interim report on the radio inductive interference research carried out under the direction of Professor T. R. Rosebrugh, at the University of Toronto, was presented to the committee. After careful consideration this report was strongly commended by the committee, which recommended that this investigation be carried to a conclusion so that a satisfactory detector of local radiation may be perfected. Attention was called to the fact that a solution of this problem is beneficial not merely to radio listeners, but also to power companies and other industrial interests, since through the elimination of faults in their equipment and apparatus it is frequently possible to prevent serious and costly damage. It was realized, however, that the complete elimination of interference in radio broadcast reception, under certain atmospheric conditions may prove to be impossible.

A certain number of the members of this committee retire each year in accordance with a regular rotation schedule adopted by the Committee. The term of appointment of Dr. Eve, Dr. Herdt, Mr. Dobson and Professor Rosebrugh expired during the year under review and the committee recommended to the National Research Council that the following gentlemen be appointed to the above vacancies: Dr. A. N. Shaw, McGill University; Prof. H. W. Price, University of Toronto; H. B. Dwight, Canadian Westinghouse Company; and Prof. C. V. Christie, McGill University. The committee also recommended that Dr. J. A. Gray, of Queen's University, be appointed to the committee to replace Dr. A. L. Hughes, who is not now resident in Canada, and that Major A. M. Steele, of the Department of National Defence, be added to the committee.

A complete list of the membership of the Associate Committee on Physics and Engineering Physics as it stood on March 31, 1925, will be found on page 79 of this report.

Associate Committee on Mining and Metallurgy

The eighth annual meeting of the Associate Committee on Mining and Metallurgy was held in Ottawa on March 7, 1925, with seven members in attendance. The chair was occupied by Dr. J. B. Porter in the absence of Dr. F. D. Adams, Chairman of the committee.

Dr. Porter reported briefly on the results which had been obtained in his investigation of screening methods. He stated that the total cost of this research to date had been approximately $3,500, of which the contribution of the National Research Council had been $750. To continue the work for another year would entail an expense on the part of the Council of about $1,000, the remainder of the cost being borne by the Mining Department at McGill University. He asked the committee for an expression of opinion as to the advisability of making a favourable recommendation to the Council. It was unanimously agreed that such a recommendation should be made.

Mr. Denis brought up the question of the necessity of metallurgical research, particularly in the provinces of Quebec and Ontario, with a view to developing methods for the electrical recovery of metals occurring in those provinces. He stated that there would shortly be available in the province of Quebec alone some 600,000 horse-power, of which as yet only about one-third

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had been contracted for, the balance being available at a low rate for use in electrometallurgy. The Quebec Government had been approached by companies operating in the province for assistance in researches in electrometallurgy, but he felt that before such research was undertaken in any province it might be advisable for the Council to collect all the information available on this subject, for publication in the form of a pamphlet. It was agreed by the committee that Dr. Stansfield be appointed a committee of one, with power to add in consultation with the chairman of the meeting, to investigate and report on the advisability of the Council compiling a pamphlet such as suggested. It was realized that it would be impossible to cover the whole field of hydrometallurgy in such an investigation, and the determination of the exact field to be considered was left to the judgment of the sub-committee.

Dr. Sexton introduced the subject of the occurrence of sulphur in Nova Scotian coal and the advisability of researches leading to its elimination or reduction. He considered the question to be of importance in view of a probable increase of by-product coke in Canada for use in domestic heating, with the concurrent production of a large quantity of gas which would require purification from sulphur.

Dr. Porter pointed out that Nova Scotian coals contained both inorganic and organic sulphur, the former being removable by hydraulic concentration, but the latter remaining after mechanical treatment. Mr. McDougall stated that coal washing was generally practised by the operating companies, but in most cases this did not remove more than half of the total sulphur.

A sub-committee consisting of Dr. Porter, Mr. McDougall and Dr. Sexton was appointed to consider this question further, and to report to the main committee such data as might enable them to make a definite recommendation to the Council, if action by that body seemed desirable.

The secretary read a communication from Mr. Morrow, Chairman of the Sub-Committee on Iron Ores, reporting progress in connection with the work being carried on by it during the year, and asking for authorization to prepare a history of the iron industry. After full discussion it was recommended that the balance at the credit of the sub-committee be placed at their disposal for another year, together with a further sum of $600, which it was estimated would be necessary to complete the work outlined.

Mr. Tyrrell mentioned the difficulties encountered by the mining companies operating in the Kirkland Lake district of Ontario, in connection with the treatment of gold ores containing tellurides. He stated that the loss from one of the mills amounted to about $5 per ton, owing chiefly to the insolubility of tellurides in cyanide solution. Attempts had been made to recover this by finer grinding, but so far without success. He also pointed out that the same difficulty would probably be encountered with the extension of mining operations into northern Quebec. Careful scientific research would be necessary in order to solve the problem, and he did not believe this work could be done to advantage at the mines, owing to the lack of trained men who could undertake such an investigation.

A sub-committee consisting of Dr. Porter and Mr. Tyrrell was appointed to consider this problem and report to the main committee as to the advisability of making a recommendation to the Council.

Dr. Sexton reported that a research on oil shales, which had been carried on throughout the year at the Nova Scotia Technical College, had resulted in definite progress being made. A summary report on this research appears on page 47.

The Sub-Committee on Telluride Ores, to which Mr. A. A. Cole, mining engineer for the Timiskaming and Northern Ontario Railway, was subsequently added, made a study of the telluride problem as affecting the companies in the Kirkland Lake district, and recommended by letter to the members of the main

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committee that the investigation should be undertaken at once. One of the managers at Kirkland Lake had expressed his willingness to furnish the Council with ore for the purpose of carrying out a series of experiments. It was suggested that the research should be started at once in the laboratories at McGill University, the National Research Council to provide not more than half of the amount required to finance it, and the university supplying the rest.

Associate Biological Committee

A. The Destruction of Marine Piling by Borers

In Europe and parts of the United States enormous damage has been done to wooden structures in harbours by the shipworm (*Teredo navalis*) and the gribble (*Limnoria lignorum*). Wharves costing millions of dollars have been rendered almost useless within a few years. The damage along the Canadian coast line has not as yet been serious, but it was felt that an effort should be made to secure as much information as possible regarding the life habits of the borers in view of the possibility of greater destruction in future. The United States Government has been carrying out a similar investigation along the coast farther south and the closest co-operation has existed.

For two years the Associate Biological Committee of the National Research Council has been conducting an investigation along the eastern coast. In 1923 a general survey was made of the coast line from the Maine border to the St. Lawrence estuary, and in the year under review this has been supplemented by a more detailed study of the coast of Nova Scotia from Halifax to Sydney. This coast is without railroad facilities and a boat was therefore necessary for the survey, one being loaned by the Biological Board. The gribble was found along the whole coast except in portions of the estuaries, while the shipworm was in most places nearly or altogether absent. The following is a summary of the observations made:—

1. High salinity with low temperature favours the activity of Limnoria.
2. Low salinity with high temperature favours the activity of Teredo.
3. Variations in hydrographic conditions are unfavourable to both borers.
4. Light is an unfavourable factor for Limnoria.
5. Hydrogen-ion concentration is not a significant factor in the distribution of marine borers on the Atlantic coast of Canada.
6. Both borers apparently work in depths greatly exceeding those at which wood is ordinarily used.
7. Bark on piling is an efficient protection from both borers while it lasts.
8. Limnoria protects piling from Teredo, if the latter does not attack too heavily in the first season.

The detailed results of this survey are being published as Report No. 15 by the National Research Council of Canada. A similar report on United States conditions has been issued by the National Research Council of the United States.

B. The Chemistry of Fish Muscle

A knowledge of the character of fish muscle and of its chemical behaviour under the influence of heat is of fundamental importance in the process of curing fish. Nevertheless very little attention has in recent years been given to this subject and such information as was secured by early investigators needs confirmation in the light of modern chemical discoveries. The fundamental problem involved is whether the soluble muscle proteins apart from the gelatin of muscle

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tissue represent several well defined individuals or merely a group of individuals so similar in properties and so labile as to be easily capable of change from one to another.

In this investigation, which was carried out by Dr. J. F. Logan of McGill University, under the auspices of the Associate Biological Committee, an effort was made to determine what factors influence the coagulation and precipitation of fish proteins in order that methods may be worked out for their separation and quantitative determination. It has been discovered that light denatures the proteins found in distilled-water extracts of fish muscle, and alsc those soluble in salt solutions of certain strengths, but not in others. On heating salt solutions of proteins cloudiness followed by coagulation took place at foui different temperatures indicating that at least four different proteins were present. Coagulation due to heat and acid were found to be very closely related. An investigation was therefore started to determine the separate influence of these factors, but as yet this work has been only partly completed. The question of the solubility of proteins in solutions of varying salinity and acidity is also being studied. Interesting results have already been obtained and it is expected that a continuation of the work will throw further light upon this important subject.

III. ANALYSIS OF REPORTS ON ASSISTED RESEARCHES

Many detailed reports have been received during the year of researches carried out both by Associate Committees of the National Research Council and by specialists to whom the Council has made grants for the purchase of apparatus or the securing of technical assistance. Most of these papers have been printed in technical periodicals or in the transactions of technical societies, but to reproduce them in full in this report would be out of the question. In order, therefore, to give a general idea of the work performed, there is presented in this section a short summary of the principal researches conducted during the year under review with a brief explanation of the main problems involved. A complete list of the researches to which financial assistance has been granted will be found in Appendices "B," "C," and "D."

The Inheritance of Sugar and Starch in Corn

It is a well known fact that under the climatic conditions prevailing in Western Canada and Northwestern United States the growing of dent corn is almost impossible. When planted it reverts quickly to the character of flint corn, a definitely inferior variety.

This research has therefore been undertaken to determine whether a strain can be developed which will retain the true dent characteristics. In order to save time and preclude delay through loss of corn, by frost or otherwise, the co-operation of the United States Bureau of Plant Industry has been secured, and all experiments are being duplicated at the Iowa Experiment Station.

Work by other investigators on this problem has depended largely upon the visual examination of the corn produced. A method of quantitative chemical analysis has now been worked out and it is expected that it will be possible to determine much more closely how the inheritance actually takes place. The programme adopted may be outlined as follows:—

I. Selection of standard varieties of dent and sugar corn, to be analysed for starch and sugar content.

II. The quantitative analysis by methods recently developed of both the parental stocks.

III. The isolation by means of quantitative analysis of pure races of the two strains thus selected.

IV. The crossing of strains of dent corn having the maximum possible starch content with sugar corn strains having the maximum sugar content.

V. The analysis of the seed of the first generation of hybrids for starch and sugar content.

VI. The analysis of the second generation of hybrids for starch and sugar to determine the precise manner of the inheritance.

Work of this nature in which a whole season is required to give the results of a single series of experiments will necessarily require some years in order to carry it to a successful issue. Should it be possible, however, to develop even one strain of a superior character, such a result would be of immense value to western Canada.

—*(Investigation under the direction of Professor H. F. Roberts, University of Manitoba.)*

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Cultivation of Drug-Yielding Plants in British Columbia

It has long been realized that the climate of parts of British Columbia is very favourable to the growth of many drug-yielding plants. Some of these, notably the cascara tree, already grow wild there, in fact British Columbia is now one of the principal sources of cascara bark. One drug, however, is not sufficient for the establishment of a manufacturing industry and work has therefore been undertaken to determine whether or not other trees, herbs and plants can be grown to advantage in the province.

The botanical work in connection with this investigation has consisted in the trial of a very large number of drug-yielding plants from other countries, especially Europe. All have been raised from the seed, as the importation of so many plants would not be economically sound, and the results of analysis of species raised under different conditions of soil and climate would not be a reliable guide to the possibilities of plants grown from seed in British Columbia. Certain varieties have been found to germinate poorly and no strong specimens of these have been produced, but it is hoped in such cases to develop strains suited to British Columbian conditions.

The results secured have on the whole been very encouraging. It has been ascertained that not only the bark of the cascara tree, but also its wood, heretofore a waste product, possesses active medicinal properties. The percentage of salicin in native poplars and willows has been ascertained. British Columbian foxglove has been found to be equal or superior in content of the drug digitalin to the best grown elsewhere. Poison hemlock furnishes a heavier crop than in Europe, its native country. Experiments on the growth of certain oil-yielding plants have not yet given conclusive information but will be continued. An effort will also be made to grow Digitalis lutea, which in certain parts of the United States is preferred to Digitalis purpurea, the usual source of digitalin. If the same is found true in British Columbia it will be of much value to those interested in drug farming in the province.

—(Investigation under the direction of Professors J. Davidson and R. H. Clark, University of British Columbia.)

The Drug Content of British Columbian Thorn Apple and Spotted Hemlock

Thorn apple, botanically known as Datura stramonium, grows wild in many parts of British Columbia. The drug obtained from it is used in medicine to relieve the bronchial spasm. It was formerly imported from Germany and Hungary, but is now being cultivated in both England and America. As a part of the investigation of drug-yielding plants in British Columbia this species has received particular attention.

The alkaloids obtained from thorn apple are atropine, hyoscyamine and hyoscine. The relative proportions of these compounds are somewhat variable, but their percentage compares favourably with that of plants grown elsewhere. Both the leaves and seeds of the British Columbian thorn apple have been analysed and found about equally high in alkaloid content.

Spotted or poison hemlock, also called Conium maculatum, is very common in Great Britain, where it grows to a height of two to six feet. In British Columbia, however, its average height is about nine feet, and this extraordinary growth is what first attracted attention to this species. It was therefore particularly gratifying to find that British Columbian spotted hemlock contained a considerably higher percentage of alkaloid than the average found elsewhere. Where growth is so rank it is usually found that plants are correspondingly low in drug content.

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A paper giving analyses of these plants and other detailed information was presented at the Ottawa meeting of the Royal Society of Canada in May, 1925, and aroused favourable comment. There is evidently a great opportunity for British Columbia to become an important source of these two valuable drugs.

—(Investigation under the direction of Professors R. H. Clark and J. Davidson, University of British Columbia.)

Winter Hardiness in Crop Plants

Why do certain kinds of plants winter-kill badly while others are unaffected by low temperatures? Why do certain varieties resist prolonged exposure to winter weather much better than others of the same species? How can one determine the hardiness of a promising new variety of winter wheat without conducting tests over a period of several years? Information which would enable us to answer these questions would be of enormous value to the agricultural industry of Canada, where the very climate which appears to be responsible for the superior quality of our cereals at the same time limits the areas in which they can be grown.

This investigation was therefore undertaken: first, to discover the fundamental nature of frost resistance and thus to place the problem of breeding varieties resistant to winter-killing on a sound scientific basis; second, to develop reliable methods by which the plant breeder may estimate accurately the hardiness of a new strain in one season. This is an instance in which a contribution to pure science may have an immediate value in its application to industry.

It has been held that damage by frost is due to the precipitation of proteins in the plant protoplasms. This can be demonstrated experimentally, but the actual cause of the precipitation has been in doubt. The present investigation has shown that both salting out and influence of acids play a part. A new and very sensitive method of determining the degree and character of this precipitation has been devised, consisting in the microscopic examination of the treated juice on glass slides. When precipitation does occur it is found to be irreversible, that is, the precipitate cannot be redissolved on reversing the conditions. This supports the view that when the freezing of plant tissues proceeds to the extent of causing precipitation of the protein the injury is permanent. The immediate objective then becomes the discovery of the means by which nature in some instances prevents such precipitation even under severe weather conditions. By analysing at progressive dates the juice of the plant as well as the entire tissue it has been possible to study the distribution of the most important constituents between the fluid cell contents and the inert supporting framework. Only the tissue fluids are concerned in physiological activity. Proteins and sugars have been found very important in the tissue fluids of wheat plants. Carbohydrate colloids and fat seem relatively unimportant, although the latter has been found by other workers to accumulate in certain trees during the winter months.

The most important single factor in protecting protoplasmic proteins from precipitation has been found to be sugar. Laboratory experiments have shown that the protection afforded by sugar increases with its concentration, at least within reasonable limits. The naturally occurring sugar concentrations in wheat plants have been studied for a number of years, and it is therefore not surprising to find that in general the hardiest varieties contain the largest amount of sugar throughout the entire winter.

Results already obtained in this investigation may therefore be said to indicate that one of the chief causes of winter hardiness has been discovered. If subsequent work confirms these findings it may be possible by chemical analysis to determine in advance the winter hardiness of varieties being tested.

—(Investigation under the direction of Professor R. Newton, University of Alberta.)

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The Problem of Sex in Mushrooms

The variety of mushroom chosen for this study was that of Coprinus lagopus. The fruit-bodies employed in the investigation were collected from four widely separated points in Canada and from three places in England.

All the strains studied proved to be heterothallic. Both the English and Canadian strains were found to be similar morphologically. It was determined that sex is governed by several factors which operate according to the well-known Mendelial law.

Monosporous mycelia from any individual fruit-body of Coprinus lagopus belong to four sexual groups. Complete fertility results when such mycelia from wild fruit-bodies of different sexual strains are paired together.

Two fruit-bodies from a secondary bisporous mycelium produce spores belonging to but four sexual groups, the same four groups being present in both fruit-bodies. Monosporous mycelia from a first-generation hybrid fruit-body react with the parent mycelia strictly in accordance with the theory of dihybridism. The reduction of sex factors in Coprinus lagopus takes place with the second division of the fusion nucleus resulting in the production of (*a*) basidia with spores of only two kinds, and (*b*) basidia with spores of four kinds. No correlation has been found between the rapidity of germination of spores from individual basidia and the segregation of sex factors. The primary condition of the mycelium was found to be associated with the production of imperfect fruit-bodies bearing spores of only one sex, the sex being identical with that of the parent mycelium; the secondary condition of the mycelium was found to be associated with the production of perfect fruit-bodies bearing spores of the four sexual groups.

Imperfect fruit-bodies were produced by three successive generations of primary mycelia originating from a single spore; fruit-bodies of the first two generations had spores of only one sex, the sex being identical with that of the parent mycelium. The imperfect fruit-bodies which are sometimes produced by secondary mycelia were found to arise, not from primary, but from secondary strands of mycelium. One monosporous mycelium appears to have mutated from the primary to the secondary condition, and in so doing it has given rise to a fruit-body having some spores of a new sexual strain.

—(Investigation under the direction of Professor A. H. Reginald Buller, University of Manitoba. This research was made possible by financial assistance from the Canadian Society of Technical Agriculturists as well as from the National Research Council).

The Physical and Chemical Condition of Evergreen Leaves During the Winter

The leaves of nearly all varieties of trees and plants are killed by the low temperatures encountered during our Canadian winters. A striking exception to this is found in certain varieties of trees, which from their uniform condition the year round we call "evergreen." To what peculiar property do they owe their ability to resist frost? An answer to this question might well shed valuable light upon the general question of winter hardiness in plants.

This investigation was largely carried out in the Edmonton district on varieties of evergreen trees found locally. Amongst those whose winter behaviour was studied were various spruces and pines. In order to observe the effect of a different winter climate, however, observations were also carried out at the Pacific coast, on spruces, pines, firs and red cedar.

The remarkable changes in the shape and position of the chloroplasts have been carefully followed, and observations have been made on these trees kept at green-house temperatures during two successive winters. Experiments with Irving's method have been performed to determine the ability of the chlorophyll apparatus to carry out carbon assimilation in the winter condition, and it has been found that material previously exposed to very low temperatures is capable of carbon assimilation in the laboratory. Further experiments and observations will be made to determine the ability of evergreen leaves to form sugars while still kept at low temperatures.

—(Investigation under the direction of Professor Francis J. Lewis, University of Alberta).

The Action of Inorganic Salts on Plant Cells

The importance of practical agricultural research is now almost everywhere recognized. It has already resulted in advances which have been of the greatest assistance to the industry. Yet it is true that practical problems can in most cases be solved only by an understanding of the fundamental changes taking place in the maintenance of life processes. It is therefore important that the study should be undertaken of all those factors which influence germination, growth, fertilization, ripening, the quality of the product, and resistance to cold, drought and disease.

The researches carried out under this grant have all been of a scientific nature, and all have yielded results which mark a distinct advance in knowledge. While the details of such researches are too technical to be of general interest, it may be noted that six different papers descriptive of them have been published in scientific periodicals, the following general subjects being treated:—

1. The effect of the agents on the physical properties and structure of protoplasm.—Three scientific papers.

2. Penetration of the agents into the cells, and their influence on the rate of penetration.—One paper.

3. The effect on viability of the cells.—One paper.

4. The elasticity of gelatin.—One paper.

—(Investigation under the direction of Professor G. W. Scarth, McGill University).

Insulin-like Substances in Plant Extracts

No other medical discovery ever made in Canada has attracted so much attention all over the world as that of insulin. So many of the so-called discoveries prove of little practical value that it has been particularly gratifying to find in this case that the claims of the discoverers have been fully borne out by the results everywhere obtained in the use of insulin. The mortality from diabetes has fallen off very rapidly and most of those who still have the disease may work and enjoy life once more.

The discovery has now been made that certain plant extracts contain a substance or substances having a physiological action like that of insulin. In view of the great importance of insulin it was considered highly desirable that an investigation should be carried out to determine whether plants might become a commercial source of this extract.

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From a scientific standpoint the results obtained are of great interest in that a substance of the nature of insulin appears to be present in plant as well as animal tissue. While it is not proved it is nevertheless probable that carbohydrate metabolism in the plant world is mediated by insulin-like substances as in the case of the animal world. From a practical standpoint the results have been disappointing. It has been found impossible to obtain a sufficient yield of the insulin-like substances from plant sources to allow of their preparation at a cost at all comparable with that of the preparation of insulin from the pancreas of animals or the principal islets of certain fishes.

—(Investigation under the direction of Professor J. B. Collip, University of Alberta.)

Bacteriology of Haddock

The Maritime Provinces have long been known for their large fishing industry which has supplied both home and foreign markets with a very necessary food as well as furnishing employment to a large number of people. In order that this industry should have the development which its importance merits, it is essential that it be maintained on a sound scientific basis. This refers alike to those conditions necessary for the maintenance of the supply of fish and to the methods of catching and preparation for the market. It is to the last problem that the National Research Council has given most attention. Information of great value to the industry has previously been reported as a result of researches on the discoloration of cod-fish and lobster. The present investigation has been devoted chiefly to a study of haddock fishing and particularly to the determination of the influence of methods of handling upon the bacterial content.

In the course of this investigation methods of handling fish have been observed on the large steam trawlers and on smaller trawlers operating around St. Andrews, New Brunswick, and at some points on the Maine coast. Methods vary greatly. On the larger and more up-to-date boats the fish are carefully cleaned as soon as caught, washed and placed in iced boxes where they are kept until shipment. On other boats, however, the fish are allowed to lie in slime and blood on the bottom of the boat for perhaps an hour pending their delivery on shore. Here they are cleaned, thrown unwashed with pitchforks on scales and then dumped into the hold of another boat. Ice is thrown in with them and they remain here unwashed until carried to the shipping wharves, sometimes as much as twenty-four hours later, the delay depending on the size of the catch. Here they are again pitchforked out, iced and prepared for shipment. Each time the fish are handled with a pitchfork they are punctured by the tines, affording the ever-present bacteria an opportunity to get inside and multiply.

The experimental work carried out was for the purpose of determining the bacterial content of fish handled by different methods. First of all the flesh of eight freshly caught haddock was examined and no bacteria were found. They were then kept for various periods of time at different temperatures and again tested. Those which had been carefully washed and kept at room temperature for six hours showed a bacterial content of about 200 per gram weight, after twenty-four hours up to 4,000 and after thirty-six hours up to 26,000. These tests showed that the number of bacteria was much larger and the rate of increase was much more rapid near the gills of the fish than through the centre and towards the tail. The importance of keeping them at as low a temperature as possible was fully established.

Experiments were then carried out on the freezing of fish. They were kept for various lengths of time, the bacterial content noted, then frozen and again kept for periods of from one day to several months, when the bacterial content

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was once more determined. It was found that the bacteria did not multiply after freezing, in fact the number was usually a little lower after being frozen for some time. This investigation shows conclusively that it is essential to freeze fish as soon as possible after they are caught, and that if properly kept they will not deteriorate.

—(Investigation under the direction of Principal F. C. Harrison, Macdonald College.)

Oil from Shale

The use of oil has greatly increased within the last few years. The widespread adoption of automobiles as a means of locomotion has been responsible for an enormous demand for gasolene. Oil-burning locomotives and steamships have taken a large quantity of crude and fuel oils. The Diesel oil engine after many years of use on a small scale has finally become established as a valuable source of power, particularly in isolated districts, and its use is now being extended to ships and locomotives. Oil fuel when sufficiently cheap to compete with pulverized coal is largely used in chemical and metallurgical industries and is now finding wide application for domestic heating. As a result of these extensive uses nations and large corporations alike are active in trying to secure control of new oil fields.

So great have been the demands on the oil produced and so rapidly have newly discovered fields been exploited that it has been freely predicted that a world shortage of oil would result within twenty-five years. With that possibility in view attention has been drawn to other possible sources of oil. Of these only three appear to be of any great importance, but fortunately for Canada all of them are capable of development in this country. First comes coal, convertible into oil by a hydrogenation process which is now just emerging from the experimental stage in Europe, but has not yet entered that stage in Canada. Second is the great deposit of oil sands in our Canadian Northwest, which is dealt with at greater length under "The Constitution of the Bituminous Tar Sands of Northern Alberta." Third come the deposits of oil shale found in the Maritime Provinces. These are not as extensive as some in the western United States and elsewhere but nevertheless contain sufficient oil to make their thorough investigation highly desirable.

Shales have been worked for oil in Scotland and some other places for many years but commercial success has been achieved only under favourable conditions. Better methods of treatment are urgently needed, in fact the method to be adopted in any particular case depends largely upon the character of the individual shale and that of the contained oil. It is for this reason that some experimental work will have to be done on each deposit before commercial development will be possible.

The preliminary work in this research consisted of a study of several shales in order to bring out their general variations and to afford information on which the construction and development of laboratory apparatus and procedure might be based. The relation between the specific gravity and oil yield of any shale was investigated. While shales from different districts varied greatly, both in specific gravity and oil content, it was found that for those of any one district a curve could be plotted from which the oil yield might be approximately determined by simple specific gravity tests, thus eliminating much tedious and expensive analysis. Three different types of shale retorts were tried but all proved unsuitable and a special one had to be designed. This proved very satisfactory.

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Using this apparatus a long series of experiments was made and for different shales there were determined: the oil, water and gas yields; the temperature to which the shales could be heated for drying purposes without loss of oil; the maximum temperature necessary to distill the oil; the effect of varying distillation speed; the effect of size of crushing on retorting; the distribution of sulphur in the shale and its products; the chemical analysis of spent shale; the results of fractional condensation. The oil yield of some shales exceeded thirty gallons per ton. Practically all the oil distilled between 600 and 900°F. Very rapid runs resulted in more carbon remaining in the spent shale.

When these preliminary experiments had been completed a ten-deck continuous retort of the Hartman type was installed. This had a capacity of 1,300 pounds of shale per twenty-four hours. A few runs showed that fractional condensation was necessary in order to avoid clogging the condenser and this was therefore carried out in all the later tests. A good quantity of oil was obtained and full analytical and treatment tests are to be made.

This large retort was originally built for demonstration purposes and was not entirely suitable for accurate research work. The proprietors of the retort have designed and will shortly construct a new test retort with which the investigation will be continued. This retort will be of two tons daily capacity and will embody all those features which the preliminary work has shown to be desirable.

In this investigation much assistance has been received from Messrs. Newcombe and Winchester, proprietors of the large retort, and their engineer, Mr. Gulick. The co-operation was also secured, and is hereby gratefully acknowledged, of the Imperial Oil Company, the Nova Scotia Tramways and Power Company, The British Empire Steel Company, and Oil and Nitrates, Limited.

—*(Investigation under the direction of Professor A. E. Flynn, Nova Scotia Technical College.)*

The Constitution of the Bituminous Tar Sands of Northern Alberta

Practically the whole of the world's supply of petroleum now comes from oil wells, the greatest production being in the United States. Canada has produced a little oil from Ontario wells, and recent discoveries in Alberta indicate that deposits of some importance may occur there. In the McMurray District of Alberta, however, there exist enormous deposits of tar sands, consisting, for the most part, of clear quartz grains cemented together by petroleum residues called bitumen. The extent of the deposits may be estimated from the fact that outcrops are visible at frequent intervals along the Athabasca river and its tributaries for a distance of more than 220 miles. These outcrops probably represent parts of an almost continuous occurrence, and although the greater part of the area underlain by these bituminous sands may never be of commercial importance it is certain that the district contains one of the world's greatest potential sources of oil.

An investigation of these deposits has been carried on for nearly ten years by the Dominion Department of Mines. This has involved a study of the local geology, the extent of the deposits, their oil content and possible uses both for the natural sands and the products of distillation. As yet, however, but little is known of the chemical constitution of the bitumen, and an investigation of this subject is therefore being undertaken at the University of Alberta under a grant from the National Research Council. While the work is only in its initial stages it may be stated that a detailed study will be made, not only of the sands exposed along the outcrops on the rivers but also of those secured from shafts sunk into deposits previously covered by heavy overburden.

—*(Investigation under the direction of Professor A. Lehmann, University of Alberta.)*

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The Deterioration of Concrete in Alkali Soils

The rapid deterioration of concrete structures in many places in Western Canada has for some years been the cause of grave concern to property owners and engineers. It has been generally believed that damage was caused by the action of alkaline waters in the soil, but it was not known to what constituents of the water or soil such action was due, nor if it could be prevented by any commercially feasible method.

Professor Thorvaldson, of the University of Saskatchewan, began a study of this subject as far back as 1920, and general interest was aroused when a joint investigation was proposed under the Engineering Institute of Canada and the National Research Council. Financial assistance was contributed not only by the National Research Council but by the Governments of Saskatchewan and Alberta, the Canada Cement Company, the Canadian Pacific Railway and the City of Winnipeg.

This investigation, which was begun in 1921, has consisted chiefly of a series of chemical tests, the nature of the deterioration being determined by an extended series of experiments and by careful analyses of corrosive waters and of concrete in various stages of disintegration. Physical examination was made of a great number of concrete structures, test blocks composed of different mixtures were subjected to the action of alkaline waters for several years, these test blocks being periodically inspected, and various surfacing materials were tried for the protection of concrete from chemical action. While such an investigation may to advantage be extended over many years the fundamental problems in connection with the deterioration have now been fairly well worked out.

When Portland cement clinker is treated with water, alkalinity is developed, due to the formation of calcium hydroxide from the calcium silicates, and also, to a smaller extent, by the reaction of water with tricalcium aluminate in the cement. Thus by shaking finely ground cement with a liquid and following the development of alkalinity in the latter it becomes possible to determine the effect of the presence of various substances in solution on the decomposition of the calcium silicates. The principal compounds tested for action on cement were sodium and magnesium sulphates and chlorides, parallel tests being also run with distilled water.

The solvent action of sodium sulphate solutions on lime in cement was found to be more rapid than that of distilled water alone. This is probably due to the fact that pure water quickly becomes saturated with calcium hydrate and further solution can take place only with the concurrent separation of this compound. When sodium or any other soluble sulphate is present the lime reacts with it, forming the slightly soluble calcium sulphate, and thus rendering the solution capable of taking up more lime.

$$Na_2SO_4 + Ca(OH)_2 = CaSO_4 + 2\ NaOH$$

As a matter of fact, the experiments indicate that by long-continued treatment, even with pure water, it may be possible to dissolve all the lime. This indicates the importance of making concrete impermeable even when in contact with pure water.

Magnesium sulphate has the same action as the sodium compound, but it removes lime from the solution even more quickly, at least in the initial stages, on account of the low solubility of both the compounds formed by the reaction.

$$MgSO_4 + Ca(OH)_2 = Mg(OH)_2 + CaSO_4$$

Magnesium hydrate is so insoluble that solutions containing magnesium sulphate or other soluble magnesium salts remain practically neutral, even though lime is being continuously dissolved from the cement. In spite of this action of magnesium compounds their effect on concrete is not much worse than that of the corresponding sodium salts, because the insoluble precipitates tend to fill up the pores of the concrete and retard diffusion of the solutions.

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There is in addition, particularly when structures are subjected to alternate drying and wetting, a marked physical effect of these sulphates. The formation of crystals of the products of chemical action in the pores of the concrete may be accompanied by an increase in volume sufficient to disrupt the whole mass.

Chlorides were found to be of comparatively little importance in the disintegration of concrete. The effect of sodium chloride is certainly not greater than that of the sulphate, and when both salts are present the action is not increased. Calcium chloride actually decreases the solvent action of solutions containing it, as might be expected from the presence of a common ion.

—(Chemical investigation by Professor Thorvaldson, of the University of Saskatchewan, under a committee of the Engineering Institute of Canada (Dean C. J. Mackenzie, Chairman), in co-operation with the National Research Council.)

Rubber

Rubber has been known for several hundred years, but it was little more than a curiosity until the process of vulcanization was invented about 1840. Since the beginning of the present century great advances have been made in the chemistry of rubber, and there has been a corresponding increase in its commercial applications. The world's consumption is now about 1000 per cent greater than twenty-five years ago, and it has been estimated that at the present time over 30,000 different articles are being made either wholly or in part of rubber. But great as is the present rubber industry of the world there is no prospect of a halt in its development. If the chemistry of rubber can be more perfectly worked out further advances in its applications will become possible.

For several years researches on the constitution and treatment of rubber have been in progress in the Department of Chemistry at McGill University. As a result of these researches the nature of rubber resin appears to have been fully determined, and in addition it has been discovered how protein-free rubber can be conveniently prepared.

This last discovery opens up an entirely new field of rubber research, one which it is intended to explore actively during the next two or three years. It has previously been impossible to obtain rubber free from the 2 to 3 per cent of protein which normally accompanies it. Now it becomes possible to investigate the influence of protein on the vulcanization of rubber in all the various commercial processes. The chemically pure rubber hydrocarbon can also be obtained for the first time, and a study will be made of the influence of various additions on its behaviour.

A large oil-bath vulcanizer is to be installed for use in this investigation. There is also available an experimental rubber mill. With this apparatus and the new knowledge already gained it is expected that good progress will be made in vulcanization and other methods of treatment.

—(Investigation under the direction of Professor G. S. Whitby, McGill University.)

The Measurement of Light Affecting Life Processes

It is a matter of common knowledge that most crops require a certain amount of direct sunlight for their normal growth. One often sees in a garden the result of planting corn in the shade of a tree—stunted growth, thin stalks, pale green colour. So also it has long been known that people living under conditions of good sunlight and fresh air were healthier than those confined to

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quarters poorly lighted and ventilated. Life in the open has often been contrasted with that in the crowded tenements of our large cities, yet until recently few have suspected the vital part played by the sun's rays in the maintenance of health.

Since the biological effect of ultra-violet rays was discovered public attention has been drawn to the subject of light. At present it is recognized that light is not only essential to the preservation of good health but may be used to great advantage in the treatment of various diseases. To some extent it may even compensate for the absence of certain vitamines in the diet.

But what is light? To most people it constitutes just that portion of the sun's rays which is visible to the human eye. This includes only that radiation of wave lengths from about 0.0004 mm. (violet) to 0.0007 mm. (red). As a matter of fact the earth is constantly receiving radiation from the sun of wave lengths far outside these limits in both directions. The portion with which the biologist is concerned is that in the range which, at the violet end of the spectrum, has a wave length sufficient to enable it to penetrate the earth's atmosphere, and, at the red end, has an influence upon organisms other than that of a mere heating effect. The wave lengths corresponding to these limits are about 0.0003 mm. and 0.00073 mm., respectively.

The measurement of light of this range is of great importance in biological study, but it is rendered difficult by the fact that light varies in quality as well as in intensity. A photometer of the maximum usefulness must therefore yield data on both the total intensity, and the spectral quality (wave-length) of light, and be at the same time accurate, portable, easy of adjustment and manipulation, adapted for use in air and under water, and give results in percentages.

This investigation has had for its primary object the development of a biological photometer which would meet these requirements. Success has been attained by the construction of an instrument in which plates sensitive to all colours of the spectrum are exposed beneath a series of neutral filters of known transmitting power. Thus if the same result is obtained by equal exposures through filters of 50 per cent and 5 per cent transmitting power in two different locations it follows that the light in the latter is ten times as intense as in the former. It is also possible, through the use of colour filters, to determine the intensity of each kind of light of which the rays are composed, a matter of great importance to the biologist and ecologist. The application of this instrument in field studies has only begun, but already results of great scientific interest are being secured.

—(*Investigation under the direction of Professor A. B. Klugh, Queen's University.*)

Radio Inductive Interference

Perhaps no invention has even been so quickly adopted by the public as that of radio. Placed on the market only a few years ago it now rivals even moving pictures as a source of entertainment, and perhaps is second only to the press as a means of distributing information. So rapidly has the manufacturing radio industry been developed that science has been hard pressed to keep pace with the demands made upon it for improved methods of broadcasting and reception. One of the troubles early experienced was that of inductive interference. Our centres of population have become a vast network of electric wires, and the influence of the current so distributed or of electrical machinery in operation has at times been most unpleasant to radio devotees.

This investigation, which is being conducted by the National Research Council in co-operation with the Radio Branch of the Department of Marine

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and Fisheries, has been carried on simultaneously in the Electrical Laboratories of the University of Toronto and at such outside points as radio interference was found to exist. It was intended to make a thorough scientific study of the nature of electrical surges, but it has been found advisable to first concentrate on the practical methods of locating and suppressing actual cases of interference outside the laboratories.

Among the practical results so far obtained are the following:—

1. The design of portable apparatus for the purpose of tracing interference to its source. The most important unit of this apparatus is the specially designed radio receiver, which indicates the direction of interference. Another instrument has also been constructed for use in special cases, such as in power houses, to locate the source of interference more definitely.

2. Procedure has been worked out in detail to assist radio owners in tracing interference to its source.

3. The means whereby a radio club may assist in reducing inductive interference in its district have been formulated and are now being put into practice by several clubs.

4. Surge traps have been installed to prevent those surges which originate on certain electrical machinery from following along the power wires and radiating to nearby receivers.

An example of this is the case of electrical ozonators which are used for bleaching purposes in flour mills. These ozonators cause electrical surges to travel along the power wires for distances up to one-and-a-half miles, and cause interference to radio receivers in the neighbourhood. With the co-operation of manufacturers, operators and radio users surge traps have been installed in several flour mills which have reduced this interference about 90 per cent.

5. The co-operation has been secured of many power companies, manufacturers and radio dealers for the purpose of dealing with inductive interference throughout Canada.

6. A bulletin based on the preliminary results of this investigation is being issued by the Radio Branch of the Department of Marine and Fisheries and copies may be obtained from that source.

It is proposed to carry this investigation further and make a scientific study of the electrical surges which cause radio inductive interference. It is hoped that improved apparatus may be devised for locating the sources of such interference, and that surge traps may be developed which will more effectively reduce the interference from such sources. Recommendations will also be prepared to the manufacturers of electrical apparatus in order to prevent, where possible, the marketing of apparatus which is liable to cause radio interference.

—(*Investigation under the direction of Professor T. R. Rosebrugh, University of Toronto.*)

Research in the Field of Low Temperatures

(*a*) *Phosphorescence.*

This work involved a study of the spectra produced by the bombardment of certain elements by electrons at very low temperatures. Such bombardment displaces electrons within atoms from their normal orbits, and in falling back to their original position they emit a radiation revealed as lines of definite wave length in the spectrum.

The spectrum of solid nitrogen phosphorescing at the temperature of liquid hydrogen was found to be unique in that it consists of a single wave length, at 5,231 Angström units. In the case of solid argon irradiated by electrons the spectrum was found to consist of two wave lengths 5,300 Å and 4,750 Å.

(*b*) *The Secondary Spectrum of Hydrogen.*

The secondary spectrum of hydrogen has been observed to be much simplified at low temperatures. Results previously obtained have been very difficult to interpret, owing to simultaneous changes in a number of experimental conditions. In this research an attempt has been made to simplify the atomic and molecular processes involved, with the aid of low temperature, so as to obtain the effects due to variation of one condition at a time. A paper on this subject has been presented before the Royal Society of Canada.

(*c*) *A New Type of Metal Vacuum Flask.*

Glass Dewar flasks for the storage of liquid air and hydrogen are necessarily fragile, and there is danger of explosions, due to the sudden breaking of flasks. Metal vacuum flasks are therefore highly desirable. In this investigation flasks have been developed for two different purposes—to store quantities of liquefied gases and to envelop the expansion coil of the hydrogen liquefier. These flasks have almost entirely replaced glass flasks in the cryogenic laboratory of the University of Toronto.

(*d*) *The Origin of the Aurora Green Line.*

For fifty years scientists have discussed the cause of the green line at 5,577.35 Å, a line found in the spectrum of aurorae but until recently not obtained in any laboratory. Professor Végard put forward the theory that this originated in finely divided nitrogen crystallized in the upper atmosphere at a temperature of -252 deg. C. The line was supposed to be emitted by small crystals when bombarded by electrons emitted by the sun.

There is evidence, deduced from a study of meteors, that the temperature at an elevation of 100 kilometres, where the light of aurorae is produced, cannot be nearly so low as that of liquid air. The pressure is probably only a few millimetres of mercury. This investigation was therefore first directed towards a study of electric discharges in rarefied gases and mixtures of gases known to be present in the atmosphere.

In the course of the experiments it was found that with a mixture of helium and oxygen at low pressures a sharp line possessing all the characteristics of the auroral green line appeared at 5,577 Å. This line was not found in the spectrum of either gas by itself. It is attributed to oxygen, the helium probably maintaining the gas in a state which permits it to emit this line under electrical stimulations.

(*e*) *Method of Liquefying Helium.*

Most gases are liquefied by utilizing their property to cool when expanded under reduced pressure. Data given by other investigators indicated that this property held true for helium at the temperature of liquid air. This would be of considerable importance, if true, but a long series of experiments has shown that the cooling effect thus obtained with helium is insufficient for the liquefaction of the gas. It is therefore necessary to revert to the former practice, in which helium is cooled to -252 deg. C. by means of liquid hydrogen. At this temperature there is sufficient cooling effect on expansion, and the liquefaction of helium therefore becomes possible.

—(Investigations under the direction of Professor J. C. McLennan, University of Toronto.)

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Ultra-Sonic Beams

It is common knowledge that the pitch of a musical note increases with the frequency of the vibrations which cause it. When an electric motor is being started one sometimes hears a musical sound of rapidly rising pitch, which at last reaches a point where it is inaudible. The vibrations are still there, but the human ear no longer perceives them. They are "ultra-sonic". In a similar way we have light of wave length so short or so long as to be imperceptible to the eye, when we call it "ultra-violet" or "infra-red," and experiments are showing that the light we cannot see and the sounds we cannot hear are alike productive of very remarkable phenomena.

Research on ultra-sonic waves is only a few years old, and many of their properties are still very imperfectly known. There is found, however, a close relation between these rapid sound waves and the even more rapid waves of light. Thus beams of ultra-sound may be made to travel in straight lines, like light, instead of spreading out in all directions, as does ordinary sound. The nature of these beams is the subject of the present investigation.

The phenomenon of diffraction of ultra-sound waves has been studied in detail. For this they are particularly adapted, being intermediate between those of ordinary sound, which are too long for laboratory investigation, and those of light, which are almost too short. The laws of ultra-sound diffraction may therefore be determined with considerable accuracy and may be usefully applied in a study of light and ordinary sound.

Maxwell showed that a beam of light exerted pressure on objects which it struck and others have proved that the same must be true in the case of sound. In ultra-sonics it has been very easy to measure this. Small particles of dust of low specific gravity, usually in the form of pulverized coal cinders, were dropped into water through which ultra-sonic waves were passing. The dust particles, moved ahead by the force of the waves, were collected as they fell to the bottom, and dried and photographed in place. The results were most instructive.

A method of audibly detecting ultra-sonic beams in water was successfully developed. The excitation of the ultra-sonic generation is electrical, and when the current used is alternating the ultra-sonic waves form pulsating trains. These may be detected by placing in the path of the beam a tube to one end of which a small mica-sided capsule is attached, and to the other the ear tubes of a good stethoscope. This renders possible a detailed study of cross sections of ultra-sonic beams.

The above methods are only qualitative, that is, they reveal the nature of the beam, but do not actually measure its intensity. To obtain quantitative results a delicate torsion pendulum was devised. A disc was suspended from its side at right angles to the beam, the pressure of which caused it to turn, and the angle of twist in the suspending wire gave a measure of the force exerted.

The reflection of ultra-sonic beams was also investigated. The nature of the reflected waves was found to vary greatly with the character of the reflecting material. Steel was discovered to be an almost perfect reflector of ultra-sonic beams in water, rock was moderately good, and ice was about the poorest of all the common materials.

It is altogether likely that the information gained in this scientific research will find numerous practical applications. Some of these are now being studied.

—(Investigation under the direction of Dean R. W. Boyle, University of Alberta.)

Detecting Unseen Objects at Sea

It would be of the utmost importance to navigation if a method could be developed by which the presence of near-by objects could be detected under water, particularly when unfavourable light conditions prevail. Ships travelling in fogs are in danger of collision with each other, with icebergs or other floating objects. They may run against uncharted reefs, even in broad daylight. In time of war the presence of undersea craft of an enemy nation may be entirely unsuspected.

In the discussion of ultra-sonic beams it was mentioned that the reflection of such beams from various surfaces under water had been noted, and some comparative values were given. The facts given there were an indication that ultra-sonic beams might be sent out from vessels at sea, and the reflection of these beams would reveal the presence of solid surfaces within a reasonable distance. This subject was of such importance that it was felt a study of it should be made. There are as yet no results available for publication, but it may be stated that good progress has been achieved and valuable results are expected.

—(Investigation under Dean R. W. Boyle, University of Alberta.)

Electrodeless Discharge in Gases and Vapours

Much information has been obtained regarding the constitution of matter by means of a study of the spectra produced by the different elements. Such spectra have usually been obtained with the elements under examination at very high temperatures. Recently the method has been developed so as to permit of a study of spectra at exceedingly low temperatures, under bombardment by electrons. Another development is the production of spectra by means of electrodeless discharge in gases and vapours. This is the method adopted in the present investigation.

A quartz spectrograph was obtained, quartz being considerably more transparent than glass, also several quartz tubes in which the discharge might be obtained by electromagnetic induction. These tubes were used for the vapours of lithium, tin and other metals.

Two rather surprising results were obtained in the early experiments. One of the tubes containing tin under a high vacuum gave a spectrum of the metal even when cold. As the vapour pressure of the metal under these conditions is exceedingly low it suggests the possibility of extending this study to certain metals not easily vapourized.

In spite of the care taken to secure a practically perfect vacuum in the tubes, all those containing tin showed the lines characteristic of water vapour. The tubes had been washed out with hydrogen to remove oxides, it is true, and there is a possibility that enough hydrogen remained to unite with any oxygen in combination with the tin and thus produce water vapour. This would, however, require a catalytic action of the tin similar to that observed by others for gold and silver. If this supposition is correct it is a fact not previously recorded.

—(Investigation under the direction of Professor J. K. Robertson, Queen's University.)

The Electrical Conductivity of Solutions

The purpose of this investigation was to determine the variations in the conductivity and vapour pressure of thin films of solutions containing highly

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deliquescent salts, with changes in the temperature and concentration. The following objects were kept in view:—

1. The development of a precision electrical hygrometer with which it would be possible to obtain the moisture content of samples of gas to an accuracy of one-tenth of one per cent.

2. The construction of a simple electrical hygrometer suitable for general industrial use.

3. The obtaining of data necessary for the correction of electrolytic formulas in general usage, which do not hold for such concentrated solutions. The accumulation of further information with reference to the theory of electrical conduction in concentrated solutions.

Solutions of deliquescent salts were found to be so sensitive in change of weight, when exposed in the form of thin films, as to indicate any change in the surrounding aqueous vapour pressure with a precision exceeding that of any existing hygrometer. It was also found that the change in concentration of such films could be determined with the greatest precision and speed by measurement of the electrical conductivity.

In order to develop the method further so that quantitative measurements could be made over any ordinary range of conditions it was found necessary to obtain more data about the relations between vapour pressure, concentration, conductivity and temperature of suitable deliquescent solutions than have yet been recorded in available tables. The conductivity and the density of calcium chloride solutions have therefore been measured with great precision over a wide range of concentration and temperature. It is considered that the completed table of results will materially improve the accuracy with which these quantities are at present known, and will form a contribution of merit in tables of physical constants, as well as render possible the continuation of the original program of work.

(Investigation under the direction of Professor A. N. Shaw, McGill University.)

The Senses of Vision, Touch and Taste

It is through the five special senses of vision, hearing, touch, taste, and smell that man receives practically all his information regarding the outside world. To be deprived of any one of them is a great hardship, as well as a serious handicap in almost any profession or occupation. And while there are fortunately but few, comparatively speaking, who are entirely deprived of any of the special senses, it is nevertheless a fact that most people suffer, though often unconsciously, some impairment of one or more.

Yet in spite of the importance of the special senses very little is known of the way in which the sense organs function, and comparatively little research has been done to establish scientific foundations for the various theories which have been advanced. The reason for this doubtless lies in the difficulty of devising any really accurate measure of the efficiency of the sense organs. Qualitative data there have been in abundance, quantitative data have been practically absent.

The great success which has been achieved in this investigation is due primarily to the fact that a method has been devised whereby quantitative results can be obtained. The method, which is fundamentally the same for each of the special senses investigated, consists in determining the rapidity of intermittent impulses when produced at such a rate that they become a continuous sensation. This point may be called that of critical frequency, and it is a study of the variation in critical frequency with changing conditions that has been productive of such remarkable results.

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Vision

This is possibly the most important of all the special senses, and it is the one which has been most fully investigated. Experiments have been carried out not only on ordinary white light but on the various colours as well, and on light from which certain colours were absent. The results have given a surprising amount of information, not only of theoretical but also of the greatest practical interest, being applicable to methods of lighting our homes, public buildings and factories. The eye, as is well known, exhibits a remarkable power of adjusting itself to varying conditions, but the experiments show, nevertheless, the very detrimental effects of feeble illumination, causing excessive fatigue and reducing the sensitiveness of the eyes to light and colour impressions. Artificial lighting has been studied in detail. The light which in quality varies most from daylight, that is, is deficient in certain of the colours which go to make up white, has been found the most injurious to the eyes.

Touch

In measuring the delicacy of the sense of touch the index finger of the right hand was used, this being possibly the most sensitive portion of the body. Some difficulty was at first experienced in finding a proper means of interrupting stimulation of the skin of the finger. It was finally decided to use an air jet. This has the advantages over any solid substance that its pressure can be accurately controlled and measured, that it is elastic and therefore the sensations produced by it do not persist and that the force of the impulse delivered by it is directly proportional to the pressure used, provided the nozzle is kept at a constant distance from the finger. The air stream was interrupted so as to give pulsations of any desired frequency. A strange fact was discovered. On increasing the frequency of the interruptions at any given pressure it was found, as expected, that a point was reached at which the separate impulses were felt as a continuous pressure, but on increasing the speed the impulses again became distinguishable, finally merging at a second critical frequency. By plotting these points for different pressures two distinct curves were found. No adequate explanation of this fact has been suggested, but it is supposed that one represents a superficial, and the other a deep, sensation.

By plotting time values of the critical frequency of percussion against the logarithms of the air pressure the curves become straight lines, conforming to an equation similar to that deduced for the critical frequency of vision.

TASTE

This is probably the first time that the sense of taste has been subjected to quantitative tests. At first sight it seems impossible to subject the sense to rapidly interrupted stimuli, and this would in fact be true if such substances as salt or sugar were used. Success was attained, however, by taking advantage of the fact that an electric current applied to the tongue arouses the sensation of taste. The current may obviously be interrupted as often as desired.

Four curves were obtained which correspond to, and confirm the existence of, four primary tastes,—sweet, salt, sour and bitter. The results conform to a law similar to those observed for the other special senses.

General

As a result of these and other experiments there has been formulated a theory of sensory reflex action, which explains the phenomena observed for each of the special senses so far studied. It may be expressed as follows: An afferent stimulus (one towards the brain) which produces a sensation also

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evokes two reflex efferent effects (from the brain) on the entire sense organ, the resulting condition of enhancement or depression at any point being the measure of the excess of one process over the other.

—(Investigation under the direction of Professor Frank Allen, University of Manitoba.)

Ball Paths in Tube Mills

The tendency in recent metallurgical practice has been definitely towards finer crushing as a preparation for metal recovery. With the widespread adoption of cyanidation in the treatment of gold and silver ores and the rapid development of the oil flotation process in the concentration of sulphides of the base metals there has come a great demand for efficient machinery for fine grinding. Tube mills containing either steel balls or pebbles as the grinding medium have been widely adopted in recent years to do this class of work.

A great deal of discussion has taken place as to the proper design of mills of this type, but most of the discussion has been based on guesswork, for no one really knew what proportion of the crushing was performed by the balls merely sliding over each other as the mill rotated, or how much by balls carried to the top of the mill and falling directly to a point near the bottom. Much light has been thrown upon these points and others by this investigation. By the construction of ball mills with glass ends it has been possible to actually see what happens inside mills of different sizes, rotated at various speeds, and in actual crushing operations. It has been shown that crushing may take place in either of the ways mentioned above, or by a combination of the two, according to the conditions of operation.

But it was not enough to build experimental mills and rotate them in a university laboratory for the benefit of local observers. It was highly desirable that engineers in all parts of the country should be able to study these operations. To make this possible the ultra-speed moving-picture camera was developed, and films were made illustrating the various methods of operation. These films have been exhibited at technical society meetings and mining schools all over America and have aroused the most favourable comment.

During the last year this work has been extended to cover the following:—

1. The effect of using lifters in the lining of ball mills.
2. The behaviour of cubes used instead of balls.
3. The paths of balls in conical mills.

The first film showed clearly the fundamental errors in the use of large lifters, as practised in some of the western mills. The third is really the beginning of a series on the action of the Hardinge mill. Great difficulty was experienced in securing clear films, but success was finally attained. This film showed plainly the segregation that takes place between large and small balls in this type of mill—a point that has been widely discussed but not previously established to the satisfaction of engineers in general.

—(Investigation under the direction of Professors H. E. T. Haultain and F. C. Dyer, University of Toronto.)

Rock Crushing

Crushing is a necessary preliminary to practically every ore-dressing operation. So also crushing is the first step in the treatment of cement rock, calcite, magnesite, feldspar and other non-metallic minerals. In addition to the many millions of tons of ore or rock crushed annually in the above industries there is a great quantity of rock used in building highways throughout the country. Any knowledge which may lead to economies in crushing methods will therefore be of value in many different industries.

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In the present investigation there has been constructed an integrating dynamometer to measure the energy required in crushing. Experiments have been carried out on a large number of ores and under different conditions, in order to determine the methods necessary to secure the maximum crushing efficiency.

During the year under review a series of experiments has been made with rolls and the integrating dynamometer on the very tough taconite ores of the Mesabi Range. Much light has been shed on the peculiar crushing problems of this ore.

With the rolls a series of tests of road materials has been made in conjunction with the Highways Department. It would appear that this apparatus gives a much simpler, quicker and more concordant method than those now used for testing abrasion and resistance. Further work will be conducted by the Highways Department in connection with this problem.

A series of experiments has been made with the rolls and integrating dynamometer to determine the actual efficiency of rock crushing by measuring the heat developed in the process. This shows conclusively that practically all the energy utilized in crushing operations appears in the form of heat. An effort is being made to draw up a complete heat balance sheet.

—(Investigation under the direction of Professor H. E. T. Haultain, University of Toronto).

The Efficiency of Screening

Screening is an essential part of practically every ore-dressing operation. The separation of minerals into classes of different size is the usual preliminary to hydraulic concentration, and the better this classification is done the higher will be the grade of the resultant products.

Screening, however, is not a simple operation, either theoretically or practically. It is influenced by so many factors that it is exceedingly difficult to secure really comparative results on two different ores, and it is no easy matter to so adjust a screen in operation as to secure both efficient separation of sizes and maximum capacity.

The experiments carried out, covering a wide variety of conditions, indicated as follows:—

1. Abrasion of particles of ore on screens is appreciable, but is not in ordinary cases of much importance.
2. There is a definite rate of feed which for each screen will secure maximum efficiency, this being the percentage of material which does pass through to that which theoretically should pass through. This rate of feed, however, varies greatly under different conditions.
3. With increasing speed the capacity of a vibrating screen increases up to a certain limit, without lowering the efficiency.
4. The " blinding " of screens by particles covering the holes or wedging in them is an important factor, especially at low vibrations.
5. The efficiency and capacity of a screen are not greatly interfered with by the presence of a moderate amount of larger material, and may even be improved by very large particles—probably due to less blinding.
6. The efficiency is lowered little by the presence of a small quantity of very fine material.
7. Blinding may be overcome by tapping the screen with a hammer at intervals. This indicates the possibility of designing a screen which will be vibrated gently as at present and will in addition be struck a harder blow at intervals of one or two seconds. This should result in additional capacity.

—(Investigation under the direction of Professor J. B. Porter, McGill University).

FINANCIAL STATEMENT FOR THE FISCAL YEAR ENDING MARCH 31, 1925

RECEIPTS

Appropriation	$ 120,000 00	
Imperial College of Science and Technology Scholarships	900 00	
Refunds	3,897 10	
		$ 124,797 10

EXPENDITURES

Grants in aid of Research	$ 50,972 25	
Fellowships	$ 6,060 00	
Studentships	11,500 00	
Bursaries	21,641 66	
Imperial College Scholarships	900 00	
	$ 40,101 66	
Fees to International Research Council, its Scientific Unions, etc.	599 55	
Library	1,415 18	
Printing	412 25	
Administrative expenses of Associate Committees	798 96	
General administration	1,647 76	
Travelling expenses of members of National Research Council and staff	4,864 39	
Travelling expenses of Associate Committees	2,209 59	
Salaries and honoraria	17,989 17	
	$ 121,010 76	
Refund to Receiver General	3,786 34	
		$ 124,797 10

APPENDIX A

THE RESEARCH COUNCIL ACT

14-15 George V

CHAP. 64

(Assented to 19th July, 1924)

HIS MAJESTY, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:— 1917, c. 20.

1. This Act may be cited as The Research Council Act, 1924. Short title.

2. In this Act, unless the context otherwise requires,— Definitions.

(*a*) "Committee" shall mean the Committee of the Privy Council on Scientific and Industrial Research; Committee.

(*b*) "Chairman" shall mean the Chairman of the Committee of the Privy Council on Scientific and Industrial Research; Chairman.

(*c*) "Council" shall mean the Honorary Advisory Council for Scientific and Industrial Research; Council.

(*d*) "President" shall mean the President of the Honorary Advisory Council for Scientific and Industrial Research. President.

3. There shall be a Council to be called "The Honorary Advisory Council for Scientific and Industrial Research." Advisory Council.

4. (1) The Council shall consist of not more than fifteen members who shall be appointed by the Governor in Council on the recommendation of the Committee. Appointment of Council.

(2) The members of the Council, with the exception of the President, shall hold office for a period of three years, and not less than four members shall retire each year. Provided that of the members first appointed under this Act, not more than five shall each be appointed for a period of three years, not more than five members shall each be appointed for a period of two years, and not more than five members shall each be appointed for a period of one year. Tenure of office.

(3) Any retiring member shall be eligible for re-appointment. Re-appointment.

5. There shall be a President of the Council who shall be appointed by the Governor in Council on the recommendation of the Committee. The President shall be the chief executive officer of the Council and shall have supervision over, and direction of, the work of the Council and of the officers, technical and otherwise, appointed for the purpose of carrying on the work of the Council. He shall receive such salary and be employed for such term of office as the Governor in Council may prescribe, and such salary shall be paid out of the monies provided for the work of the Council. President of the Council.

6. The Council shall have charge of all matters affecting scientific and industrial research in Canada which may be assigned to it by the Committee, and shall also have the duty of advising the Committee on questions of scientific and technological methods affecting the expansion of Canadian industries or the utilization of the natural resources of Canada. Duties of Council.

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Council incorporated.

7. The Council is hereby constituted a body corporate capable of suing and being sued and having the power to acquire money, securities, real estate or property by gift, grant, bequest, donation or otherwise, and of holding lands, tenements, hereditaments, goods, chattels and any other property, movable or immovable, for the purpose of, and subject to, this Act.

Meeting of Council.

8. The Council shall meet at least four times a year in the city of Ottawa on such days as may be fixed by the Council, and may also meet at such other times and places as the Council may deem necessary.

Remuneration.

9. No member of the Council, with the exception of the President, shall receive any payment or emolument for his services, but each member shall receive such payment for travelling and other expenses in connection with the work of the Council as may be approved by the Governor in Council.

Powers of Council.

10. Without thereby limiting the general powers of the Council conferred upon or vested in it by this Act, it is hereby declared that the Council may exercise the following powers namely:—

(*a*) To make by-laws for the conduct of its business;

(*b*) To control and direct the work of the Council through the President, and, in case of the illness, absence or suspension of the President, or in the case of vacancy in the office of President, through an Acting President temporarily appointed by the Council;

(*c*) To undertake in such way as may be deemed advisable—

(i) To promote the utilization of the natural resources of Canada;

(ii) Researches with the object of improving the technical processes and methods used in the industries of Canada, and of discovering processes and methods which may promote the expansion of existing or the development of new industries;

(iii) Researches with the view of utilizing the waste products of said industries;

(iv) The investigation and determination of standards and methods of measurements, including length, volume, weight, mass, capacity, time, heat, light, electricity, magnetism and other forms of energy; and the determination of physical constants and the fundamental properties of matter;

(v) The standardization and certification of the scientific and technical apparatus and instruments for the Government service and for use in the industries of Canada; and the determination of the standards of quality of the materials used in the construction of public works and of the supplies used in the various branches of the Government service;

(vi) The investigation and standardization, at the request of any of the industries of Canada, of the materials which are or may be used in, or of the products of, the industries making such a request;

(vii) Researches, the object of which is to improve conditions in Agriculture;

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(*d*) To have charge of, and direction or supervisions over, the researches which may be undertaken, under conditions to be determined in each case, by or for single industrial firms, or by such organizations or persons, as may desire to avail themselves of the facilities offered for this purpose;

(*e*) To expend such sums of money as may be annually appropriated by Parliament for the work of the Council or which shall have been received by the Council through bequest, donation or otherwise;

(*f*) With the approval of the Committee, to appoint such scientific, technical and other officers as shall be nominated by the President, and to fix the tenure of such appointments, to prescribe the several duties of such officers, and, subject to the approval of the Governor in Council, to fix their remuneration;

(*g*) Subject to the approval of the Chairman, to publish, from time to time, such scientific and technical information as the Council may deem necessary.

Discoveries and inventions control of.

11. (1) All discoveries, inventions and improvements in processes, apparatus or machines, made by a member or any number of members of the technical staff of the Council shall be vested in the Council and shall be made available to the public under such conditions and payment of fees or royalties or otherwise as the Council may determine, subject to the approval of the Governor in Council.

Payment of bonuses and royalties.

(2) The Council, with the approval of the Governor in Council, may pay to its technical officers and to others working under its auspices who have made valuable discoveries, inventions or improvements in processes, apparatus and machines such bonuses or royalties as in its opinion may be warranted.

Audit of expenditures.

12. All the receipts and expenditures of the Council shall be subject to examination and audit by the Auditor General.

President's report.

13. (1) The President shall report annually to the Council upon the progress and efficiency of the work of the Council and as to its requirements, and shall make such recommendations therein as he may deem necessary.

Council's report.

(2) The Council shall, after the conclusion of the fiscal year, make a report to the Committee containing the report of the President to the Council and also containing a statement of the receipts and expenditures of the Council during the preceding fiscal year. Such reports shall be printed and laid before Parliament within fifteen days of the making thereof, or, if Parliament is not then in session, within fifteen days after the commencement of the next session of Parliament.

Repeal.

14. Chapter twenty of the statutes of 1917 is repealed.

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APPENDIX B

Assisted Researches Granted During 1924-25

Subject of Research	Grantee	Where carried on	Amount awarded
			$ cts.
Grain Rust	Associate Committee on Cereal Grain Rust.	Various co-operating labaratories	15,000 00
Tuberculosis	Associate Committee on Tuberculosis Research	Various co-operating laboratories	12,500 00
The Influence of Diet on the Fur and Health of Captive Foxes.	Associate Committee on Nutritional Problems of the Fox Industry.	Research Station, Department of Agriculture, Hull, Que.	2,250 00
The Utilization of Canadian Iron Ores	Sub-Committee on Iron Ores of the Associate Committee on Mining and Metallurgy.	Hamilton, Ont	600 00
Interference in Radio Broadcast Reception.	Prof. T. R. Roseburgh	Department of Electrical Engineering, University of Toronto, Toronto, Ont.	2,000 00
The Lake Agassiz Clay Deposit	Prof. R. C. Wallace	Department of Geology, University of Manitoba, Winnipeg, Man.	500 00
The Nature of Winter Hardiness in Crop Plants.	Dr. R. Newton	Department of Field Husbandry, University of Alberta, Edmonton, Alta.	2,500 00
Life History and Damage Caused by Wireworms.	Prof. E. H. Strickland	Department of Entomology, University of Alberta, Edmonton, Alta.	1,200 00
Colour Vision	Dr. F. Allen	Department of Physics, University of Manitoba, Winnipeg, Man.	1,400 00
Researches in the Field of Low Temperature.	Dr. J. C. McLennan	Department of Physics, University of Toronto, Toronto, Ont.	2,500 00
Oil from Shales	Prof. A. E. Flynn	Department of Mining Engineering, Nova Scotia Technical College, Halifax, N.S.	2,000 00
Grinding Ore in Ball Mills and Rock Crushing in Rolls.	Prof. H. E. T. Haultain	Department of Mining Engineering, University of Toronto, Toronto, Ont.	1,500 00
Bacteria in Frozen Fish	Dr. F. C. Harrison	Macdonald College, Que	1,200 00
The Chemistry of Fish Curing	Dr. A. B. Macallum	Department of Biochemistry, McGill University, Montreal, Que.	1,700 00
The Biological Origin of False Wild Oats.	Prof. J. R. Fryer	Department of Field Husbandry, University of Alberta, Edmonton, Alta.	500 00
An Ecological Study of the Oat Plant	Oswald McConkey	Department of Field Husbandry, Ontario Agricultural College, Guelph, Ont.	250 00
The Onion Maggot	Dr. E. M. DuPorte	Department of Zoology, Macdonald College, Que.	650 00
The Life History and Habits of the Tabanidae (Horseflies).	Prof. A. E. Cameron	Department of Zoology, University of Saskatchewan, Saskatoon, Sask.	1,200 00
Diseases and Enemies of the Oyster	Prof. L. J. Dalbis	Department of Biology, University of Montreal, Montreal, Que.	425 00
The Preparation (Production) of Metallic Barium.	Prof. H. E. Bigelow	Department of Chemistry, Mount Allison University, Sackville, N.B.	125 00
Crystallization of Bicarbonate of Soda	Prof. P. Riou	Department of Chemistry, University of Montreal, Montreal, Que.	300 00
The effect of Light on Life processes	Prof. A. B. Klugh	Department of Biology, Queen's University. Kingston, Ont.	500 00

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APPENDIX C

Additional Researches in Progress during 1924-25 under Grants Previously Awarded

Subject of Research	Grantee	Where carried on
Reforestation Experiments in Cut-over and Burnt-over Lands in New Brunswick.	Associate Committee on New Brunswick Forest Problems..	Forestry Branch, Department of the Interior, Ottawa, and Lands and Mines, Fredericton, N.B.
Best Methods for Obtaining Accurate Results in Testing Varieties, Strains and Treatment of Grains.	Associate Committee on Accurate Plot Work.	Dominion Experimental Farms.
Deterioration of Concrete in Alkali Soils and Waters of Western Canada.	Committee of the Engineering Institute of Canada.	Departments of Chemistry and Engineering, University of Saskatchewan, Saskatoon, Sask.
Chemistry and Bacteriology of Fish Curing..	Associate Biological Committee.	Department of Biochemistry, McGill University, Montreal.
Artificial Propagation of the Sturgeon.....	Associate Biological Committee.	Department of Biology, University of Toronto, Toronto, Ont.
The Destruction of Wooden Piling by Marine Boring Animals.	Associate Biological Committee.	Atlantic Biological Station, St. Andrews, N.B.
The Recovery of Helium from Natural Gas..	Associate Committee on Helium.	Department of Physics, University of Toronto, Toronto, Ont.
Vitamines.....	Associate Food Research Committee.	Laboratory of Food Chemistry, University of Toronto, Ont.
Acidity and Lime Requirements of Soils in Quebec and New Brunswick.	Dr. J. F. Snell.....	Department of Chemistry, Macdonald College, Que.
The Influence of Acid in the Soil on Useful (Nitrogen Fixing) Bacteria.	Dr. F. C. Harrison.....	Macdonald College, Ste. Anne de Bellevue, Que.
Insulin-Like Substances in Plants.....	Dr. J. B. Collip.....	Department of Biochemistry, University of Alberta, Edmonton, Alta.
The Cultivation of Medicinal Plants in British Columbia.	Dr. R. H. Clark and Dr. J. Davidson.	Departments of Chemistry and Botany, University of British Columbia, Vancouver, B.C.
The Resistance of Plants to Low Temperatures.	Dr. F. J. Lewis.....	Department of Botany, University of Alberta, Edmonton, Alta.
The Inheritance of Sugar and Starch in Corn.	Prof. H. F. Roberts.....	Department of Botany, University of Manitoba, Winnipeg, Man.
Fungi.....	Dr. A. H. R. Buller.....	Department of Botany, University of Manitoba, Winnipeg, Man.
Ultra Sonics. (Inaudible Sound Waves).....	Dr. R. W. Boyle.....	Department of Physics, University of Alberta, Edmonton, Alta.
X-Rays.....	Dr. J. A. Gray.....	Department of Physics, McGill University, Montreal, Que.
Fog Signalling.....	Dr. L. V. King.....	Department of Physics, McGill University, Montreal, Que.
The Spectrum of Infra-Red Rays.....	Dr. J. C. McLennan.....	Department of Physics, University of Toronto, Toronto, Ont.
Chemical Reactions at High Pressures.....	Dr. J. C. McLennan.....	Department of Physics, University of Toronto, Toronto, Ont
The Spectrum of Tin.....	Prof. J. K. Robertson.....	Department of Physics, Queen's University, Kingston, Ont.
Conductivity and Vapour Pressure of Salt Solutions.	Dr. A. N. Shaw.....	Department of Physics, McGill University, Montreal, Que.
Surface Energy of Solids.....	Prof. F. M. G. Johnson.....	Department of Chemistry, McGill University, Montreal, Que.
Separation of the Bitumen of the Alberta Tar Sands into its Chemical Constitutients.	Dr. A. Lehmann.....	Department of Chemistry, University of Alberta, Edmonton, Alta.
Power Losses in Dielectrics.....	Dr. H. J. MacLeod.....	Department of Physical and Electrical Engineering, University of Alberta, Edmonton, Alta.
Effect of Fatigue on the Blood.....	Dr. J. J. R. MacLeod.....	Department of Physiology, University of Toronto, Toronto, Ont.
The Food Relations of Certain Minute Organism (Entomostraca) in the Cultivation of Fresh Water Fishes.	Prof. A. B. Klugh.....	Department of Biology, Queen's University, Kingston, Ont.
Channel Interference in Wind Channel Testing.	Prof. J. H. Parkin.....	Department of Mechanical Engineering, University of Toronto, Toronto, Ont.
Laws Governing the Screening of Crushed Ores.	Dr. J. B. Porter.....	Department of Mining Engineering, McGill University, Montreal, Que.
The Corrosion of Iron and Steel in the Soil..	Dr. J. W. Shipley.....	Department of Chemistry, University of Manitoba, Winnipeg, Man.
The Deterioration of Rubber by Oxidation and the Nature of Resin present in Rubber.	Dr. G. S.Whitby.....	Department of Chemistry, McGill, University, Montreal, Que.
Action of Pure Salts on the Structure and Growth of Vegetable Cells.	Prof. G. W. Scarth.....	Department of Botany, McGill University, Montreal, Que.

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APPENDIX D

Assisted Researches Completed prior to 1924-25

Subject of Research	Grantee
The Use of Canadian Oils in Ore Concentration	Dr. J. B. Porter.
The Extraction of Benzine and Toluene (Valuable Liquids) from Coal Gas.	Dr. H. S. Davis.
Nicotine from Tobacco Waste	Arthur D. Hone.
De-Tarring of Gas by Electrical Precipitation	Dr. J. G. Davidson.
Canadian Waste Sulphite Liquor as a Source of Alcohol	Dr. V. K. Krieble.
The Inheritance of Earliness and Lateness in Wheat	Dr. W. P. Thompson.
Reduction of Iron Ores by Gases	Dr. A. Stansfield.
The Action of Ultra-Violet Rays	Prof. L. Bourgoin.
Water Requirements of Crops in Western Soils	E. S. Hopkins.
The Relation of Bacteria to the Quality of Graded Butter	Prof. W. Sadler.
The Properties and Liquifaction of Helium	Dr. J. C. McLennan.
A Method of Smelting Titaniferous Iron Ores	Dr. C. W. Drury and A. F. G. Cadenhead.
The Microscopic Examination of Cement During Hardening	F. M. Dawson.
Surface Tension in Liquids and Emulsions	Dr. J. C. McLennan.
Utilization of Milk Weed	Dr. A. C. Neish.
The Testing of Oil Shales in the Field	Louis Simpson.
Fungi	Dr. A. H. R. Buller.
Constitution of Rubber	Dr. G. S. Whitby.
The Discolouration of Cured Codfish	Dr. F. C. Harrison.
The Discolouration of Canned Lobster	Dr. F. C. Harrison.
The Treatment of Silver-Lead-Zinc Ores	H. Freeman.
Problems of Industrial Fatigue	Associate Committee on Industrial Fatigue.
The Utilization of Peat	Department of Mines.
Causation of Cracks in Concrete Protective Coating on Iron and Steel Structures.	Prof. Peter Gillespie.
Intensity Measurements in Spectra	Prof. J. K. Robertson.
The Bridging of the Gap in the Ether Waves Between those Produced by the Ultra-Violet Light and the So-called X-Rays.	Prof. J. K. Robertson.

APPENDIX E

List of Scholarships Awarded 1924-25

A. FELLOWSHIPS

Grantee	Graduated	Where Held	Subject of Research Work
E. H. Boomer, Ramsay Memorial Fellowship.	B.Sc., University of British Columbia, M.Sc., Ph.D., McGill.	Department of Physical Chemistry, Cavendish Laboratory, Cambridge University, Eng.	Experiments on the chemical activity of helium.
J. H. Mennie.....	B.A., M.A., University of British Columbia B.Sc., Oxford Ph.D., McGill.	Department of Chemistry, McGill University, Montreal.	Vapour densities of substances liquid at ordinary temperature and of two-component systems.
L. A. Munro.....	B.A., M.A., Dalhousie.....	Department of Chemistry, McGill University, Montreal.	The Adsorption of benzene vapour by alumina.
Miss D. E. Newton.....	B.S.A., McGill, M.Sc., McGill	Department of Botany, University of Manitoba, Winnipeg.	Sexuality in the rust fungi and hymenomycetes.

B. STUDENSHIPS

B. S. W. Buffam.....	B.Sc., M.Sc., McGill.....	Department of Geology, McGill University, Montreal.	The geology of Pelzer Claim, Clericy Township.
G. C. Chamberlain.....	B.S.A., Ontario Agricultural College.	Department of Botany, University of Toronto, Toronto.	Some aspects in life history of the apple scab organisms Venturia Inaequalis.
Miss H. D. Chataway..	B.A., B.Sc., M.Sc., Manitoba.	Department of Chemistry, McGill University, Montreal.	The action of sulphur, sulphur halides and other reagents on some unsaturated compounds.
H. R. Chipman.....	B.A., Dalhousie, M.A., Harvard, Ph.D., McGill.	Department of Chemistry, McGill University, Montreal.	The heat of solution for the following salts: Sodium chloride; potassium chloride; potassium bromide and anhydrous sodium bromide.
H. B. Hachey.....	B.S., St. Francis Xavier M.Sc., McGill.	Department of Physics, McGill University, Montreal.	Resonance radiations.
Paul Larose.....	B.Sc., M.Sc., Ph.D., McGill.	Department of Chemistry, McGill University, Montreal.	Diffusion of oxygen through silver.
Miss A. P. Macdougall..	B.A., McMaster, M.A., University of British Columbia.	Department of Biology, University of Toronto, Toronto.	Taxonomy and histology of the Aphididae of British Columbia
J. E. Maynard.....	B.A., B.Sc., M.Sc., Manitoba.	Department of Geology, University of Manitoba, Winnipeg.	The clays of Lake Agassiz (1) their colloidal content (2) their mechanical composition and seasonal character (3) their utilization.
S. R. McDougall.....	B.Sc., M.Sc., University of British Columbia.	Department of Chemistry, McGill University, Montreal.	Ozonization of aerial oxidation products of caoutchouc and other studies revelant to the question of the constitution of caoutchouc.
A. B. McLay.....	B.A., McMaster, M.A., Toronto.	Department of Physics, University of Toronto, Toronto.	The Structure of atoms of various elements.
D. D. Mossman.....	B.Sc., McGill, M.A., Toronto.	Department of Chemistry, University of Toronto, Toronto.	An investigation of the oxidation products of dimethylaniline in the presence of aluminium chloride.
W. W. Thomson.....	B.Sc., M.Sc., McGill.....	Department of Chemistry, McGill University, Montreal.	The preparation and properties of the margarines.
H. A. Dunlop.....	B.A., M.A., University of British Columbia.	Department of Biology, University of Toronto, Toronto.	Resigned.
R. H. F. Manske.....	B.Sc., M.Sc., Queen's.....	Department of Chemistry, Queen's University, Kingston.	Resigned.
D. C. Rose.....	B.Sc., M.Sc., Queen's.....	Department of Physics, McGill University, Montreal.	Resigned.

C. BURSARIES

W. F. Baker.....	B.A., B.Sc., M.Sc., Manitoba.	Department of Geology, University of Manitoba, Winnipeg.	A study of the erosive actions of the Red River; the material carried mechanically and in solution, their bearing in the formation of clays.
P. A. Bérard.....	B.A., Joliette.....	Department of Chemistry, University of Montreal, Montreal.	The rapidity of absorption of gas SO^2 in alkali solutions.
E. G. Bishop.....	B.Sc., M.Sc., McGill.....	Department of Geology, McGill University, Montreal.	Trend lines of the Canadian shield.
L. L. Bolton.....	B.A., M.A., University of British Columbia.	Department of Biology, University of Toronto, Toronto.	The histological structure of the digestive tracts of some Pacific coast fishes.

C. BURSARIES—*Concluded*

Grantee	Graduated	Where Held	Subject of Research Work
Paul Cartier	B.Sc., Ste. Hyacinthe	Department of Chemistry, University of Montreal, Montreal.	The effect of viscosity on the rapidity of absorption of gases.
Edmour Chauret	I. Ch. Montreal	Department of Chemistry, University of Montreal, Montreal.	The influence of hydrogen ion concentration on the coagulation of milk.
N. D. Clare	B.Sc., M.Sc., Manitoba	Department of Chemistry University of Toronto, Toronto.	The supersaturation of water with oxygen.
A. B. de Passillé	B.A.Sc., I.C., Montreal	Department of Chemistry, University of Montreal, Montreal.	On the mixtures of colloidal, organic and mineral solutions.
W. L. Gordon	B.S.A., M.Sc., McGill	Department of Biology, Macdonald College.	Problems in oat rust.
R. S. Jane	B.A.Sc., University of British Columbia, M.Sc., Ph.D., McGill.	Department of Chemistry, McGill University, Montreal.	Some of the colloidal properties of rubber solutions.
E. J. King	B.A., M.A., McMaster	Department of Chemistry, University of Toronto, Toronto.	The synthesis of some new compounds by Friedel and Crafts' reaction, from phthalide and various aromatic hydrocarbons with aluminium chloride as a catalyst.
A. L. Kuehner	B.A., M.A., Queen's	Department of Chemistry, Queen's University, Kingston.	Condensation of aldehydes and ketones with active methylene compounds.
J. E. Machacek	B.S.A., Saskatchewan	Department of Pathology, University of Saskatchewan, Saskatoon.	The Disease known as "the foot-rot of cereals", caused by helminthosporium sativum.
W. M. Martin	B.S.A., Alberta	Department of Plant Biochemistry University of Alberta. Edmonton.	The nature of winter hardiness in crop plants.
G. C. McLachlan	B.A.Sc., M.A.Sc., University of British Columbia.	Department of Mining, University of British Columbia, Vancouver.	Synthetic testing for flotation.
Gerald Molleur	I.C., Montreal	Department of Physics, University of Montreal, Montreal.	The absorption in dielectrics.
M. J. Mulligan	B.A., M.A., Toronto	Department of Chemistry, University of Toronto, Toronto.	Studies in Glass Conductivity.
Miss I. J. Patton	B.A., M.Sc., McGill	Department of Chemistry, McGill University, Montreal.	Absorption of gases by metals.
R. A. Pelletier	B.Sc., M.Sc., McGill	Department of Geology, McGill University, Montreal.	The geology of Mount Royal Heights, Montreal.
R. A. Prosser	B.Sc., Acadia	Department of Chemistry, University of Toronto, Toronto.	Reaction between phthalic-anhydride from benzene and aluminium chloride.
Miss C. E. Robertson	B.Sc., M.Sc., McGill	Department of Chemistry, McGill University, Montreal.	The determination of the conductivities of aqueous solus of sulphur dioxide at various strengths.
Bernard Shaffer	B.A.Sc., M.A.Sc., Toronto	Department of Chemistry, University of Toronto, Toronto.	Investigation on the Chemistry of Rubber.
Christian Sivertz	B.A.Sc., University of British Columbia M.Sc., McGill.	Department of Chemistry, McGill University, Montreal.	A study of the systems Propylene HCl, Propylene HBr, Propylene HCl and HBr with a view to reaction, velocities, coefficient of temperature, molecular compound formation, mechanism of the reaction.
C. W. Small	B.Sc., Acadia, M.A., Toronto.	Department of Chemistry, University of Toronto, Toronto.	Investigation of the catalytic properties of some partially reduced compounds.
H. D. Squires	B.A., University of New Brunswick, M.A., McGill.	Department of Geology, McGill University, Montreal.	Dyke rocks of Mount Royal Tunnel between station 260+04 and 233+99.
C. W. Sweitzer	B.A., M.A., Toronto	Department of Chemistry, University of Toronto, Toronto.	Light scattering in salt solutions.
Kenneth Thomson	B.A., M.A., University of Western Ontario.	Department of Physics, University of Western Ontario, London.	The effect of pressure on the relative intensities of the lines of the Balmer series in the hydrogen spectrum.
A. S. Townshend	B.Sc., M.Sc., Queen's	Department of Chemistry, Queen's University, Kingston.	A study of the reactions of diphenylsuccinic acid and its derivatives.
J. O. Wilhelm	B.Sc., Saskatchewan	Department of Physics, University of Toronto, Toronto.	The crystal structure of solidified gases.
F. H. Yorston	B.Sc., M.Sc., McGill	Department of Chemistry, McGill University, Montreal.	A study of the constituents of Hevea (rubber) resin and serum.
J. F. Smith	B.Sc., Mt. Allison	Department of Economic Biology, University of Toronto, Toronto.	Resigned.
Miss C. M. Urquhart	B.A., University of British Columbia M.A., California.	Department of Chemistry, McGill University, Montreal.	Resigned.

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APPENDIX F

Scholarship Graduates

The following is a complete list of persons who have been enabled to secure special post-graduate training in science under National Research Council Scholarships and who completed their work under these awards prior to 1924-25.

Grantee	University where undergraduate training received	Present occupation
F. B. Adamstone, B.A., M.A., Ph.D.	Toronto	Instructor in Zoology, University of Illinois, Urbana, Ill.
D. S. Ainslie, B.A., M.A.	Toronto	Instructor in Physics, University of Western Ontario, London, Ont.
Miss M. Anderson, B.A., M.Sc.	New Brunswick	No information.
F. M. Archibald, B.Sc.	Acadia	Chemist, Imperial Oil Refineries, Ltd., Sarnia, Ontario.
H. C. Bates, B.A., M.A.	Toronto	Demonstrator and Research Assistant in Physics, University of Toronto, Toronto, Ont.
A. H. Bell, B.A.	Toronto	Geologist, Texas Company, Kansas Division, Wichita, Kansas.
H. P. Bell, B.Sc., M.Sc., M.A., Ph.D.	Dalhousie	Associate Professor of Biology, Dalhousie University, Halifax, N.S.
G. H. Berkeley, B.A., M.A., Ph.D.	Queen's	Pathologist-in-Charge, Dominion Field Laboratory of Plant Pathology, St. Catharines, Ont.
Miss E. L. Bishop, B.A., M.A.	Toronto	Teacher of Mathematics, Collegiate Institute, Picton, Ont.
H. A. Bracndlc, B.A., M.A.	Toronto	Assistant Superintendent, Ames-Holden Tire and Rubber Company, Ltd., Kitchener, Ont.
O. C. Bridgeman, B.A., M.A.	Saskatchewan	No information.
J. W. Burns, B.Sc., M.Sc., F.C.I.C.	New Brunswick	Instructor in Chemistry, University of Western Ontario, London, Ont.
Miss F. M. Cale, B.A., M.A.	Toronto	Married (Mrs. W. C. McQuarrie).
Miss M. L. Clark, B.A., M.A.	Toronto	Teacher of Mathematics, Collegiate Institute, Sarnia, Ont.
R. J. Clark, B.A.	McGill	Demonstrator, Department of Physics, McGill University, Montreal, Que.
Miss L. Corbett, B.A., M.A.	Queen's	Married (Mrs. H. Rowley).
R. G. Corneil, B.Sc., A.C.I.C.	Queen's	No information.
Miss A. E. Dempsey, B.A., M.A.	McMaster	Assistant Chemist, Maple Leaf Milling Company, Port Colborne, Ont.
E. P. Dolan, B.Sc., M.A., M.Sc.	St. Francis Xavier	Deceased.
V. H. Emory, B.A.Sc.	Toronto	Research, Abitibi Power and Paper Co., Iroquois Falls, Ont.
T. S. C. Fawcett, B.A.Sc., M.A.Sc.	Toronto	No information.
R. E. Foerster, B.A., M.A., PhD.	British Columbia	Research, Dominion Government Hatcheries at Cultus Lake, Vedder River Crossing P.O., .B.C.
J. C. Forbes, B.A., M.A., Ph.D.	Saskatchewan	Assistant Director, Atlantic Experimental Station for Fisheries, Biological Board of Canada, Halifax N.S.
H. R. Foreman, B.A., M.A.	Toronto	Assistant Manager, Keith's Refrigeration Co., Ltd., Toronto, Ont.
Miss C. W. Fritz, B.A., M.Sc., Ph.D.	McGill	Timber Pathologist, Forest Products Laboratories, Montreal, Que.
Miss M. A. Fritz, B.A., M.A.	McGill	Geological Survey, Department of Mines, Ottawa, Ont.
W. A. Gale, B.A.Sc., M.Sc.	British Columbia	American Trona Corporation, Trona, Cal.
J. L. F. German, B.A., A.R.C.S.	Montreal	Director, Quebec Testing Laboratories, Rouyn, Que.
B. E. Gilbert, B.A., M.A., Ph.D.	McMaster	Head, Chemical Department of Rhode Island Agricultural Experimental Station, Kingston, R.I.
Miss K. F. Godwin, B.A., M.Sc.	McGill	Married (Mrs. J. W. Pinhey), Holding Philip Carpenter Fellowship in Zoology, McGill University, Montreal, Que.
C. Greaves, B.Sc., M.Sc., Ph.D.	McGill	Junior Chemist in Division of Wood Preservation, Forest Products Laboratories, Montreal, Que.
R. Hamer, B.A., M.A., PhD.	Saskatchewan	Assistant Professor of Physics, University of Pittsburgh, Pittsburgh, Pa.
R. H. Harris, B.A., M.A.	Saskatchewan	Chemist, Quaker Oats Company, Saskatoon, Sask
W. H. Hatcher, B.A., M.Sc., Ph.D.	McGill	Associate Professor of Chemistry, McGill University, Montreal, Que.
E. Hearle, B.S.A., M.Sc.	Toronto	Entomological Branch, Department of Agriculture, Ottawa, Ont.
G. H. Henderson, B.A., B.Sc., M.A., Ph.D.	Dalhousie	Professor of Mathematical Physics, King's College, Dalhousie University, Halifax, N.S.
Paul G. Hiebert, B.A., M.A., M.Sc., Ph.D.	Manitoba	Lecturer in Chemistry, University of Manitoba, Winnipeg, Man.
Miss E. M. Hill, B.A., M.Sc.	McGill	No information.
W. V. Howard, B.A., M.Sc., Ph.D.	McGill	Instructor in Mineralogy and Economic Geology, Williams College, Williamstown, Mass.
H. J. C. Ireton, B.A., M.A.	Toronto	Demonstrator and Research Assistant, Department of Physics, University of Toronto, Toronto, Ont.
A. B. Jackson, B.S.A.	Toronto	Assistant Plant Pathologist, Dominion Laboratory of Plant Pathology, St. Catharines, Ont.

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Grantee	University where undergraduate training received	Present occupation
W. F. James, B.A., M.Sc., Ph.D.	St. Francis Xavier	Associate Geologist, Geological Survey, Department of Mines, Ottawa, Ont.
Miss M. B. Kearney, B.A., M.A.	Toronto	Instructor in Mathematics and Physics, Converse College, Spartanburg, S.C.
K. H. Kingdon, B.A., M.A., Ph.D.	McMaster	Physicist, Research Laboratory, General Electric Co., Schenectady, N.Y.
W. A. Lawrance, B.A., M.A., Ph.D.	McMaster	Stanley Professor of Chemistry, Bates College, Lewiston, Me.
J. F. Lehmann, B.Sc., M.Sc.	Alberta	Holding 1851 Exhibition Scholarship at Cambridge, England.
S. Lehrman, B.A., M.A.	Toronto	No information.
A. H. Leim, B.A., Ph.D.	Toronto	Ichthyologist to Biological Board of Canada, Biological Station, St. Andrews, N.B.
Miss M. Levi, B.A., M.A.	Toronto	Married (Mrs. M. Rotenberg).
F. R. Lorriman, B.A., M.A., Ph.D.	Toronto	Research Chemist, Dye-Stuffs Department, E. I. du Pont de Nemours and Company, Inc., Wilmington, Del.
G. H. W. Lucas, B.A., M.A., Ph.D.	Toronto	Biochemist, Department of Pharmacology, University of Toronto, Toronto, Ont.
A. D. Macallum, B.A. M.Sc., Ph.D.	Toronto	Acting professor of Chemistry, Manitoba Agricultural College, Winnipeg, Man.
D. G. MacGregor, B.A.	Dalhousie	Professor of Physics, Mount Allison University, Sackville, N.B.
C. A. Mackay, B.A., M.A., Ph.D.	Dalhousie	Professor of Physics, University of Saskatchewan, Saskatoon, Sask.
D. J. MacLeod, B.A., M.A.	Queen's	Pathologist-in-charge, Field Laboratory of Plant Pathology, Fredericton, N.B.
R. H. F. Manske, B.Sc., M.Sc.	Queen's	Holding 1851 Exhibition Scholarship in England.
A. W. McCallum, B.Sc.F., M.A.	Toronto	Forest Pathologist, Division of Botany, Department of Agriculture, Ottawa, Ont.
W. H. McCurdy, B.A., M.A., Ph.D.	Dalhousie	Fellow in Physics, Johns Hopkins University, Baltimore, Md.
J. L. McDonald, B.A.	St. Francis Xavier	Harvard Medical School, Cambridge, Mass.
J. W. McKinney, B.Sc., M.Sc., Ph.D.	Alberta	Chemist, Department of Health, Ottawa, Ont.
H. R. McLarty, B.A., M.A.	McMaster	Pathologist-in-charge, Dominion Laboratory of Plant Pathology, Summerland, B.C.
Stuart McLean, B.A., M.A.	McMaster	Experimental Engineer, Lab. of National Lamp Works, General Electric Company, Nela Park, Cleveland, Ohio.
T. C. McMullen, B.A., M.A., Ph.D.	Toronto	Dean, Albert College, Belleville, Ont.
Miss A. I. McPherson, B.A., M.Sc.	McGill	No information.
W. C. McQuarrie, B.A., M.A.	Toronto	Instructor in Physics, Lafayette College, Easton, Pa.
J. A. McRae, M.A., Ph.D., F.I.C.	Queen's	Associate Professor of Chemistry, Queen's University, Kingston, Ont.
John Melville, B.A.Sc., M.A.Sc.	British Columbia	Water Works Department of City of Vancouver, B.C.
Miss B. K. E. Mossop, B.A., M.A., A.A.A.S.	Toronto	Assistant Pathologist, Queen Alexandra Sanatorium, London, Ont.
Miss Irene Mounce, B.A., M.A., M.Sc.	British Columbia	Assistant Plant Pathologist, Experimental Farm, Ottawa, Ont.
Miss M. Newton, B.S.A., M.Sc., Ph.D.	McGill	Plant Pathologist, Dominion Department of Agriculture, Winnipeg, Man.
Miss M. K. O'Brien, B.A., M.A.	Toronto	No information.
H. G. Oddy, B.A., M.A., Ph.D.	McMaster	Lecturer in Chemistry, University of Alberta, Edmonton, Alta.
H. B. O'Heir, B.A., B.Sc., M.Sc.	McGill	Geologist, J. Mackintosh Bell, Keeley Mines, 92 Wellington St., S., Hamilton, Ont.
Miss M. Olding, B.A.	McGill	Married (Mrs. W. R. McClelland).
A. L. Patterson, B.Sc., M.Sc.	McGill	Holding C. E. Moyse Travelling Fellowship of McGill University in London, England.
J. F. Phillips, B.A.Sc., M.A.	Toronto	Teacher, Malvern Collegiate, Toronto, Ont.
H. R. Racicot, B.A.	McMaster	Pathologist-in-charge, Dominion Laboratory of Plant Pathology, Ste. Anne de la Pocatière, Que.
C. D. Reid, B.Sc., M.Sc.	Alberta	Assistant, Department of Physics, Harvard University, Cambridge, Mass.
H. L. Robson, B.Sc., A.C.I.C.	Sask.	Teaching Fellow, University of California, Berkeley, Cal.
D. C. Rose, B.Sc., M.Sc.	Queen's	Holding 1851 Exhibition Scholarship, Cambridge, Eng.
P. V. Rosewarne, B.A., M.A.	McMaster	Chemist-in-charge, Oil Lab. Fuel Testing Station, Department of Mines, Ottawa, Ont.
W. W. E. Ross, B.A.	Toronto	Assistant Magnetician, Meteorological Service, Toronto, Ont.
J. O. G. Sanderson, B.Sc., M.Sc.	Alberta	Assistant Geologist, Yale University, New Haven, Conn.
J. E. Saunders, B.Sc., M.Sc.	McGill	Mining Engineer, South American Gold Areas, Ltd., Sao Bento, E.F.C.B., Minas Geraes, Brazil
D. A. Scott, B.A., M.A.	Toronto	Associate Director, Insulin Division, Connaught Laboratory, University of Toronto, Toronto, Ont.
W. F. Seyer, B.A., M.Sc., Ph.D.	Alberta	Associate Professor of Physical Chemistry, University of British Columbia, Vancouver, B.C.
Miss E. Shanly, B.A., M.Sc.	McGill	Research in Department of Pathology, McGill University, Montreal, Que.
W. W. Shaver, B.A., M.A., Ph.D.	Toronto	No information.
G. M. Shrum, B.A., M.A., Ph.D.	Toronto	Senior Research Fellow, Department of Physics, University of Toronto, Toronto, Ont.

Grantee	University where undergraduate training received	Present occupation
H. G. Smith, B.A., M.A.	Toronto	No information.
Miss J. D. Spier, B.A., M.Sc.	McGill	Biochemical work in Department of Metabolism, Montreal General Hospital, Montreal, Que.
H. N. Stephens, B.A., M.A., Ph.D.	McMaster	Instructor in General Inorganic Chemistry, University of Minnesota, Minneapolis, Minn.
Miss E. M. Taylor, B.A., M.A., Ph.D.	Toronto	No information.
William Ure, B.A.Sc., M.A.Sc.	British Columbia	Teaching fellow in Chemistry, California Institute of Technology, Pasadena, Cal.
W. H. Vining, B.Sc., M.Sc.	Queen's	No information.
O. J. Walker, B.A., M.A., Ph.D.	Saskatchewan	Associate Professor of Chemistry, University of Alberta, Edmonton, Alta.
Miss M. Weinberg, B.A., M.A., M.Sc.	Manitoba	Research Assistant, Department of Physics, University of Manitoba, Winnipeg, Man.
E. F. Whyte, B.A., M.A., Ph.D.	Dalhousie	Assistant Chemist, Department of Health, Halifax, N.S.
D. Wolochow, B.A., M.A., B.Sc.	Saskatchewan	Research, Department of Chemistry, University of Saskatchewan, Saskatoon, Sask.
C. A. H. Wright, B.Sc., M.Sc., Ph.D.	British Columbia	Consolidated Mining and Smelting Company of Canada, Trail, B.C.
K. S. Wyatt, B.A., B.Sc.	Mount Allison	No information.
W. S. Yarwood, B.Sc., M.Sc.	Manitoba	Research Assistant, Department of Geology, University of Minnesota, Minneapolis, Minn.
E. G. Young, B.A., M.Sc., Ph.D.	McGill	Professor of Biochemistry, Dalhousie University, Halifax, N.S.
J. F. T. Young, B.A., M.A., Ph.D.	Toronto	Associate Professor of Physics, University of Manitoba, Winnipeg, Man.

APPENDIX G

Statement of Expenditures to Date

Year	Grants in aid of Research	Scholarships	Library and publication	Administration of Council and Committees	Travelling expenses		Salaries	Total
					Research Council and Staff	Associate Committees		
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
1916–17	163 00	.....	.....	4,104 67	2,630 60	.....	3,256 98	10,155 25
1917–18	8,344 79	5,550 00	1,316 64	7,714 30	6,877 06	698 60	19,610 35	50,111 74
1918–19	19,519 96	7,150 00	1,737 95	4,087 12	3,628 46	2,507 25	22,520 88	61,151 62
1919–20	38,815 24	20,850 00	2,421 87	4,703 44	4,672 33	2,500 99	25,908 55	99,872 42
1920–21	61,731 24	17,700 00	1,874 62	3,117 71	5,297 48	4,627 57	21,057 39	115,406 01
1921–22	24,795 46	38,575 00	3,067 13	9,170 56	4,317 39	3,301 88	19,125 77	102,353 19
1922–23	39,472 79	35,725 00	2,794 47	5,249 91	2,857 78	3,190 94	16,703 76	105,994 65
1923–24	60,854 04	37,830 00	1,642 89	2,853 97	4,281 90	2,762 89	15,091 37	125,317 06
1924–25	50,972 25	40,101 66	1,634 40	3,239 30	4,864 39	2,209 59	17,989 17	121,010 76
Total	304,668 77	203,481 66	16,489 97	44,240 98	39,427 39	21,799 71	161,264 22	791,372 70
Average shown in percentage	38·8%	25·6%	2·0%	5·6%	4·9%	2·8%	20·3%	100%

The above figures represent gross expenditures.
The total net expenditure during fiscal year 1924–25 was $117,113.66.

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APPENDIX H

Publications of the National Research Council

ANNUAL REPORTS

Annual Reports covering the years 1917–18 to date

GENERAL REPORTS

Report Number	Title	Author
1	The Briquetting of Lignites	R. A. Ross, E.E., D.Sc.
2	The Recovery of Vapours from Gases	Harold S. Davis, M.A., Ph.D. and Mary Davidson Davis, B.A.
3	The De-tarring of Gas by Electrical Precipitation.	J. G. Davidson, Ph.D.
4	Nicotine and Tobacco Waste	A. D. Hone, M.A.
5	Canadian Waste Sulphite Liquor as a Source of Alcohol.	V. K. Krieble.
6	An Investigation into the Question of Early Putrefaction of Eviscerated Fish in which the Gills have been left.	L. Gross, M.D.
7	Survey of General Conditions of Industrial Hygiene in Toronto.	The Associate Committee on Industrial Fatigue of the National Research Council.
8	A Method of Smelting Titaniferous Iron Ore	W. M. Goodwin.
9	Food Requirements of the Ranch Fox	G. E. Smith, B.A.Sc.
10	Fuel Saving Possibilities in House Heating	L. M. Arkley and James Govan.
11	The Red Discolouration of Cured Codfish	F. C. Harrison, D.Sc., F.R.S.C., and Miss Margaret E. Kennedy, B.A., M.Sc.
12	The Discolouration, Smut, or Blackening of Canned Lobster.	F. C. Harrison, D.Sc., F.R.S.C., and E. G. Hood, Ph.D.
13	Cultural Criteria for the Distinction of Wood-destroying Fungi.	Miss Clara W. Fritz, B.A., M.Sc.
14	On the Utilization of the Low Grade Iron Ores of Canada.	Sub-Committee on Iron Ores, J. G. Morrow, Chairman.
15	Marine Borers on the Atlantic Coast of Canada.	R. H. M'Gonigle, B.A.

BULLETINS

1	The Need for Industrial Research in Canada	Frank D. Adams, Sc.D., LL.D., F.R.S.
2	Researches on Sound Measurement with reference to the testing of fog signal machinery.	Louis V. King, M.A., D.Sc., F.R.S.C.
3	How to Handle Frozen Fish	E. E. Prince, D.Sc., LL.D.
4	Hints on Frozen Fish	E. E. Prince, D.Sc., LL.D.
5	Science and Industry	Prof. J. C. Fields, Ph.D., F.R.S.
6	Heating of Houses, Coal and Electricity Compared (out of print).	A. S. L. Barnes.
7	The Manufacture of Ethyl-Alcohol from Wood Waste.	G. H. Tomlinson, B.A.
8	Some Problems of the Fox-Raising Industry (out of print).	Andrew Hunter, M.A., M.B., Ch. B. Edin.
9	The Honorary Advisory Council for Scientific and Industrial Research and its Work, A Brief Resume of the Activities of the Council up to 1921.	Frank D. Adams, ScD., LL.D., F.R.S.
10	A Plan for the Development of Industrial Research in Canada.	R. F. Ruttan, B.A., M.D., F.R.S.C.
11	Nitrogen Fixation	Nitrogen Fixation Committee, Prof. J. C. McLennan, Chairman.

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APPENDIX "I"

LISTS OF MEMBERS OF ASSOCIATE COMMITTEES

1924-25

Associate Committee on Cereal Grain Rust

REPRESENTING THE NATIONAL RESEARCH COUNCIL OF CANADA

Dr. H. M. Tory (Joint Chairman)	President, National Research Council and President, University of Alberta, Edmonton, Alta.
Dr. A. H. R. Buller	Professor of Botany, University of Manitoba, Winnipeg, Man.
Dr. W. C. Murray	Member of the National Research Council and President of the University of Saskatchewan, Saskatoon, Sask.
Dr. Robt. Newton	Professor of Plant Biochemistry, University of Alberta, Edmonton, Alta.
Dr. W. P. Thompson	Professor of Biology, University of Saskatchewan, Saskatoon, Sask.
Mr. W. T. G. Wiener	Assistant Professor in Field Husbandry, Manitoba Agricultural College, Winnipeg, Man.

REPRESENTING THE FEDERAL DEPARTMENT OF AGRICULTURE

Dr. J. H. Grisdale (Joint Chairman)	Deputy Minister, Department of Agriculture, Ottawa, Ont.
Mr. E. S. Archibald	Director, Experimental Farms, Department of Agriculture, Ottawa, Ont.
Dr. D. L. Bailey	Plant Pathologist-in-Charge of Plant Pathological Station, Agricultural College, Winnipeg, Man.
Mr. W. P. Fraser	Pathologist-in-Charge, Field Laboratory of Plant Pathology, Federal Department of Agriculture, Saskatoon, Sask.
Mr. H. T. Gussow	Dominion Botanist, Central Experimental Farm, Ottawa, Ont.
Mr. L. H. Newman	Dominion Cerealist, Central Experimental Farm, Ottawa, Ont.

Associate Committee on Tuberculosis

H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S., Joint Chairman	President, National Research Council, Ottawa, Ont.
J. H. Grisdale, B.Agr., D.Sc.A., Joint Chairman	Deputy Minister, Department of Agriculture, Ottawa, Ont.
J. A. Baudouin, M.D., D.P.H.	Professor of Hygiene and Director of School of Applied Social Hygiene, University of Montreal, Montreal, Que.
J. G. FitzGerald, M.D., LL.D., F.R.S., C.	Professor of Hygiene and Preventive Medicine, and Director, Connaught Laboratories, University of Toronto, Toronto, Ont.
George Hilton, V.S.	Veterinary Director General, Department of Agriculture, Ottawa, Ont.
O. Klotz, M.D., C.M.	Professor of Pathology and Bacteriology, University of Toronto, Toronto, Ont.
A. B. Macallum, Ph.D., Sc.D., LL.D., F.R.S.	Professor of Biochemistry, McGill University, Montreal, Que.

Associate Committee on Tuberculosis—Concluded

G. B. Reed, B.Sc., Ph.D.	Professor of Bacteriology, Queen's University, Kingston, Ont.
E. A. Watson, V.S.	Chief Pathologist, Department of Agriculture, Ottawa, Ont.
J. A. Amyot, C.M.G., M.D.	Deputy Minister, Department of Health, Ottawa, Ont.
Arthur Bernier, M.D.	Bacteriologist, Quebec Provincial Bureau of Health, Montreal, Que.
Albert Dauth, M.V.	Secretary, School of Veterinary Medicine, Montreal, Que.
S. Hadwen, D.V.S., F.E.S.	Research Professor of Animal Diseases, University of Saskatchewan, Saskatoon, Sask.
N. MacL. Harris, M.D.	Chief, Laboratory of Hygiene, Department of Health, Ottawa, Ont.
H. W. Hill, M.D., D.P.H.	Professor of Public Health, Bacteriology and Nursing, University of British Columbia and Director of Laboratories, Vancouver General Hospital, Vancouver, B.C.
Odilion Leclerc, M.D.	Professor of Physiology, 82 rue St.-Louis, Quebec, Que.
C. D. McGilvray, M.D.V., D.V.Sc.	Principal, Ontario Veterinary College, Guelph, Ontario.
A. G. Nicholls, M.A., M.D., C.M., D.Sc., F.R.S.C.	Professor of Pathology and Bacteriology, Dalhousie University, Halifax, N.S.
A. C. Rankin, C.M.G., M.D., C.M., D.P.H., M.R.C.S.	Professor of Bacteriology and Hygiene, Director, Provincial Laboratory, and Dean, Faculty of Medicine, University of Alberta, Edmonton, Alta.
J. W. Robertson, C.M.G., LL.D., D.Sc.	Chairman, Canadian Red Cross Society, 474 Wilbrod St., Ottawa, Ont.
A. Savage, B.S.A., D.V.M.	Professor of Animal Pathology, Manitoba Agricultural College, Winnipeg, Man.
P. R. Talbot, V.S., M.D.V.	Provincial Veterinarian, Department of Agriculture, Edmonton, Alta.
A. Vallée, M.D.	Professor of Pathology and Bacteriology, Laval University, Quebec, Que.
R. E. Wodehouse, O.B.E., M.D., D.P.H.	Secretary, Canadian Tuberculosis Association, Plaza Bldg., Ottawa, Ont.

Associate Members

W. A. Dryden, Esq.	Brooklin, Ont.
Geo. H. Hutton, Esq.	Superintendent of Agriculture and Animal Industry, Department of Natural Resources, C.P.R. Company, Calgary, Alta.
P. H. Moore, B.S.A.	Superintendent, Colony Farm, Essondale, B.C.
R. R. Ness, Esq.	Howick, Que.
D. Raymond, Esq.	President, Windsor Hotel, Montreal, Que.
R. A. Wright, Esq.	Drinkwater, Sask.

Associate Committee on Helium

J. C. McLennan, O.B.E., Ph.D., Sc.D., LL.D., F.R.S., Chairman	Professor of Physics and Director of the Physics Laboratory, University of Toronto, Toronto, Ont.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, National Research Council (Ex-officio).

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Associate Committee on Helium—Concluded

R. T. Elworthy, B.Sc.	Chemist, Mines Branch, Department of Mines, Ottawa, Ont.
R. B. Harkness, Esq.	Commissioner of Gas, Department of Mines, Toronto, Ont.
A. S. Mackenzie, Ph.D., D.C.L., LL.D., F.R.S.C.	President, Dalhousie University, Halifax, N.S.
J. McLeish, B.A., F.S.S.	Director, Mines Branch, Department of Mines, Ottawa, Ont.
J. Patterson, M.A., F.R.S.C.	Assistant Director, Meteorological Service, Toronto, Ont.
R. F. Ruttan, B.A., M.D., D.Sc., F.R.S.C.	Professor of Chemistry and Director of the Chemical Laboratories, McGill University, Montreal, Que.
Wing Commander, E. W. Stedman, O.B.E., M.E.I.C.	Assistant Director, Royal Canadian Air Force, Department of National Defence, Ottawa, Ont.

Associate Committee on the Nutritional Problems of the Fox Industry

Andrew Hunter, M.A., B.Sc., M.B., Ch.B., F.R.S.C., Chairman	Professor of Biochemistry, University of Toronto, Toronto, Ont.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, National Research Council (Ex-officio).
V. J. Harding, D.Sc.	Professor of Pathological Chemistry, University of Toronto, Toronto, Ont.
George Hilton, V.S.	Veterinary Director General, Department of Agriculture, Ottawa, Ont.
G. Spencer Melvin, M.D.	Professor of Physiology, Queen's University, Kingston, Ont.
Arthur Vallée, M.D.	Professor of Pathological Anatomy, Laval University, Quebec, Que.
E. A. Watson, V.S.	Chief Pathologist, Biological Laboratory, 41 Cliff Street, Ottawa, Ont.

Associate Committee on New Brunswick Forest Investigations

G. H. Prince, Chairman	Acting Deputy Minister, Department of Lands and Mines, Fredericton, N.B.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, National Research Council, (Ex-officio).
L. S. Webb, Esq.	Acting Provincial Forester, Fredericton, N.B.
D. R. Cameron, B.A., B.Sc.F.	Assistant Director of Forestry, Forestry Branch, Department of the Interior, Ottawa, Ont.
W. M. Robertson, B.Sc.F.	Forestry Branch, Department of the Interior, Ottawa, Ont.

Associate Food Research Committee

A. B. Macallum, M.A., Ph.D., Sc.D., LL.D., F.R.S., Chairman	Professor of Biochemistry, McGill University, Montreal, Que.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, National Research Council (Ex-officio).
Clara C. Benson, Ph.D.	Department of Food Chemistry, University of Toronto, Toronto, Ont.

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Associate Food Research Committee—Concluded

A. T. Cameron, M.A., B.Sc.	Department of Biochemistry, University of Manitoba, Winnipeg, Man.
J. W. Crane, M.B.	Professor and Chief of the Department of Pharmacology, University of Western Ontario, London, Ont.
A. Bruce Macallum, M.A., M.D., Ph.D.	Professor and Chief of the Department of Biochemistry, University of Western Ontario. London, Ont.

Associate Committee on Aeronautical Research

A. S. Eve, M.A., C.B.E., D.Sc., F.R.S.C., F.R.S., Chairman	Director, Department of Physics, McGill University, Montreal, Que.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, National Research Council, (Ex-officio).
R. J. Durley, M.Inst.C.E., M.E.I.C., M. Am.Soc.M.E.	General Secretary, Engineering Institute of Canada, 176 Mansfield St., Montreal, Que.
J. C. McLennan, O.B.E., Ph.D., Sc.D., LL.D., F.R.S.	Professor of Physics and Director of the Physics Laboratory, University of Toronto, Toronto, Ont.
J. H. Parkin, B.A.Sc., M.E., F.R.Ae.S., M.A. S.M.E.	Assistant Professor of Mechanical Engineering, University of Toronto, Toronto, Ont.
Wing Commander E. W. Stedman, O.B.E., M.E.I.C.	Assistant Director, Royal Canadian Air Force, Department of National Defence, Ottawa, Ont.
Commander C. P. Edwards, R.N.C.V.R., A.M.E.I.C.	Director, Radio Telegraph Service, Department of Marine and Fisheries, Ottawa, Ont.

The Following are Associate Members of this Committee

C. Batho, D.Sc., A.M.E.I.C.	Associate Professor of Applied Mechanics and Mathematics, McGill University, Montreal, Que.
R. W. Boyle, M.A., Ph.D., F.R.S.C.	Professor of Physics, University of Alberta, Edmonton, Alta.
Flight Lieut. R. J. Grant	84 Charles St. W., Toronto, Ont.
Louis V. King, M.A., D.Sc., F.R.S.C.	Professor of Physics, McGill University, Montreal, Que.
C. M. McKergow, M.Sc., M.E.I.C.	Professor of Mechanical Engineering, McGill University, Montreal, Que.
John Patterson, M.A., F.R.S.C.	Assistant Director, Meteorological Service, Toronto, Ont.
J. B. Porter, E.M., Ph.D., Sc.D., M.Inst. C.E., M.E.I.C.	Professor of Mining Engineering, McGill University, Montreal, Que.
C. A. Robb, B.Sc., M.Sc., A.M.E.I.C.	Professor of Mechanical Engineering, University of Alberta, Edmonton, Alta.
Stanley Smith, M.A., B.Sc.	Lecturer in Physics, University of Alberta, Edmonton, Alta.
Sir Frederick Stupart, F.R.S.C.	Superintendent and Director, Meteorological Service, Toronto, Ont.
W. R. Turnbull, M.E., F.R.Ae.S., (F.R. Met.S.)	Consulting Engineer, Rothesay, N.B.

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Associate Committee on Accurate Plot Work in Agricultural Research

J. H. Grisdale, B.Agr. D.Sc.A., Chairman	Deputy Minister, Department of Agriculture, Ottawa, Ont.
L. H. Newman, B.S.A., Secretary	Experimental Farms Branch, Ottawa, Ont.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, National Research Council, (Ex-officio).
E. S. Archibald, B.A., B.S.A.	Director of Experimental Farms, Ottawa, Ont.
P. A. Boving, Cand. Ph., Cand. Agr.	Professor of Agronomy, University of British Columbia, Vancouver, B.C.
Manley Champlin, M.S.A.	Professor of Field Husbandry, University of Saskatchewan, Saskatoon, Sask.
A. T. Charron, M.A., D.Sc.	Director, Dairy School, Ste. Hyacinthe, Que.
J. A. Clark, B.S.A.	Superintendent, Experimental Station, Charlottetown, P.E.I.
T. J. Harrison, B.S.A.	Professor of Field Husbandry, University of Manitoba, Winnipeg, Man.
Dr. C. A. Langelier	Superintendent, Experimental Station, Cap Rouge, Que.
G. P. McRostie, M.A., Ph.D.	Dominion Agrostologist, Central Experimental Farm, Ottawa, Ont.
Robt. Newton, B.S.A., M.Sc., Ph.D.	Professor of Plant Biochemistry, University of Alberta, Edmonton, Alta.
Robt. Summerby, M.S.A.	Cerealist, Macdonald College, Que.
M. J. Tinline, B.S.A.	Superintendent, Experimental Station, Brandon, Man.
C. A. Zavitz, B.S.A., D.Sc.	Professor of Field Husbandry, Ontario Agricultural College, Guelph, Ont.

Members of the Associate Committee of Chemists

R. F. Ruttan, B.A., M.D., D.Sc., F.R.S.C., Chairman	Director, Department of Chemistry, McGill University, Montreal, Que.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, National Research Council, (Ex-officio).
E. H. Archibald, B.Sc., A.M., Ph.D.	Professor of Chemistry, University of British Columbia, Vancouver, B.C.
J. S. Bates, Ch.E., Ph.D., A.M.E.I.C.	Chief Chemist, The Bathurst Company, Bathurst, N.B.
F. J. Birchard, M.A., Ph.D.	Research Chemist, Dominion Grain Laboratory, Winnipeg, Man.
Maitland C. Boswell, B.A.Sc., Ph.D.	Faculty of Applied Science, University of Toronto, Toronto, Ont.
Alfred Burton, Esq.	Middlesex Mills, London, Ont.
Paul Cardinaux, D.Sc.	Professor of Inorganic Chemistry, Laval University, Quebec, Que.
T. Linsey Crossley, A.M.E.I.C., F.C.I.C.	208 King Street West, Toronto, Ont.
A. G. Fleming, B.A., F.C.I.C.	Chief Chemist, Canada Cement Co., Ltd., Phillips Square, Montreal, Que.
Horace Freeman, F.C.I.C.	Canada Carbide Company, Shawinigan Falls, Quebec.
H. G. Girvin, Esq.	Chief Chemist, Steel Company of Canada, Hamilton, Ont.
L. F. Goodwin, Ph.D., F.I.C., F.C.S., A.C.G.I.	Professor of Chemistry, Queen's University, Kingston, Ont.
A. E. Macintyre, Ph.D.	Explosives Division, Department of Mines, Ottawa, Ont.
A. R. M. MacLean, B.Sc., M.Sc., Ph.D.	J. T. Donald & Co., 40 Belmont St., Montreal, Que.
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inserted between
P. 512 & 513.

OTTAWA, February 18, 1925.

The Hon. THOS. A. LOW,
Chairman, Sub-Committee of the Privy Council on
Scientific and Industrial Research,
Ottawa.

SIR,—I have the honour of presenting to you the report of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1924.

As required by the Research Council Act, it consists of two parts, the report of the President, and a statement of the receipts and expenditures of the Council during the preceding fiscal year.

Your obedient servant,

H. M. TORY,
President of the Honorary Advisory Council
for Scientific and Industrial Research.

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W. T. MacClement, M.A., B.Sc., D.Sc.	Professor of Botany, Queen's University, Kingston, Ont.
J. P. McMurrich, M.A., Ph.D., LL.D., F.R.S.C.	Professor of Anatomy, University of Toronto, Toronto, Ont.
E. E. Prince, B.A., LL.D., F.R.S.C.	Dominion Commissioner of Fisheries, Department of Marine and Fisheries, Ottawa, Ont.

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ASSOCIATE COMMITTEE ON INDUSTRIAL FATIGUE, 1923-24

J. J. R. Macleod, M.B., Ch.B., D.P.H., F.R.S.C., Chairman	Professor of Physiology, University of Toronto, Toronto, Ont.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, Research Council of Canada (Ex-officio).
E. A. Bott, M.A., Ph.D., Honorary Secretary	Associate Professor of Psychology, University of Toronto, Toronto, Ont.
Mrs. Geo. Hambleton, M.A	511 Gilmour St., Ottawa, Ont.
John Lowe, Jr	Representative of Canadian Manufacturers' Association, Montreal Cottons, Ltd., Valleyfield, Que.
A. B. Macallum, Ph.D., Sc.D., LL.D., F.R.S.	Professor of Biochemistry, McGill University, Montreal, Que.
J. A. McClelland	Representative of Trades and Labour Congress, 113 Coronation Building, Montreal, Que.

THE BRITISH COLUMBIA ADVISORY COMMITTEE, 1923-24

J. M. Turnbull, B.A.Sc., Chairman	Professor of Mining and Metallurgy and Head of Department of Metallurgy, University of British Columbia, Vancouver, B.C.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, Research Council of Canada (Ex-officio).
Judson F. Clark, M.A., Ph.D.	Forest Engineer, 420-424 Vancouver Block, Vancouver, B.C.
C. McLean Fraser, M.A., Ph.D., F.R.S.C.	Curator, Biological Station, Nanaimo, B.C.
George Kidd	General Manager, British Columbia Electric Railway Co., Vancouver, B.C.
L. S. Klinck, M.S.A., D.Sc.	President, University of British Columbia, Vancouver, B.C.
H. R. MacMillan, B.S.A., M.F.	President, The H. R. MacMillan Timber Export Co., Vancouver, B.C.
P. H. Moore, B.S.A.	Superintendent, Colony Farm, (British Columbia Government Farm), Easondale, B.C.
J. S. Raphael, B.Sc.	1236-13th Ave. W., Vancouver, B.C.
R. H. Stewart, B.Sc.	Consulting Mining Engineer, 736 Granville St., Vancouver, B.C.
Campbell Sweeny	Vancouver, B.C.
James J. Warren	Manager, Consolidated Mining and Smelting Co. of Canada, Trail, B.C.
Horace Freeman, F.C.I.C.	567 Hornby St., Vancouver, B.C.

THE FOLLOWING CONSTITUTE THE EXECUTIVE COMMITTEE OF THE BRITISH COLUMBIA ADVISORY COMMITTEE.

J. M. Turnbull, B.A.Sc., Chairman	Professor of Mining and Metallurgy and Head of the Department of Metallurgy, University of British Columbia, Vancouver, B.C.
Horace Freeman, F.C.I.C., Secretary	567 Hornby St., Vancouver, B.C.
C. McLean Fraser, M.A., Ph.D., F.R.S.C.	Curator, Biological Station, Nanaimo, B.C.
H. R. MacMillan, B.S.A., M.F.	President, the H. R. MacMillan Timber Export Co., Vancouver, B.C.

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ASSOCIATE COMMITTEE ON THE NUTRITIONAL PROBLEMS OF THE FOX INDUSTRY, 1923-24

Andrew Hunter, M.A., B.Sc., M.B., Ch.B., F.R.S.C., Chairman	Professor of Biochemistry, University of Toronto, Toronto, Ont.
H. M Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S	President, Research Council of Canada (Ex-officio).
V. J. Harding, D.Sc	Professor of Pathological Chemistry, University of Toronto, Toronto, Ont.
George Hilton, V.S	Veterinary Director General, Department of Agriculture, Ottawa, Ont.
G. Spencer Melvin, M.D	Professor of Physiology, Queen's University, Kingston, Ont.
Arthur Vallée, M.D	Professor of Pathological Anatomy, Laval University, Quebec City, Que.
E. A. Watson, V.S	Chief Pathologist, Biological Laboratory, Dept. of Agriculture, 41 Cliff St., Ottawa, Ont.

ASSOCIATE COMMITTEE ON PACIFIC INVESTIGATIONS, 1923-24

J. P. McMurrich, M.A., Ph.D., LL.D., F.R.S.C., Chairman	University of Toronto	Biology.
C. McLean Fraser, M.A., Ph.D., F.R.S.C., Secretary	University of British Columbia	Biology.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, Research Council of Canada (Ex-officio)	
R. W. Brock, M.A., LL.D., F.G.S., F.R.S.C	University of British Columbia	Geology.
Chas. Camsell, B.Sc., LL.D	Deputy Minister of Mines, Ottawa, Ont	Geology.
J. S. Plaskett, B.A., D.Sc., F.R.S.C	Dominion Astrophysical Observatory, Victoria, B.C	Astronomy and Allied Sciences.
Sir Frederick Stupart, F.R.S.C.	Meteorological Office, Toronto, Ont	Meteorology and Allied Sciences.
Arthur Willey, M.A., D.Sc., F.R.S	McGill University	Biology.

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ASSOCIATE COMMITTEE ON ACCURATE METHODS FOR DETERMINING YIELD OF GRAIN, 1923-24

J. H. Grisdale, B. Agr., D.Sc., Chairman	Deputy Minister, Department of Agriculture, Ottawa, Ont.
L. H. Newman, B.S.A., Secretary	Experimental Farms Branch, Ottawa, Ont.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, Research Council of Canada (Ex-officio).
E. S. Archibald, B.A., B.S.A.	Director of Experimental Farms, Ottawa, Ont.
P. A. Boving, Cand. Ph., Cand. Agr.	Professor of Agronomy, University of British Columbia, Vancouver, B.C.
Manley Champlin, M.S.A.	Professor of Field Husbandry, University of Saskatchewan, Saskatoon, Sask.
A. T. Charron, M.A., D.Sc.	Director, Dairy School, Ste. Hyacinthe, Que.
J. A. Clark, B.S.A.	Superintendent, Experimental Station, Charlottetown, P.E.I.
T. J. Harrison, B.S.A.	Professor of Field Husbandry, University of Manitoba, Winnipeg, Man.
Dr. G. A. Langelier	Superintendent, Experimental Station, Cap Rouge, Que.
G. P. McRostie, M.A., Ph.D.	Dominion Agrostologist, Central Experimental Farm, Ottawa, Ont.
Robert Newton, B.S.A., M.Sc., Ph.D.	Department of Plant Biochemistry, University of Alberta, Edmonton, Alta.
Robt. Summerby, M.S.A.	Cerealist, Macdonald College, Macdonald College, Que.
M. J. Tinline, B.S.A.	Superintendent, Experimental Station, Scott, Sask.
C. A. Zavitz, B.S.A., D.Sc.	Professor of Field Husbandry, Ontario Agricultural College, Guelph, Ont.

ASSOCIATE COMMITTEE ON NEW BRUNSWICK FOREST PROBLEMS, 1923-24

Col. T. G. Loggie, Chairman	Deputy Minister, Department Lands and Mines, Fredericton, N.B.
H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S.	President, Research Council of Canada (Ex-officio).
G. H. Prince, Secretary	Provincial Forester, Fredericton, N.B.
D. R. Cameron, B.A., B.Sc.F.	Forestry Branch, Department of Interior, Ottawa, Ont.
W. G. Wright, B.Sc.F.	Forestry Branch, Department of Interior, Ottawa, Ont.

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REPORT

OF THE

HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

I. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL

The Council met six times during the year with an average attendance of seven members, one meeting being held in Montreal, one in Toronto and four in the office of the Council at Ottawa.

The members of the Research Council hold office for a period of three years, a certain number retiring from office each year. During the year 1923-24, the following members automatically retired from the Council: Sir George Garneau, Dr. W. L. Goodwin, Dr. A. B. Macallum and Mr. Arthur Surveyer.

Dr. Goodwin and Mr. Surveyer, owing to their inability to devote the necessary time to the work of the Council, expressed the desire to retire from membership and to succeed them Prof. A. L. Clark, Dean of Faculty of Applied Science, Queen's University, Kingston, and Prof. Augustin Frigon, Dean, Ecole Polytechnique, Montreal, and General Director of Technical Education in the province of Quebec, were appointed members of the Council. Sir George Garneau and Dr. Macallum were reappointed for a further term of three years. The present members of the Council will be found on page 6.

During the year, Dr. Frank D. Adams, who had rendered such conspicuous service as Administrative Chairman for nearly two years, retired from that position and Dr. H. M. Tory, President of the University of Alberta, was appointed to fill the vacancy.

It is deemed advisable to call attention to the extent to which the activities of the Research Council are carried on by persons who, without receiving any remuneration for their services, give generously of their time and experience in furthering the work of the Council, because they are convinced that the programme of the Council affords them an opportunity to make a very definite contribution toward industrial and national progress in Canada. During the year under review, in addition to the small administrative staff maintained by the Council at its headquarters at Ottawa, there were two hundred and eighty-seven persons serving under the auspices of the Research Council in some capacity. Of this number, one hundred and twenty-two men, prominent in their respective professions or in the business world, served on Associate and Advisory Committees appointed by the Council; thirty-three holding responsible positions on the staffs of the scientific departments of Canadian universities, co-operated in supervising the work of those in receipt of Fellowships, Studentships and Bursaries; while forty-eight other persons with special scientific qualifications assisted the Council in carrying out approved researches toward which the Council had granted financial assistance.

Therefore, during the year 1923-24, in addition to the eleven members of the Council, there were two hundred and three trained scientists who, without remuneration, were actively engaged in furthering the work of the Council.

Besides the above, there were also at work under the auspices of the Council, in the scientific departments of various Canadian universities, forty-five carefully selected university graduates, many of them with several years' research experience, as the holders of Fellowships, Studentships and Bursaries awarded by the Research Council.

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Finally, twenty-five persons were engaged as research assistants, working under the auspices of highly qualified experts on research problems, toward which financial assistance had been granted by the Council.

The foregoing statement is made to show to what a large degree the activities of the Council are dependent upon the goodwill and co-operation of men trained in science and industry. It seems, however, not unfair to others who have assisted, to point out that the work of the Council would be impossible but for the willingness of the scientific leaders in our universities and colleges to undertake, without compensation, the solution of special problems and the training of the men who are to be the researchers of the future. The universities and colleges in turn have benefited by the fact that the Studentships, Fellowships and Bursaries awarded by the Council have opened the way for a practical development of their laboratory system.

1. Assisted Researches

Since the inauguration of the Council, grants have been made to sixty-six different researches: of these twenty were completed before the beginning of the year 1923-24. Forty-six researches therefore were in progress during the year under review to which assistance was granted by the Council: these were being carried on in twelve departments of science at nine of our leading universities. Eleven of these investigations were conducted in departments of physics, seven in departments of chemistry, six in departments of botany, five in each of the departments of biology and mining, three in departments of biochemistry, two in each of the departments of physiology, electrical engineering and general engineering and one in each of the following departments: forestry, bacteriology and mechanical engineering.

The total amount of the grants awarded for these investigations was $155,620.54. A considerable part of this total was, of course, granted in previous years, the researches not having yet been completed. During the year under review, there was paid, out of the total appropriation of $120,000, for assisted researches, $59,392.66, nearly 50 per cent of the total grant. During the seven years in which the Council has been in existence, $252,032.21 has been expended in these special researches, approximately 40 per cent of the total expenditure to date. A list of the investigations completed and of those under way will be found on pages 61 and 62.

A review of special reports on these investigations received during the year will be found on page 23.

Of the forty-six investigations being carried on, it will be seen that progress reports are available on nineteen of them.

It is respectfully submitted that while investigations of a purely scientific character can be carried on advantageously in the universities and colleges, special investigations of a more purely industrial nature cannot be so dealt with. Until laboratory accommodation is made available to the Council for the purpose of these special industrial investigations, the Council is labouring under a very severe handicap. It is true that some industrial establishments are of such a magnitude that they can undertake research in their own laboratories, but, generally speaking, this is not true of Canadian industry. Research therefore of this kind remains to a considerable extent impossible, until the long-felt want of laboratory accommodation is provided.

2. Training Research Workers

The method followed by the Council in previous years for the training of researchers was continued, during the year covered by this report, viz., the granting of Bursaries, Studentships and Fellowships. This system has come to be recognized all over the civilized world as sound in principle and effective in practice in that it brings the possibility of continued study and research

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training to those whose previous achievement in study has shown them to be specially fitted for research work by removing the handicap of material circumstances. As an illustration of this, there is made available through the various agencies granting scholarships in the United States, over 2,000 such scholarships to promising students. Fortunately for Canadian students many of these are made available to them. Unfortunately, however, for us, we have not the facilities either in funds or laboratories to hold them for our own work.

During the year 1923-24, twelve Fellowships, eight Studentships and twenty-five Bursaries were granted by the Council. The work is being done in eight of the universities of Canada with the co-operation of nineteen different university departments. Awards were made in all of the departments authorized under the regulations of the Council. The total grants made for the year was $37,830, approximately one-third of the total expenditure of the Council. A list of the subjects taken for research with details concerning them will be found on page 59.

It might be interesting by way of review to point out that during the seven years since the inauguration of the Council ending with March 31, 1924, seventy-seven Bursaries, eighty-two Studentships, and forty-two Fellowships have been awarded. These 201 awards were held by 117 persons at eighteen universities and in twenty-four departments of science. Sixty-eight members of the scientific staffs of the universities co-operated in supervising the work carried out by the holders of these awards.

According to returns furnished to the Research Council, 224 scientific papers have been published by these grantees. One hundred and seven of the persons concerned secured the degree of M.A., of M.Sc., and thirty-four proceeded to the doctorate. Of the one hundred and seventeen grantees, fourteen had their awards renewed for the year 1923-24. The Research Council has therefore during the past seven years contributed one hundred and three trained investigators to the various branches of science and research. Of the above number fifty-seven held a Bursary, Studentship or Fellowship for one year only, thirty-seven for two years and twenty-three for three years. These figures point to the fact that there is still a great dearth of specially trained men in scientific research in Canada and emphasizes the necessity for maintaining a steady supply for our schools, universities and industries.

It is of special interest to note the present occupation of the one hundred and three grantees who have finished the training which they proposed to take under these awards: twenty-one are continuing their studies, some of them having received scholarships from other sources and others having gone to foreign universities. Twenty-nine persons are engaged in the teaching profession, twenty-three having accepted positions in large universities where they will have an opportunity of continuing their scientific training, of doing research work themselves and of assisting in the training of other men. Seventeen are employed in the industries of the country, sixteen having accepted positions in the technical branches of the federal and provincial Governments. Only fifteen have accepted positions in foreign countries. All the others, so far as we have been able to get information, are living in Canada with the exception of a few who are continuing their studies in the United States or in England.

It would appear from this record that the initial purpose in the minds of the Government and the Council, when this scheme was inaugurated, that of training men for Canadian service, has been realized.

On page 57 will be found a complete list of the names of those who have been trained and of their present occupations. It will be seen at once how broadly representative their occupations are at the moment in relation to the intellectual and industrial life of the country.

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The following is a tabulated statement showing the number of Fellowships, Studentships and Bursaries given in each of the years since these awards were instituted, with the expenditure represented by the same:—

Years	Fellowships	Studentships	Bursaries	Expenditure	Additional awards resigned		
					Fellowships	Studentships	Bursaries
				$ cts.			
1917–18	3	4	.....	5,550 00	.....	2	
1918–19	3	5	.....	7,150 00	1	4	
1919–20	5	16	5	20,100 00	1	3	2
1920–21	5	10	8	16,925 00	3	3	7
1921–22	7	9	28	37,725 00	.....	6	7
1922–23	3	22	13	34,975 00	.....	5	7
1923–24	12	8	25	37,548 89	1	3	3
	38	74	79	159,973 89	.....	.....	

3. Publications

In addition to the annual report published each year there have been published under the authority of the Council, since its inception, fourteen general reports and eleven bulletins. A number of papers are now in process of preparation for publication. Reference to these individually is made later in this report. These are in addition to the 224 scientific papers mentioned above as being produced by workers through the agency of the Council.

4. Expenditure

From time to time the Research Council has been criticized in uninformed quarters for the manner in which its funds have been expended, and many absurd assertions have been made regarding expenditures on travelling expenses, etc.

In the seven years during which the Council has been in existence, including the first years when the process of organization was taking place, during which administration expenses were, of necessity, proportionately greater than expenditures on research, the percentage of expenditure under the various items was as follows:—

	%
Assisted researches	39·2
Fellowships, Studentships and Bursaries	42·9
Library and printing of seientific publieations	3·1
Travelling expenses—	
(a) Research Counеil	4·7
(b) Assoeiate and Advisory Committees	3·2
Salaries	20·2
Other administrative expenses	4·7

It is respectfully suggested that comment on these figures is unnecessary.

It might be pointed out that the amount of money spent by the Council in productive research through its grants to assisted researches and its Fellowships, Studentships and Bursaries represents only a small portion of the money actually expended in research work. If the time of those directing research and to whom no compensation is paid was taken into consideration as well as the overhead charges of laboratories and equipment in the universities, it would be apparent at once that the grants made by the Council constitute but a small portion of the total service which the Council is causing to be rendered to science.

5. Special Activities During the Year 1923-24

Nitrogen Fixation

For several years past, a Committee of the Research Council, under the chairmanship of Prof. J. C. McLennan of the Department of Physics of the University of Toronto, has been studying the question of nitrogen fixation and, from time to time, this committee presented very complete and valuable reports to the Research Council dealing with this subject. A summary of these reports has recently been compiled and published by the Research Council as its Bulletin No. 11, under the title "Nitrogen Fixation." The conclusions which have been arrived at as a result of these reports will be found in Appendix "L."

Industrial Alcohol

The Committee of the Research Council on Industrial Alcohol has continued its activities during 1923-24. The committee is of the opinion that it is both desirable and necessary that there should be greater freedom in the denaturing of alcohol for industrial purposes in Canada.

Fuel

The Research Council has during the year under review given a great deal of consideration to the question of fuel through its special Committee on this subject. This committee has worked in close co-operation with the Dominion Fuel Board, of which Dr. Charles Camsell is chairman. It is perhaps worth mentioning one investigation on this subject. The Research Council was requested by prominent citizens of the province of New Brunswick to undertake an investigation on the utilization of New Brunswick coals. In order to meet this request, the Research Council arranged with the Dominion Fuel Board to have such an investigation carried out in the laboratories and by the expert staff of the latter organization and, as a result of this investigation, it has been found that New Brunswick coal has the best coking value of any coal tested by the board.

Utilization of Flax Straw

Several years ago, the Research Council arranged with the Bureau of Standards at Washington to undertake a thorough investigation on the possibilities of utilizing cut flax straw as papermaking material. The purpose of this investigation was to demonstrate that the straw of flax grown for seed, when cut in the ordinary way, could be utilized as papermaking material. Owing to unforseen circumstances which arose at the Bureau of Standards, it was not possible to make as rapid progress in connection with this investigation as had at first been hoped, but it has now been brought to a conclusion and the report of this research was published in the paper, "Trade Journal," in August, 1923, under the title of "Seed Flax Straw as Papermaking Material." The summary of the report is as follows:—

"The tests in which the sulphate pulping process was used, indicate that:—

(1) A fair quality of wrapping paper can be made from whole seed flax straw.
(2) A good quality of writing paper can be made from seed flax tow, provided especial care is taken to eliminate specks.
(3) Pulp prepared from seed flax tow can be readily bleached.
(4) The chemical consumption for the preparation of pulp from the whole straw is about double that required for wood.
(5) The chemical consumption for the pulping of a good quality of seed flax tow is only slightly in excess of that required for wood.
(6) At the present time, it is not economically feasible to use seed flax fibre for the making of paper of any description, using the sulphate cooking process."

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Pan-Pacific Science Congress

During the year under review, a meeting of the Pan-Pacific Science Congress was held in Australia and the Research Council of Canada was represented at this meeting by Prof. J. P. McMurrich, Director of the Anatomical Department at the University of Toronto and Prof. McLean Fraser, Head of the Department of Zoology at the University of British Columbia. As was natural, the interests of the congress centered about Australian affairs and so far as the more northerly nations, such as Japan, and, especially, Canada are concerned, the proceedings of the congress yielded only incidental results. The Canadian delegates took part in the work of the discussion of various sections of the congress, but the chief result of the participation of Canada was the very strong feeling which was aroused that the Dominion appreciated the importance of the congress and was desirous of co-operating in the fulfillment of its purpose. For this reason alone, the participation of Canada in the congress was well worth while. The next meeting of the congress is to be held in Japan in 1926, and it is probable that on this occasion the problems of the north Pacific will receive greater attention. A copy of the report presented to the Research Council by Professor McMurrich will be found in Appendix "J."

Publication of Scientific Papers in Canada

The Research Council during the year under review has given a great deal of attention to the question of the publication of scientific papers in Canada, and a committee of the Council has been appointed to enquire thoroughly into this problem in conjunction with similar committees appointed by the Royal Society of Canada and the Universities Conference. Several meetings of the various committees have been held and some progress has been made, and it is to be hoped that a satisfactory solution of this problem will be achieved in the near future.

Catalogue of Scientific Periodicals

Acting on a suggestion from its Associate Committee of Chemists, the Research Council about the beginning of the year under review, decided to undertake the compilation and publication of a catalogue of scientific periodicals found in Canadian libraries on the subjects of chemistry and physics. As a result of a questionnaire sent to Canadian libraries, it was ascertained that the library at McGill University was already engaged in the compilation of a more complete catalogue of all of the scientific periodicals, available in every important library in Canada. Consequently, on receipt of assurance from the librarian of McGill University that, if the Research Council would assist the larger scheme financially, it would be possible to promptly complete and publish their catalogue, the Research Council decided to abandon its original plans and, instead, it granted financial assistance for the publication of the larger catalogue. By the end of the year under review, very considerable progress had been made and it was then expected that the catalogue would be ready for distribution within a few weeks. It is hoped that this may be the basis for the systematic development of a central scientific library for Canada to which all research workers may have access.

Patent Regulations

Another question which has received attention by the Research Council during the year under review is the change made at the last session of Parliament with respect to the Canadian patent regulations, especially those affecting chemical patents. Representations on this question were made to the Research Council and Dr. Ruttan was instructed, as chairman of the Associate Committee of Chemists, to inquire into the matter on behalf of the Council, with the result that he presented a complete report, which may be found on page 48 of the Proceedings of the 56th meeting of the Council.

The International Research Council and its Unions

The Research Council of Canada maintains Canada's membership in the International Research Council, which has headquarters at Brussels, thereby entitling Canada to be represented in any of the scientific unions affiliated with the International Research Council. Canadian committees of each of the various international scientific unions which have been established to date in Canada have been organized by your Council. The policy in this matter has been to act as an organizing agency bringing committees into existence upon proper request or upon the necessity therefor becoming evident. The Council has also provided the fees of each committee for the first year of its existence on the understanding that each committee will make arrangements to stand on its own feet financially thereafter.

During the year under review, the Research Council received requests to organize two such committees in Canada in connection with the International Mathematical Union and the International Union of Pure and Applied Physics. Acting on these requests the Research Council established Canadian committees in each of the above unions and, in accordance with the usual practice, provided the membership fee payable during the first year of existence of the committees. In addition to the above committees, the Council had previously established Canadian committees in the following scientific unions of the International Research Council: The International Union of Pure and Applied Chemistry; the International Astronomical Union; and the International Union of Geodesy and Geophysics.

6. Co-operation with Various Departments of the Federal Government

It has always been the policy of the Research Council to co-operate in every possible way with the various departments of the federal Government and to avoid duplication of effort. The Research Council is not a body acting in antagonism to the Government departments, where research work is done, but is intended to be a co-ordinating agency for the purpose of the promotion and development of research wherever possible throughout the whole of Canada and, to this end, to co-operate with and assist scientific divisions of the Government service in every possible way in furthering the work which they are in a position to undertake.

As an indication of the activities of the Research Council in this regard, the following specific examples of co-operation with Government departments may be mentioned.

Department of Agriculture

The Research Council has been in constant communication with the federal Department of Agriculture regarding problems in agricultural research which require solution and, in a number of cases, has undertaken investigations jointly with that department. Three such investigations may be mentioned, viz: (*a*) an investigation on the nutritional problems of the fox-breeding industry; (*b*) an investigation to determine the best methods for obtaining accurate results in testing varieties, strains and treatments of grains; and (*c*) an investigation of the wheat rust problem.

Customs and Excise Department

The Research Council has co-operated with the Department of Customs and Excise in connection with the determination of the various grades of industrial alcohol to be manufactured in Canada, and also in connection with other problems of a similar nature.

Department of the Interior, Forestry Branch

(*a*) Shortly after it was established, the Research Council made arrangements for the reservation of a part of the Petawawa Military Reserve as a forest

experiment station and made a grant for four consecutive years for the purpose of carrying out a forest survey of this area and for the starting of research work in connection therewith. The Council secured the co-operation of the Forestry Branch of the Department of the Interior and the above work was carried out entirely under the officers of that branch and financed by the Research Council. After the investigation had been in progress for four years, the Forestry Branch was in a position to continue the investigation under its own auspices and the Research Council, therefore, withdrew from this work.

(*b*) At the present time, in co-operation with the Dominion Forestry Branch and the Forest Service of the province of New Brunswick, the Research Council is investigating the possibility of reseeding certain burned-over and cut-over areas in New Brunswick.

Mines Department

The Research Council has been in close and constant touch with the officials of the Department of Mines in connection with problems relating to the mining industry, particularly with reference to the solution of the fuel problem in Canada.

Marine and Fisheries Department

(*a*) At the request of the department, the Research Council has undertaken an investigation of the interference with radio broadcast reception.

(*b*) The Research Council has also on several occasions secured the co-operation of the Department of Marine in connection with researches having for their object the improvement of equipment and conditions in navigation.

(*c*) The Research Council has been in constant touch with the Fisheries Division of the department and with the Biological Board of Canada, which operates under the department, in connection with problems relating to the fish industry. The report of the valuable results obtained by Dr. Harrison, while working under the auspices of the Council, in connection with the lobster packing industry, was distributed to the industry through the co-operation of officers of the department and by its fisheries inspectors.

National Defence Department

The Research Council, through its Associate Air Research Committee, is in constant co-operation with the technical officers of the Air Service of the department, and practically all of the research work undertaken by the Air Service has been carried out under the auspices of the committee, the expenditure, in the majority of cases, being met by the Air Board.

In addition to the specific examples quoted above, there are many other instances, which might be cited, where the Research Council has co-operated with various divisions of federal Government departments. The above examples, however, will probably be sufficient to show conclusively that it has been both the policy and the practice of the Council to seek the closest possible co-operation on all occasions and the fact cannot be successfully denied that, if there has been any lack of co-operation, the fault has not been on the part of the Research Council.

It cannot be fairly contended that the Research Council has, during the past seven years, shown any inclination to *unduly* expand its activities. It has in several instances initiated important investigations and when they have been firmly established, the Research Council has voluntarily withdrawn, leaving them in the hands of the departments as soon as the latter were in a position to assume responsibility therefor. The following three examples may be quoted by way of illustration: (*a*) the Petawawa forestry investigation, which the Research Council initiated and financed for four years and subse-

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quently turned over completely to the Dominion Forest Service; (*b*) an investigation of the problems relating to industrial fatigue, which was commenced before the Department of Health was established, but, subsequently, was voluntarily turned over to the latter department; (*c*) an investigation on the utilization of low-grade lignites, which the Council recommended should be undertaken by an independent body.

II. ANALYSIS OF RESEARCH REPORTS

In this section of the report will be found a discussion in a general way of reports received during the year on researches now being carried on. An effort has been made to set out in concise form the purpose of the investigation and to indicate what progress has been made.

1. Increasing Nitrogen in the Soil

The fertility of the soil is to a large extent dependent upon the amount of nitrogen which it contains. To increase that nitrogen and maintain it at high level is a difficult problem, particularly in view of the common practice of disposing of the crops year after year without the addition of fertilizer of any kind.

Bacteria have the power of increasing the nitrogen in the soil by securing it from the air and "fixing" it in easily assimilable compounds. Some soils are nearly free from such bacteria, and consequently from nitrogen. Bacteria could be introduced into these soils in an effort to increase their fertility, but first it is necessary to determine whether or not they will propagate in the presence of acid, always found under such conditions. The present study has been directed particularly to azotobacter, the class of bacteria which, assisted by the oxygen of the air, performs the final conversion of nitrogen into nitrates, in which form it is most readily assimilated by plants. The well-known beneficial action of lime on certain soils is no doubt due mainly to the neutralization of the contained acid and if the proper application of lime or other cheap chemicals be carried out on a truly scientific basis it will mean millions of dollars added to the annual crop value of the country.

There were obtained sixty-four samples of Quebec soil, all of which were tested for acidity (hydrogen ion concentration), azotobacter and phosphates, the last named being required because in their entire absence the growth of azotobacter would be impossible. The soils which were neutral or only slightly acid nearly all showed the presence of many azotobacter, as determined by the culture method. Azotobacter were absent in most of the very acid soils. The influence of phosphates was also clearly seen, their presence in quantity greatly increasing azotobacter growth. The minimum quantity of phosphates in soil in which azotobacter would develop was determined in a series of experiments.

A number of soils containing very few azotobacter were neutralized, phosphated and otherwise treated to see if the azotobacter growth under favourable conditions would be satisfactory. This showed beyond question that bacterial growth is rapid when the soils have received proper treatment.

Three soils were then tested in a long series of experiments, two of the soils being good average samples while the third was decidedly acid. The good soils were so acidified and the poor soils so neutralized as to secure for each a range of varying acidity, the hydrogen ion concentration being measured in every case by electrometric and colorimetric methods, while the plate-count method was used for azotobacter instead of the culture method of the former experiments. It was found that with a hydrogen ion concentration of 7.0 (neutrality of pure water) azotobacter growth was from 3-6 times that with a concentration of 6.0 and 35-70 times that with a concentration of 5.0. It is worthy of

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note, however, that the neutralization of the acid soils produced a condition under which azotobacter multiplied rapidly, showing that while the latter would not increase in acid soil they were nevertheless present in an active state and capable of developing when conditions became favourable. It was also observed that the presence of organic matter increased the toleration of the soils for acid. Another series of experiments showed that the nitrogen content of the soils increased roughly in proportion to the azotobacter present, though the existence of other influencing factors was recognized.

Nature has provided countless millions of these minute organisms, which will, if given proper attention, labor tirelessly to increase the nitrogen in the soil, and thus augment the agricultural production of the country. It is therefore of the greatest importance that the farmer acquaint himself with the conditions most favourable to their growth and activity.

—(Investigation under Dr. Harrison, Macdonald College.)

2. Acidity and Lime Requirement Studies upon Quebec Soils

Soil acidity, common in humid countries, is very prevalent in Quebec, to the soils of which province this investigation was confined. Its presence is often revealed in the type of plant growth—daisy, paintbrush, sheepsorrel, etc. Many of our important crops, however, require lime for their highest development. This fact is closely related to the presence and growth of certain nitrogen-fixing bacteria made the subject of a separate research by Principal Harrison. Lime also performs useful service in rendering heavy soils more porous and acting as a plant food. It is important, therefore, that its proper application be studied thoroughly. The present research deals largely with the various methods suggested for determining the amount required on acid soils, a problem complicated by the great variation in soil composition.

Previous investigators in Quebec and New Brunswick have found 80-95 per cent of the soils acid, as shown by litmus test and methyl-orange titration (Hutchinson-MacLennan method). These tests and several others were investigated as to reliability. Litmus was found to give a rough idea of the acidity but to vary according to the methods of manufacture, while the results obtained depend to a considerable extent on the judgment of the observer. The Hutchinson-MacLennan method gave low results throughout for lime requirements, being considered unreliable compared with those that follow. The Jones method for lime requirement (titration with phenolphthalein of a calcium acetate leach solution) is fairly good, but fails to provide for the buffer effect of soluble salts. Soils given the amount of lime called for by the Jones test still showed a lime requirement when subsequently examined, as did all soils up to those slightly alkaline. A colorimetric method of determining the hydrogen ion concentration gave good results, checking with the electrometric method, using a hydrogen electrode. Soils neutralized according to these tests proved subsequently to be practically neutral in every case. Of the fifty samples of Quebec soil tested by both these methods two reacted slightly alkaline, three neutral and the rest acid. It is evident from this research that only actual hydrogen ion concentration indicates the true acidity of the soil and gives a reliable guide to the lime requirements. It is gratifying to know that two satisfactory methods have been found for its determination. The indiscriminate application of lime would be a serious mistake, even though Quebec soils may be generally acid, but its intelligent use following careful examination of the soil is to be strongly recommended.

—(Investigation under Prof. J. F. Snell, Macdonald College.)

3. The Destruction of Marine Piling by Borers

In 1919 and 1920 shipworms caused damage amounting to over $15,000,000 to docks and wharves in the upper part of San Francisco Bay. The damage

caused by these borers at more northerly points along both the Atlantic and Pacific coasts, while not so serious as in warmer waters, was nevertheless of such magnitude as to constitute a menace to marine structures along the coasts. In the United States, a nation-wide research programme was instituted in an endeavour to cope with this problem and the Research Council of Canada was invited to co-operate in this work. Consideration of this question convinced the Research Council that so far as Canada is concerned the first step should be a thorough survey of the Atlantic and Pacific coasts to determine the extent and distribution of these borers. When this information has been secured, it will be possible to determine what further action it may be necessary to take in order to protect Canadian wharves from the ravages of these pests.

During the season under review a survey was made of the Atlantic coast line from the international boundary in New Brunswick to Port-aux-Basques, Newfoundland, and Levis, Quebec. Piles were examined by inspection at low tide and by means of the "hydroscrope," an instrument designed for this work. The vertical distribution of pile borers was observed and samples of water were taken in each case, these being examined for salinity, hydrogen ion concentration and temperature.

The gribble (Limnoria) was found to be widely distributed, being most active where the salinity was high. It was entirely absent in some cases of low salinity. The ship-worm (Teredo) was absent or rare in most places, being commonest where the temperature was high and the salinity low. Up to the present there has been no great destruction anywhere, although this variety of ship borer is the one which has caused enormous damage in north-western Europe and some parts of the United States.

—(*Investigation by the Associate Biological Committee of the Research Council, carried out under direct supervision of Prof. A. G. Huntsman, Atlantic Biological Station, St. Andrews, N.B.*)

4. The Chemistry and Bacteriology of Fish Curing

The curing of fish has in Canada developed into an important industry, but it is nevertheless true that very little is known of the chemistry and bacteriology of the subject, although upon a knowledge of these the future progress of the industry must be based. Fish muscle is so different from that of the mammals that the many investigations which have been made of the latter have to be used with great caution in interpreting the observed facts in fish curing.

In beginning this research determinations were made of the protein, total solids and ash of fish muscle, and a series of experiments was performed on the coagulation temperature of the contained protein. This is of great importance in the industry because of its bearing on the artificial drying and smoking of fish. Analyses were made of five samples of salt used by the fishermen in the Maritime Provinces, the best proving to be a Nova Scotia product.

The experiments outlined above are only preliminary to a thorough investigation of the subject of fish curing, the latter being now in progress.

—(*Investigation under the Associate Biological Committee of the Research Council carried out by Dr. J. F. Logan, McGill University.*)

5. The Artificial Propagation of Sturgeon

Canada is threatened with the extinction of the sturgeon in the comparatively near future if artificial methods of propagation of this valuable fish are not worked out. Previous to the initiation of this investigation very little had been done in Canada even to study the habits of the sturgeon, and this work therefore involved the acquiring of information regarding its distribution, food, etc., as well as the more difficult problem of artificial propagation.

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Most of the work in the summer of 1922 was performed in the vicinity of Lake Nipigon, sturgeon having formerly been very common in Sturgeon river and other streams flowing into the lake. The fish were found to be very scarce, but after a great deal of effort eggs were secured, fertilized, and then rushed as fast as possible to the hatchery at Port Arthur. In spite of the observance of all precautions none of these eggs hatched. In the season of 1923, therefore, a small hatchery was taken to the scene of operations, being first tested with the eggs of pickerel, which it hatched successfully. Sturgeon eggs were then secured, after much difficulty, but for some unaccountable reason they spoiled, as in the previous season. Mr. R. L. Barney, Director of the Fairport Biological Station, has been engaged in similar work, but with no better success in propagation.

While the artificial propagation of sturgeon did not prove successful in these attempts a great deal of information was obtained regarding the habits of the fish, its food at various periods of life, its rate of growth and the age at which it reaches maturity. This information has been published by the Ontario Fisheries Research Laboratory, and will be of great value in the prosecution of further work along these lines.

—(Investigation under Associate Biological Committee of Research Council carried out by W. J. K. Harkness, Department of Zoology, University of Alberta.)

6. Reforestation in New Brunswick

The pulp and paper and lumbering industries, together with forest fires, are making serious inroads on our forest areas, great though these may be. Europe has for years given serious attention to the question of reforestation, and it has even been predicted that Canada would at some future time be importing forest products from the very countries which are buying from her now. To forestall such a possibility Canada must bend her efforts towards conserving the splendid forests which now exist and undertaking reforestation of the large areas suitable for the purpose. The Research Council has enlisted the co-operation of both the Forestry Branch of the Department of the Interior and the Department of Lands and Mines in the province of New Brunswick, in a three-year reseeding programme in that province. In the year under review the field work consisted in the reseeding of burned-over lands, forty acres having been planted in the Tabusintac watershed and twenty in the Grog Brook watershed. Six different areas were planted, in order to try out the different types of land in the district, as well as various methods of seeding. The varieties planted were white, red and jack-pine and white spruce, a good quantity of these seeds having been collected in the previous year, and tests in the meantime having shown them to be of excellent quality. From the very nature of the work its success cannot be determined for some years, but the cost of reseeding has not proved excessive, and with experienced men working on a large scale this could be materially reduced.

—(Investigation under the Associate Committee on New Brunswick Forest Problems.)

7. The Cultivation of Drug Yielding Plants in British Columbia

Many drug-yielding plants and herbs grow wild in British Columbia, and at least one of these (the Cascara tree) has been shipped in some quantity to manufacturing druggists in the East, in spite of the handicap of high freight charges on the crude material. Inquiry was made as to the possibility of a drug-manufacturing industry locating in the province, and it was learned that in order to make possible the profitable operation of a plant of that kind the number of drugs produced would have to be large. An investigation was therefore undertaken to determine whether the climate and soil of the province would

be suitable for the growth of many drug-yielding plants and herbs which up to that time had been produced almost entirely in other countries, notably Europe.

Between thirty and forty varieties of herbs and medicinal plants have been grown, and the conditions most favourable for rapid development of plant and yield of extract are being determined. Light, temperature, moisture and other factors have been found to have a pronounced influence and it has been deemed essential to secure as much information as possible along these lines before the growth of plants and herbs is undertaken on a large scale.

While only partial success has been attained in the growth of some of the plants the conditions in British Columbia have been particularly favourable for others. In the case of Poison Hemlock, Pennyroyal, Mint, Common Thyme and some others the yield has proved to be several times that usually secured in Europe. It has been found that certain plants do not require rich soil, and land may therefore be devoted to their production which is not suitable for general agricultural purposes.

On the whole it may be stated that the results of the experiments so far carried out are most encouraging, and while from the very nature of the work considerable time must elapse before the investigation is complete the establishment of a new and important industry in the province of British Columbia seems altogether likely.

—(Investigation under Professors R. H. Clark and J. Davidson, University of British Columbia.)

8. Utilization of the Low-Grade Iron Ores of Canada

Approximately 2,000,000 tons of iron ore are annually imported into Canada from the United States and Newfoundland, while vast low-grade deposits of Canadian ore remain undeveloped. Such is the deplorable condition to which attention is drawn in the recently published report of a Sub-Committee on Iron Ores appointed by the Research Council's Associate Committee on Mining and Metallurgy. This report gives the results of investigations on this subject carried out during the past three years, and the recommendations of the committee.

In large-scale tests it has been found possible to treat Canadian ores so as to yield a product suitable for reduction in blast furnaces, but the cost of such special treatment makes competition with imported ores very difficult under present conditions. However, as a result of the thorough investigation which it has carried out and the details of which appear in the report referred to, the committee is of the opinion that some Canadian deposits of siderite and magnetite ore can be mined, treated and marketed at but small loss, and that if a very little assistance were available, the establishment of an iron-mining industry in Canada would be assured. The committee also believe that with such assistance this industry would in a few years become self-supporting and ultimately profitable.

The report points out that furnaces in Central Canada could use about 1,000,000 tons of ore annually, representing an expenditure in this country of some $5,000,000 each year in areas that are at present very sparsely settled. Attention is also drawn to the fact that the iron ore business is one which greatly increases railway revenue and that activity in iron mining would materially benefit the national railway. It points out that, while there is small hope of making a very profitable iron mining industry in Canada, there is a possibility of making small profits after the industry is well established. The

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indirect benefits would be very great, for, instead of several million dollars going out annually to foreign countries, this money would be spent in Canada for labour, supplies and transportation.

—(Investigation under the Associate Committee on Iron Ores.)

9. Nutritional Problems of the Fox Breeding Industry

The breeding of fur-bearing animals in Canada has developed into an industry of considerable importance. Foxes in particular have been bred with profit, and there seems to be a great future for the industry in this country, so well adapted by nature to produce furs of the highest quality. The influence of food upon that quality has only recently been recognized, but the experiments carried out under the Research Council in co-operation with the Department of Agriculture on an experimental ranch at Hull, Que., have shown that scientific feeding will produce immediate and gratifying results.

During the year under review feeding experiments were continued along the lines that had proved most successful in previous years. Tests were not confined to the foxes on the experimental ranch, but were extended also to those of the breeders co-operating in the work. Foxes were fed during the summer on low-caloric diets of low protein content and very little fat. During the fall the protein and fat were materially increased, the caloric content remaining at about 100 calories per kilogramme of body weight. Fox-breeders were much impressed by the excellent results obtained, it being found that the fur of the animals continued in prime condition until March instead of going off colour in December, as usual.

Further progress was made in feeding pups, but additional trials will be necessary before the diet used can be universally recommended. Experiments were made in the feeding of pregnant females, two different groups of animals being fed on diets of high and low caloric content, respectively. The indications are that the low caloric content will give the better results, but the experiments are to be continued.

An investigation of conditions on fox ranches in different parts of Canada has revealed the superior results being obtained where the methods of feeding developed at the experimental ranch have been adopted. Scientific feeding would entirely prevent a great amount of the present fur wastage.

—(Investigation under Mr. G. Ennis Smith, Biochemist-in-charge of the Experimental Ranch at Hull, Que.)

10. Medicinal Value of British Columbian Foxglove

The plant foxglove is the source of the important drug digitalis, much used in the treatment of certain diseases of the heart. It is a native of British Columbia, being one of a group of medicinal plants and herbs upon the successful growth of which any drug-manufacturing industry on the Pacific coast would be dependent. This investigation was undertaken to determine the strength of the extract secured from its leaves, as this varies with the climate, fertilizer used and other conditions of growth. In the absence of suitable chemical tests for the strength of the extract its physiological value was determined by its effect on animals.

A large number of foxglove plants (Digitalis Purpurea) growing in the province, were transplanted to the gardens of the University of British Columbia at Point Grey. Five separate plants were tested. The physiological value of the leaves of British Columbian foxglove was found to be somewhat higher than that found by other investigators working on plants grown in England, the United States and Germany. Both the extract and leaves were tested in Vancouver General Hospital, with gratifying results.

In fertilizer tests it was found that the yield was doubled when cow manure was applied to the soil, and the strength of the extract was slightly higher, ammonium sulphate was of slight benefit and superphosphate appeared to be detrimental.

—(*Investigation under Professors R. H. Clark and J. Davidson of the University of British Columbia*).

11. The Cascara Content of the Wood and Bark of Rhamnus Purshiana

Cascara sagrada is one of the most important laxatives known of medical science. Its source has been the bark of Rhamnus Purshiana, a tree native to British Columbia. The present investigation, which forms a part of the larger question of the establishment of a drug-producing and drug-manufacturing industry in British Columbia, was undertaken to determine the strength of the extract produced and the conditions favourable for its successful growth.

Tests of the wood of Rhamnus Purshiana revealed the astonishing fact that it is on an average 71 per cent as effective as the bark, although no use has been made of it in the past. If it can be extracted profitably this will mean an increase of over 1,300 per cent in the production per tree.

The extract from certain trees was found to cause a marked griping action, but this was overcome by the use of hydrogen peroxide. Further tests will be necessary to determine whether this remedy can be generally made use of, as so small a percentage of the drug possesses this undesirable property. Young trees were found to be productive of a stronger extract than older ones, and a moist season was also found to be favourable. No simple physical or chemical test has yet been discovered which will serve as a satisfactory guide to the strength of the active constituent.

—(*Investigation under Professors R. H. Clark and J. Davidson of the University of British Columbia*).

12. Rock Crushing with Rolls

The ore tonnages handled by some of our larger mines are enormous, several plants treating over a million tons a year each. Where wet concentration is used this ore has to be crushed, often to a fine powder. For this purpose jaw and gyratory crushers are generally employed for the coarse ore, rolls and disc crushers for the intermediate sizes, and ball, rod and pebble mills and stamps for sliming. In spite of the large scale of operations but little is definitely known concerning the laws of crushing. This investigation was undertaken by Professor Haultain to determine as many as possible of the unknown factors in the case of rolls, while in a parallel series of experiments he has been studying ball milling.

For this work there has been designed and constructed a piece of apparatus which has proved over a period of several months' operation its accuracy, reliability, and entire suitability for the purpose. The complete unit consists of a set of rolls with driving gear, motor and rheostat, an indicating dynamometer, an integrating dynamometer, an electric revolution recorder, a feeding mechanism, speed indicator, Prony brake attachment, suction blower, dust collector and an attachment that gives a complete graph of each crushing operation, showing, for ready visual comparison, the differences in the energy required for crushing various rocks.

The economic significance of the results which have been obtained are indicated by the fact that as a result of this research the Hollinger Mining Company has donated a Fellowship to assist in the continuation of the work and the Nipissing Mining Company has founded a permanent fellowship with the

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same object in view. It is gratifying to find that the work has thus received recognition and financial support from the industry which may be expected to reap much benefit from the advances made. One paper descriptive of the experiments and showing their bearing upon the general theory of crushing has been published by the American Institute of Mining and Metallurgical Engineers, and further papers will be presented to scientific societies to mark the progress of the work.

—(Investigation under Prof. H. E. T. Haultain, Department of Mining Engineering, University of Toronto).

13. Ball Milling

With the advent of flotation and cyanidation it became necessary to crush enormous tonnages of ore to an extreme fineness and the ball mill at once became prominent as an efficient crushing device eminently suited to that particular service. The design of these mills, however, has been based upon a very meagre knowledge of what was actually taking place inside them. Upon this question Professor Haultain has shed much new light by the construction of a ball mill with glass sides and the recording of actual ball paths by means of an ultra-rapid speed camera.

The grant made by the Research Council for this work has been expended chiefly for apparatus, for which purpose it has been supplemented by assistance from the University of Toronto and the John Inglis Company. Still further additions to apparatus will be necessary as the work proceeds, but the results attained and in prospect amply justify the expenditure. The information which has been secured has attracted widespread attention throughout the metallurgical world, and will enable engineers to make considerable progress in the design and operation of these mills. When the research has progressed further it is proposed to publish the results in full.

—(Investigation under Prof. H. E. T. Haultain, Department of Mining Engineering, University of Toronto).

14. The Corrosion of Iron Pipes in Alkaline Soils

The corrosion of iron pipes by the alkaline waters found particularly in the clay soils of the West has become a serious matter, and it is therefore important that the causes of such corrosion be determined and preventive measures applied. Professor Shipley's work constitutes a marked advance in our knowledge of the subject. The experimental work consisted chiefly of the chemical and micrographical examination of a large number of samples of corroded iron, collected not only in the West but also in many different parts of the world, where corrosion had in some cases proceeded for centuries. Sometimes one piece of pipe will show side by side examples of uncorroded surface, of pitting—in which holes have been eaten into the iron—and of graphitic softening, in which the metal retains its outward form but is soft, porous and of low specific gravity, most of the iron having been leached out, leaving a mere graphitic skeleton. It was determined by the micrographic work that the resistance of uncorroded iron was due chiefly to the presence of iron carbide, and this fact was substantiated by chemical analysis. For this reason white cast iron, containing much carbide, is more resistant than grey cast iron, wrought iron or steel, and this fact also explains why certain specially chilled irons are scarcely attacked at all. Prof. Shipley believes that if chilled cast iron containing 5 per cent of carbon could be used, corrosion would be mainly overcome.

Corrosion was found to be largely caused by inter-crystal electrolytic action in iron buried in moist clay or other soil, the character of the soil having much to do with the intensity of the action. When much graphite was present the skeleton of carbon left, together with hydroxides of iron, a little iron carbide

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and other constitutents, caused the metal to retain its shape, though completely corroded. When less carbon was present no skeleton resulted and corrosion was visible as pitting. In general the corrosive action was found to proceed most rapidly between the crystals in the metal.

Many laboratory experiments were also carried out, but as corrosion is a slow process it could not be carried farther than to confirm in surface action the results found in old pipes. Electrolytic action between distant points on the iron was studied, but so little current passed that this is not considered to be an important cause of corrosion in most cases. Preliminary experiments were made in coating pipes with various resistant materials, but this work was not encouraging, as such coatings are usually permeable to solutions.

—(Investigation under Prof. J. W. Shipley, University of Manitoba.)

15. The Preservation of Structural Steel

The corrosion of steel structures is of such widespread interest that the subject has received a great deal of attention by engineers in many countries. The protective value of different coatings has been studied, and in view of the increasing use of gunite (cement applied by discharging it from a special " gun ") for this purpose it was considered by the Research Council that the conditions necessary to secure the best results should be determined.

In the investigation undertaken on this subject it was found that fine sand should be used in the gunite, as coarse sand rebounds to a considerable extent. Thorough mixing is important, otherwise local rusting will take place. The temperature at the time of application should not be excessively low, or cracking will result. Thorough reinforcing of the gunite is necessary, the reinforcing not being placed closer to the steel than three-eighths of an inch, and the overall thickness being about one and one-half inches. Even on heavily rusted plates gunite was found to stop the rusting when properly applied. The conclusion is drawn by Professor Gillespie that where good materials and workmanship are assured, and the weather during application is favourable, gunite properly reinforced will afford steel structures a satisfactory protection against corrosion.

—(Investigation under Prof. P. Gillespie, University of Toronto.)

16. The Provision of Food for Young Fresh-water Fish

Much work has been done in the past in propagating fresh-water fish for restocking our rivers and lakes. The provision of suitable food for the young fish is in many cases also of great importance, however, and this investigation was undertaken to determine whether or not Entomostraca could be propagated in large numbers for that purpose. In the progress of the work it became evident that the solution of the main problem involved the solution of several others.

First of all a considerable amount of field work was done in Ontario and New Brunswick, and a fairly accurate idea was obtained of the distribution of the Entomostraca, and a study of their habits has yielded valuable information as to the proper cultural procedure. The food of many species has been investigated and found to consist largely of various algæ. A method has been found for growing these on a large scale, and many generations of Entomostraca have been raised entirely on food thus produced. One outstanding fact which has been discovered in this connection is that the modifications in the algæ which have been brought about by variations in the salt content and hydrogen-ion concentration of the containing medium are greater than those between forms previously described as different species and even distinct genera.

—(Investigation under Prof. A. Brooker Klugh, Queen's University.)

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17. Vitamines

Through some mysterious property, which is even yet very imperfectly understood, vitamines exercise over our lives a most remarkable power. Without them we should die, yet even their very existence was not suspected until recently. Their discovery alike explains many mysteries which have baffled the medical profession in the past and points the way to perhaps undreamed-of advances in the future.

For several years the Associate Committee on Food Research has been studying vitamines, their concentration, isolation in a pure form, and properties, as well as analytical or other tests to replace the present physiological methods of detection and estimation. Good progress has been made in the methods of concentration, several important advances having been effected during the year. Much work has been done on the relation between vitamines and the yeast activator, and several papers will shortly be published covering the progress made.

Advances of this kind into the unknown fields of food chemistry require a great expenditure of time and energy, but in view of the important part which vitamines have been proved to play in the life and vigour of both human beings and animals, it is of the utmost importance that our knowledge be extended as far as possible.

—(Investigation in Laboratory of Food Chemistry, University of Toronto.)

18. Fog Signalling

Any one who has been at sea in a dense fog will realize the dangers of navigation in the absence of reliable means of fog signalling. From time to time the world is startled by the announcement in the daily press of marine disasters caused by collisions or ships running aground in a fog. Research leading to a solution of this problem will therefore benefit not Canada alone but humanity as a whole.

The greater part of the work which the Research Council carried out on this subject during the year under review was in connection with tests of shipboard wireless receiving apparatus for determining the ship's position and distance relative to a properly equipped lighthouse. The tests were carried out with apparatus installed at St. Margaret's, Quebec. A report has been prepared on the design of a lighthouse equipped so as to enable a ship to determine its position and distance once a minute.

A promising radio searchlight, making use of waves a few metres in length, has been designed and is now being perfected. Hydrophones with tunable diaphragms have been tested, and one of these has been placed in the hands of the Admiralty for trial.

—(Investigation by Prof. L. V. King, McGill University, Montreal.)

19. Helium

Recent long-distance trips of the Shenandoah and Los Angeles, giant United States army dirigibles, have attracted world-wide attention. The great gas bags of these airships were filled with helium, a non-explosive gas which makes impossible a repetition of the terrible disasters which have in the past overtaken hydrogen-filled aircraft. Thus helium has been made a useful servant of man, though when Lockyer in 1858 announced its discovery by means of the spectroscope in the sun's gases it was not anticipated that it would ever find practical importance in man's every day life.

This research of Professor McLennan's was the first carried out in the laboratories of the University of Toronto involving the use of liquid helium.

This gas was first liquefied by Professor McLennan in 1923 by the use of equipment towards the cost of which the Research Council contributed. By means of helium, which liquefies at — 269°C., only four degrees above absolute zero, it is possible to conduct experiments over the range — 259° to — 272°C., a new field being thus opened for low-temperature research.

When solid nitrogen and argon were irradiated by electrons of high and low speeds they became luminescent, and the spectra of the emitted light were found to include several new wave-lengths in the yellow-green region. The phosphorescence of nitrogen at low temperatures was found to continue for some time after excitation ceased, while that of argon persisted for a few seconds only. Solid carbon monoxide, ammonia, oxygen and water vapour did not phosphoresce at all. A comparison of the new lines found with that of the green auroral line indicates that the latter cannot be connected with either of the elements nitrogen or argon. The experiments are being continued.

—(Investigation under Prof. J. C. McLennan, University of Toronto.)

20. Colour Vision

Colour blindness has been the cause of countless accidents in the operation of trains, steamers, automobiles etc., by persons who could not properly distinguish the colours of signal lights, but who, in many cases, where entirely unaware of their disability. For the protection of the general public it is therefore important that defective vision be studied carefully, that its cause be accurately determined and that proper steps be taken to minimize the number of accidents resulting therefrom.

During the year under review Professor Allen has continued his researches on this little-understood subject, with the co-operation of two assistants whom he was able to obtain through the grant from the Research Council. The discoveries previously made on reflex sensations were checked and verified. New methods of investigation were developed, and these were applied to the study of both colour blindness and what is called anomalous vision. As a result the causes of these two abnormalities were discovered.

In order to study more exactly the basic principles upon which colour vision operates, the sense of touch was investigated by an entirely new method, and it was found that the same principles apply in this sensation as in vision. Professor Allen believes that the discoveries made will go far towards solving the problem of vision. Fourteen papers have been prepared descriptive of the work performed, and ten of these have already been published.

—(Investigation under Prof. Frank Allen, University of Manitoba.)

21. Surface Energy of Crystals

In chemical processes involving the production of crystals the size of crystals is often a matter of considerable importance, on account of the varying requirements of the trade. At the same time the factors governing the size have not been well understood, though it has been generally believed that the surface energies of the different sizes played an important part.

The object of the research is therefore to determine the surface energy of crystals by means of the heats of solution. These heats are to be determined for fine and coarse particles of salts, and differences would be due to variation in the surface energy of the particles. Owing to the complexity of the apparatus necessary to determine such small amounts of heat, and the elaborate precautions required to prevent the influence of extraneous heat, this research is still in its initial stages. Sodium chloride is the only salt so far tried, but the experiments are to be continued with many different compounds.

—(Investigation under Dr. F. M. G. Johnson, McGill University.)

22. Spectrum of Infra-red Rays

A first step in this research was the compilation of a bibliography of literature on infra-red spectroscopic work. This is now available for other workers in the same field. A study was made of filters suitable for isolating certain portions of the infra-red spectrum. These spectra for a number of the elements were then photographed and studied, and results have been published in the Proceedings of the Royal Society of London, and also in those of the Royal Society of Canada. Particularly interesting were the results obtained in the study of the spectrum of mercury. The spectra of silicon and titanium are now being investigated.

—(Investigation under Prof. J. C McLennan, University of Toronto).

III. ASSOCIATE AND ADVISORY COMMITTEES

The Research Council has appointed a considerable number of associate and advisory committees in order that it may have the benefit of the advice of a number of experts in each of the various branches of science. The chairman of each committee is usually a member of the Research Council and the membership is comprised of men eminent in the particular branch of science in which the committee functions. In some cases advisory committees have also been established to take charge of special investigations on behalf of the Council. Some of these committees have completed the work for which they were established and have, consequently, been discontinued, but during the year under review there were twelve committees in operation with a total membership of 147 persons. These committees and their chairmen were as follows:—

Associate Committee of Chemists—Dr. Ruttan.
Associate Committee on Mining and Metallurgy—Dr. Adams.
Associate Committee on Physics and Engineering Physics—Dr. McLennan.
Associate Air Research Committee—Dr. Eve.
Associate Food Research Committee—Dr. Macallum.
Associate Biological Committee—Dr. Macallum.
Associate Committee on Industrial Fatigue—Dr. Macleod.
Advisory Committee for British Columbia—Prof. Turnbull.
Associate Committee on the Nutritional Problems of the Fox Industry—Dr. Hunter.
Advisory Committee on Pacific Investigations—Dr. McMurrich.
Associate Committee on Accurate Plot Work—Dr. Grisdale.
Associate Committee on Forest Problems of New Brunswick—Col. T. G. Loggie.

In addition to these associate and advisory committees, the members of which are comprised almost entirely of persons who are not members of the Research Council, the Council has established among its own members a number of standing and special committees to deal with such subjects as grants for research Fellowships, Studentships and Bursaries, the National Research Institute, the publication of scientific papers in Canada, fuel, the disintegration of concrete in alkali soils, fish waste, helium, wheat rust, etc.

FINANCIAL STATEMENT FOR THE FISCAL YEAR ENDING MARCH 31, 1924

Receipts

	$ cts.	$ cts.
Appropriation	120,000 00	
Research grants	3,000 00	
Refunds	2,506 16	
		125,506 16

Expenditures

Assisted Researches		59,854 04	
Fellowships	13,380 00		
Studentships	7,200 00		
Bursaries	17,250 00		
		37,830 00	
Fees in International Research Council, its scientific unions, etc.		313 15	
Travelling expenses of members of the research council and staff		4,281 90	
Travelling and administration expenses of associate and advisory committees		3,660 34	
Library		866 56	
Salaries		15,091 37	
Printing of reports and bulletins		1,774 19	
General administration		1,645 51	
			125,317 06
Refunded to Receiver General			189 10
			125,506 16

COMPLETE STATEMENT OF EXPENDITURES SINCE THE ESTABLISHMENT OF THE COUNCIL

Year	Research grants	Fellowships, studentships and bursaries	Library and printing	Travelling expenses		Salaries	Administration of council and committees	Total
				Research council	Associate committees			
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
1917–18	8,344 79	5,550 00	3,253 63	6,877 06	698 60	19,610 35	5,777 31	50,111 74
1918–19	19,511 64	7,150 00	2,401 81	3,628 46	2,507 25	22,520 88	3,409 96	61,130 00
1919–20	39,875 60	20,100 00	2,946 41	4,472 33	2,392 09	22,034 25	2,686 55	94,507 23
1920–21	60,779 05	16,925 00	1,998 74	4,428 57	5,509 79	17,075 51	2,860 82	109,577 48
1921–22	24,617 28	37,725 00	3,618 22	4,317 39	3,101 88	17,619 11	8,564 49	99,563 37
1922–23	39,511 19	34,975 00	3,797 92	2,844 68	3,188 94	16,703 76	4,189 47	105,210 96
1923–24	59,392 66	37,548 89	1,602 99	3,678 53	2,915 74	15,091 37	2,580 72	122,810 90
Total	252,032 21	159,973 89	19,619 72	30,247 02	20,314 29	130,655 23	30,069 32	642,911 68
Average	36,004 60	22,853 41	2,802 82	4,321 00	2,902 04	18,665 03	4,295 62	91,844 52

COMPLETE STATEMENT OF EXPENDITURES SINCE THE ESTABLISHMENT OF THE COUNCIL—SHOWN IN PERCENTAGE

Year	Research grants	Fellowships, studentships and bursaries	Library and printing	Travelling expenses		Salaries	Administration of council and committees	Total
				Research council	Associate committees			
	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
1917–18	16·6	11·0	6·5	13·8	1·4	39·1	11·6	100
1918–19	32·0	11·7	3·8	6·0	4·1	36·9	5·5	100
1919–20	42·2	21·2	3·1	4·7	2·5	23·3	3·0	100
1920–21	55·5	15·4	1·8	4·1	5·0	15·6	2·6	100
1921–22	24·7	37·9	3·7	4·3	3·1	17·7	8·6	100
1922–23	37·6	33·2	3·6	2·8	3·0	15·8	4·0	100
1923–24	48·3	30·6	1·3	3·0	2·4	12·3	2·1	100
Average	39·2	24·9	3·1	4·7	3·2	20·2	4·7	100

APPENDIX A

Report of the Associate Biological Committee

The annual meeting of the Associate Biological Committee was held in Ottawa on May 21, 1923, eight members of the committee being present at the meeting. The chairman of the committee, Dr. A. B. Macallum, presented a report of the activities of the committee during the previous year, after which the programme of the committee for the year 1923-24 was carefully considered. It was decided to carry on three investigations under the auspices of the committee during the year under review.

The committee arranged to have a chemical investigation of the problems which are related to the curing and handling of fish carried out by Dr. J. F. Logan, in the Department of Biochemistry at McGill University. At the very outset, it was apparent that a large amount of pioneer research was necessary. The purely scientific side of the question had been investigated so little that many of the fundamentals which were indispensable for an intelligent attack on these problems were almost unknown. A knowledge of the nature of the tissue which constitutes normal fish muscle is fundamental and this involves a qualitative and quantitative study of the proteins and extractives present in the tissue. The greater part of the work already done in this field of investigation has been confined to the mammalia. The amphibia have come in for some attention; the fishes have been almost neglected. In fish the life processes, such as respiration, take place at the comparatively low temperature of, say, 12°C; the mammalia at a much higher temperature of 37-38°C, and, since it is well known that the muscle tissue is intimately involved in the respiratory process, it seems quite probable that two types of animal life with such differences in this important phase of metabolism should have more or less difference in their muscle tissue. An investigator would, therefore, not be justified in using to too great an extent data gathered in the study of mammalian tissue.

In so far as the matter has been investigated, the evidence points to important qualitative, as well as quantitative differences between the proteins of fish muscle and those of mammalian muscle. The denaturing effect of sunlight upon proteins has recently been shown to be more general than was formerly supposed. Therefore, the action of light, as well as that of heat, upon muscle proteins must be studied. Moreover, the exact chemical effect of salt upon proteins is not sufficiently understood. Again, for some reason, autolysis is a more rapid process in the dead muscle tissue of most fishes than it is in the tissue derived from mammalia. This results in the well known tendency of fish to become "soft" in the market. All these and many other points require investigation before the actual applied science of the industry can begin to function.

During the year under review, complete analyses of five different salts used by the fishermen of the eastern provinces were made and a report issued thereon, which will be found in Appendix "K" of the present report.

Another investigation carried out during the year under the auspices of this committee was in connection with the damage caused to water front structures by marine boring animals. This investigation was carried out under the personal supervision of Dr. A. G. Huntsman, Director of the Atlantic Biological Station, St. Andrews, N.B. During the summer of 1923, a survey of the Atlantic coast of Canada was made, in order to determine the geographical distribution of and the extent of the damage done by the borers that attack wood in salt water.

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Forty places in all were examined in this survey, from Welchpool, on the international boundary in southern New Brunswick, to Port-aux-Basques, Nfld., on Cabot strait, and to Levis, Que., on the St. Lawrence river. Owing to inadequate transportation facilities it was not found possible to examine the north shore of the gulf of St. Lawrence, and only a passing survey could be made of the Nova Scotian coast between Halifax and Canso.

At each point wharf piles were examined by two methods—inspection at low tide, and underwater examination by the "hydroscope", an instrument especially designed for the purpose, and resembling an inverted periscope. The vertical distribution of the borers on the piles was brought into relation to the changing surface level of the water by following these changes from low to high tide or vice versa. Samples of the water were obtained at both high and low tides both at the surface and at the bottom, and the temperature, salinity, and hydrogen-ion concentration determined for each sample.

The gribble (*Limnoria*) was found widely distributed along the coast. It was most active where the salinity was highest, or most constantly high, as at Welchpool, N.B., and Port-aux-Basques, Nfld. It was moderately active where the salinity was somewhat low, but never very low, as around Prince Edward Island. It was absent in estuaries where very low salinities are at times found, as at St. John, N.B., Weymouth, N.S., and Chatham, N.B. The height to which it rose toward and above low tide mark was found to vary greatly, apparently depending upon the freedom of the upper levels from brackish water influences.

The shipworm (Teredo) was found to be absent or rare along the greater part of the coast. It was most active in the Bras D'Or lakes and in Northumberland strait, and was regularly found only in the warm shallow water of the southern part of the gulf of St. Lawrence, that is on the Magdalen shallows. It occurred farther up the estuaries than did the gribble, as at Chatham on the Miramichi river. In general it was found in water of low salinity and of high summer temperature.

The hydrogen-ion concentration was not found to be a limiting factor for either form. The chief limiting factor for the gribble was found to be low salinity, and for the shipworm low temperature. At very few places was there very rapid destruction of wood by these borers. The very definite (and, it is believed, constant) differences found at different depths and at different places along the coast show the importance for the engineer of knowledge concerning the way in which the physical factors in the water limit the activities of these borers.

In addition to the two above researches, an investigation was also carried on during the year under review, under the auspices of the Associate Biological Committee, of the possibilities of the artificial propagation of the sturgeon, which species of important food fish has become almost extinct in Canada and which will inevitably disappear shortly unless some artificial means for its propagation are discovered.

Owing to natural conditions, over which the investigators had no control, such as weather conditions which affected the streams where the investigation was being carried on and rendered it impossible to secure the number of fish required for experimental purposes in order to carry out in full the programme for this research, it was found impossible to make the progress during the year under review, which had been hoped. Much valuable information was secured, however, and the progress made will be of value in continuing this research.

Detailed reports of the work carried out in connection with these investigations are on file in the office of the Research Council and a summary thereof will be found on pages 24 to 26 of this report.

APPENDIX B

Report of the Associate Committee of Chemists

During the year under review, six members of the committee retired under the automatic rotation schedule, viz., Mr. F. J. Hambly, Dr. H. van der Linde, Dr. T. Thorvaldson, Dr. J. W. Shipley, Dr. A. C. Neish and Mr. Robert Job. To fill the vacancies caused by the above retirements the following gentlemen were appointed by the Research Council: Dr. E. H. Archibald, Mr. A. G. Fleming, Mr. A. H. C. Heitman, Dr. D. McIntosh, Mr. W. H. Thom, and Dr. G. S. Whitby.

The annual meeting of this committee was held in Toronto on May 28, 1923, and was attended by nineteen of the twenty-one members of the committee.

The chairman, Dr. Ruttan, reviewed the activities of the Research Council during the preceding year and described in detail the work done under grants for research and in connection with the Fellowships, Studentships and Bursaries awarded by the Council.

Mr. Hambly and Dr. Macintyre explained to the committee the nature and effect of certain changes which had been proposed in connection with the Canadian patent regulations.

The chairman called attention to the necessity for the committee to very carefully consider chemical aspects of the fuel question in Canada. He pointed out that this question is engaging the attention of the leading thinkers in Canada and suggested that a frank discussion of the problem by the members of the committee, each of whom has specific information on some phase of the question, would result in definite conclusions, on which an intelligent and sound opinion could be based. The chairman stated that, with this object in view, he had invited Mr. J. F. Slee, Superintendent of the Coke Plant of the Steel Company of Canada at Hamilton, to attend the meeting, in order that he might address the committee on this subject. He called attention to the fact that Mr. Slee has charge of the economic distillation of coal, and the manufacture of coke and by-products in connection with the Steel Company of Canada. Mr. Slee, in his address before the committee, outlined the economics of coal distillation, the value of the products to be obtained therefrom and the economic possibilities of various coals for use in the manufacture of coke. Mr. Slee informed the committee that the value of the by-products obtained in connection with the production of coke more than covers the conversion costs, but is not large enough to cover the cost of freight on the coal. Considerable discussion in connection with Mr. Slee's address ensued and it was the general concensus of opinion of the members of the committee that the question of a fuel to replace anthracite for use in a domestic furnace in an ordinary residence narrows down almost exclusively to the use of coke, which might be said to be an artificial anthracite, and several members of the committee expressed the opinion that a good grade of coke is a more desirable fuel for domestic furnace purposes than anthracite.

Mr. Freeman brought before the committee the question of the relation of sodium sulphide to the complex sulphide ores of British Columbia, in connection with which problem he has been carrying on research work for several years.

Mr. R. E. Gilmore gave a full account of the present situation in Canada with respect to the denaturing of alcohol for industrial purposes. The committee thoroughly discussed this question with the result that a resolution was passed, informing the Research Council, that, after carefully considering the question, the committee strongly recommend that the Government permit a new form of denatured alcohol to be placed on the market, which would contain not more than five per cent methyl alcohol.

Professor Shipley read a paper, covering his research on the corrosion of iron and steel pipes in alkaline and clay soils and showed a large number of slides,

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illustrating the effect of clay and alkaline soil waters upon iron and steel pipes in the vicinity of Winnipeg. Professor Shipley found a great difference in the effect of soils upon iron pipes, which he attributed largely to the composition of the material and he thought it might be possible to draw up specifications for iron and steel pipes, to be used underground, which would be strongly resistant. He found that clay soils were actively corrosive and attack iron and steel quite as actively as soils containing alkaline salts. Professor Shipley announced, however, that final conclusions had not been reached in connection with this work, which is being continued.

Dr. Harold van der Linde led a discussion on the subject of the utilization of wood waste, and Mr. J. R. Donald described problems connected with the utilization of the by-products of the milk industry in Canada, pointing out that lactose and casein are not now utilized in Canada to anything like the extent they should be.

APPENDIX C

Report of the Associate Committee on Physics and Engineering Physics

The sixth annual meeting of this committee was held at Ottawa from May 24 to 26, 1923. In addition to the nine members of the committee who attended the meetings, seven other persons were present by invitation, in order that they might take part in the discussion of various phases of the work of the committee in connection with which they possessed special qualifications.

Professor Boyle, of the University of Alberta, addressed the committee on research problems in Alberta and pointed out that the most pressing problems are those connected with coal, particularly those relating to its mining, transportation, marketing and burning. It was also pointed out that Alberta coal, had largely supplanted Pennsylvania anthracite in Western Canada, but that there was great need for the development of a furnace suitable to burn Alberta coal.

Professor McGougan informed the committee that the provincial legislature of Saskatchewan had given a grant of $16,000 for research, chiefly in agricultural problems.

General McNaughton addressed the committee on "radio" and exhibited a map of Canada, showing the position of the present wireless stations and the proposed network of stations for Western Canada.

Professor Eve gave a very full account of the problems confronting radio investigators and pointed out the unique position occupied by Canada at the present time in this respect. He discussed the devices and means employed by radio investigators to overcome their difficulties.

Commander Edwards, Major Steel, Mr. Fraser, Mr. Henderson, Dr. Boyle and others took part in the discussion, while Mr. Patterson emphasized the great value to the Meteorological Service of observations from the MacKenzie River district and expressed the hope that upper air observations would also be obtained when the wireless stations were established. He stated that the Meteorological Service has been handicapped by the lack of observations from that region. A special committee was appointed to investigate and report as to action which could be taken by the committee to co-operate with the Departments of National Defence and Marine and Fisheries in the solution of radio problems.

Colonel Stedman, Technical Director of the Air Board, addressed the committee on the special problems with which the Air Board have to deal. One of the difficulties encountered in winter flying is the breaking of the steel

bracing wires in the extreme cold. This is a problem which requires careful investigation and one which could be carried out in Western Canada during the winter. The committee decided to recommend to the Research Council that assistance be granted for a research on this problem.

Another problem presented by Colonel Stedman was that of finding a suitable shock absorber for use in the extreme cold encountered in Western Canada in winter flying. It was agreed that this is too big a problem for the laboratory and must be investigated outdoors. The committee decided to refer the problem to the professors of physics in the Alberta, Saskatchewan and Manitoba universities.

Attention was also directed to the statement that track torpedoes (fog signals) were heard with difficulty in the White River district when the temperature was 40 degrees below zero. It was also agreed to refer this problem to the above universities.

There was considerable discussion on the subject of a National Research Institute, the value of assisted researches and of scholarships awarded by the Research Council, the publication of scientific papers in Canada, the publication of pamphlets on the work of the Council, written in popular language, and the question of uniformity in symbols and abbreviations.

The results of the discussion which took place on these questions are embodied in a series of resolutions which strongly endorse or recommend all of the above activities.

Some additional problems which came under review by the committee were: radio engineering as a profession; engineering physics at the universities; summer work for physicists; the standard required in mathematics and physics, in schools and universities, for research students.

During the year under review, the following members of the committee retired in the automatic rotation schedule: Dr. A. L. Clark, Dr. Louis Bourgoin, Mr. John Patterson, Dr. H. L. Bronson and Dr. A. G. McGougan. To fill the vacancies created through the retirement of the above members, the Research Council reappointed Dr. McGougan, Mr. Patterson and Dr. Bronson to the committee for a further term and added the following new members to the committee: Dr. A. Ll. Hughes, Queen's University; Dr. A. Frigon, University of Montreal.

APPENDIX D

Report of the Associate Committee on Mining and Metallurgy

The seventh annual meeting of this committee was held in Toronto on March 6, 1924, thirteen members of the committee being present.

The chairman made a general statement, outlining the activities of the Research Council during the past year dealing particularly with the scientific investigations which have been completed, or are in progress, under the auspices of the Research Council, and also with the necessity for a National Research Institute in Canada.

Professor Haultain referred to the investigation on "Rock Crushing by Rolls", which he has carried on with assistance from the Research Council, and pointed out that as a result of this research the Hollinger mines have given a fellowship of $1,200 to assist in the continuation of this work. Professor Haultain stated further that a paper covering the first phase of this investigation has been prepared and is being published. Professor Porter expressed the opinion that the results achieved by Professor Haultain through this research were very valuable to the mining industry.

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The chairman presented the report of the Sub-Committee on Iron Ores, which had recently been published as Report No. 14 of the Research Council, entitled, "On the Utilization of the Low Grade Iron Ores of Canada". He spoke of the excellent work which had been done by the sub-committee and outlined briefly the contents of this report and the sub-committee's conclusions and recommendations.

Mr. Morrow, as chairman of the Sub-Committee on Iron Ores, reported that the members of his sub-committee had worked hard and enthusiastically, and he recommended that the sub-committee be continued and that the grant at its disposal be increased to the amount of $1,000 to enable it to keep closely in touch with the iron ore situation in Canada. He pointed out that work on the beneficiation of low grade ores should be closely followed, and that it is also necessary to investigate and improve the scientific design and construction of blast furnaces in order to meet the changed conditions arising from the use of beneficiated ores in order to secure greater efficiency and possibly an improved product. The committee unanimously agreed that this suggestion should be adopted.

The committee gave consideration to urgent problems in the field of mining and metallurgy, which await solution through the application of scientific research.

Dr. Porter pointed out that he had given considerable attention to the question of sieving and of various types and sizes of sieves, and the efficiency of various motions of sieves, and requested frank discussion as to the value of continuing this investigation. He pointed out that in order to do this, it would be necessary for him to apply for assistance from the Research Council. Several members of the committee, including Professor Haultain, Mr. Denis and Mr. Whiteside, pointed out that such information is badly needed in the mining industry and strongly urged that Professor Porter continue this investigation at the earliest possible date.

APPENDIX E

Report of the Associate Committee on Food Research for Year Ending March 31, 1924

During the year under review, the committee has continued its research work on the preparation of the B Vitamine.

Since the last report was presented to the committee an extra assistant was engaged for a period of three months. This assistant has spent all her time in carrying out the concentration of a crude preparation of the active substance from rice polish and preparing material for the further concentration of the specific compound which is the objective of the work.

This phase of the work has proved very laborious and has involved the concentration of very large volumes of solutions and low temperature evaporation by means of electric fan driers and heated air currents. Steam bath and even radiator tops were used to accommodate the large quantities of fluid which accumulated. In all some fifty pounds of rice polish were treated as described above so that there is plenty of material on hand for some weeks' work in further concentration in the shape of a gummy brown residue which consists of the active substance, carbohydrate, some protein, some undetermined residue and about 30 per cent water.

The method of extraction has been to extract with 0.1 per cent acetic acid solution using 10-20 grm. of the polish to 100 c.c. of the solution. The gummy residue left on evaporation of the solution retains its activity undiminished for

at least two years, a fact recently determined by comparing the effect of a two-year old preparation against a sample of the most recent preparation on pigeons which had developed experimental polyneuritis. The gummy residue also remains sterile in so far as yeasts and moulds are concerned.

The potency of the gum is not quite so good as that shown by the original rice polish since it required 3 grms. of polish to effect a cure in pigeons as against the residue equivalent to 6 grms. of the original polishings to bring about the same effect. Some of the active substance is left after the first extraction of the polish with acetic acid, but the expense of a second extraction is not justified by the amount of active substance obtained by repeating the procedure.

The gum has been further concentrated by the method of Osborne and Mendel using various concentrations of alcohol in water and the residue from the alcoholic extract treated with commercial phosphotungstic acid. The resulting precipitate of phosphotungstate is filtered off and redissolved in dilute hydrochloric acid and the phosphotungstic acid removed by shaking the solution with a mixture of amyl alcohol and ether leaving the bases and active principle in the aqueous phase. The active substance so concentrated was found to have diminished in potency due to several defects in the method which are now under investigation. Incidentally two new facts have been discovered: (*a*) that the gum can be fractionated directly with phosphotungstic acid instead of using the alcohol method of concentration of Osborne and Mendel so that this expensive procedure can be dispensed with; (*b*) that butyl alcohol can be substituted for amyl alcohol in separating the active principle from the phosphotungstic acid without any effect on the curative action of the active substance thus reducing the cost of the procedure considerably.

Two preparations of commercial phosphotungstic acid have been used and two others of known composition have been prepared in the laboratory and are now under investigation and several others are in course of preparation.

A large amount of work on the relationship between the yeast activator and the antineuritic compound has been carried out in the past two years. This has been surveyed and several gaps in the continuity of the work are being filled in and a detailed report will be available in the near future.

Several papers will appear shortly containing some of the results of the year's work.

APPENDIX F

Fourth Report of the Associate Committee on the Nutritional Problems of the Fox Industry

COVERING YEAR ENDING MARCH 31, 1924

The results of previous years indicated that favourable results might be obtained by feeding low caloric diets of relatively low protein content from which fats were nearly eliminated during the summer (diets approximately 100 calories per kilogramme live weight, cereals 50 per cent, meat 25 per cent and milk 25 per cent, percentages being expressed in caloric values) and then low caloric diets of higher protein content containing cod liver oil or fats during the fall (diets approximately 100 calories per kilogramme live weight, cereals 25 per cent, meat 38 per cent, milk 25 per cent and added fat 12 per cent). Such diets were tried out on an extensive scale in the experimental ranch and in ranches of fox-breeders who were co-operating with the biochemist. The results were very satisfactory. The fox-breeders were very impressed with the results obtained in their ranches and reported that their foxes could have been pelted favourably in March which is in marked contrast to the general condition in the fox industry, for in the majority of cases it is necessary to

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pelt in November or early in December as the foxes are then beginning to go off-colour. With foxes on the above diets there was a good development of the guard hairs with hardly any growth of the underfur during August and September; the underfur grew very rapidly during October and November, by December the fur was exceptionally thick and heavy, the foxes gained 40 to 50 per cent in weight and the fur held a good clear black colour and lustre until late in the spring. A critical examination of the results indicates: (1) That overfeeding and diets rich in vitamin B during the summer cause a premature growth of the fur which becomes overprime and goes off-colour before the hide is prime. (2) Diets rich in vitamin B may have a favourable influence during the fall. (3) Further modification in the diets may be necessary and further information regarding the factors controlling the development of the guard hairs would be desirable.

It has already been reported that with different fox pups there is a constant ratio between the caloric value of the food ingested and the gain in weight of the animal, the ratio during the first, second, third, fourth and fifth months being 8·5 : 1, 8·5 : 1, 12 : 1, 20 : 1 and 25 : 1 to 42 : 1 respectively. Diets based on the above caloric values were drawn up and tested on an extensive scale in the experimental ranch and in other ranches. While the results were very satisfactory, further information will be required before diets for pups, drawn up from the ratio of the caloric value of the food ingested to the gain in weight of the animal, can be universally adopted.

Experiments dealing with the food requirements of breeding foxes have been continued upon the following plan:—

1. The females were fed in such a manner during the summer and fall as to insure a gain in weight of 40 to 50 per cent.

2. At the beginning of the breeding season all the females were fed a high protein diet of about 120 Cal/KW until they had mated.

3. The females that were in good condition when they mated were divided into two groups.

(*a*) One group was fed a high protein diet of about 120 Cal/KW for a month after they had mated, and then a low protein diet of about 100 Cal/KW until they whelped.

(*b*) The second group was fed a high protein diet of about 100 Cal/KW for a month after they had mated and then a low protein diet of about 90 Cal/KW until they whelped.

3. For the purpose of the experiments diets of 1·5 gm. N/KW when fed at 100 Cal/KW were considered as high protein diets; those of 1.2 gm. N/KW when fed at the same level as low protein diets.

The following is a summary of the number of litters and pups that were born during this season under the dietary conditions outlined.

Group (*a*).—These females were fed a high protein diet of 120 Cal/KW from the beginning of the breeding season until a month after they had mated and then a low protein diet until they had whelped.

Female	Male	Date of Mating	Date of Whelping	Number of Pups
No. 40	41	Feb. 2	Not pregnant	
6 A	27	" 15	Mar. 26	2
14	27	" 14	April 6	4
32	41	" 18	Not pregnant	
30	27	" 20	Not pregnant	
42	39	" 20	Not pregnant	
22 A	MA 4	" 21	April 12	5

Group (*b*).—These females were fed a high protein diet of 120 Cal/KW until they mated, then a high protein diet of 100 Cal/KW for a month after they had mated and then a low protein diet of 90 Cal/KW until they had whelped.

Female	Male	Date of Mating	Date of Whelping	Number of Pups
No. 18	27	Feb. 2	Mar. 23	3
16	45	" 11	April 4	5
20 A	1 A	" 15	" 7	3
8 A	19 A	" 20	Female destroyed her litter	
6	27	" 18	April 10	4
20	27	" 27	Female came in heat but was not bred	
22	11 A	Mar. 11	May 3	2

Females 6 and 14 deserted their litters, which eventually died. It would seem therefore that the dietary plan followed with group (*b*) was the more successful. The issue is complicated however by the fact that the particular females were given immediately after whelping an extra ration calculated to meet the requirements of the pups, while the other females received no such extra ration until a week after the birth of their litters. Obviously further experiments along the indicated lines are desirable.

During the latter part of the year the biochemist inspected a number of ranches in British Columbia, Alberta, Saskatchewan, Ontario and Quebec for the Live Stock Branch of the Department of Agriculture for the purpose of registration. In visiting the ranches in this manner it was necessary to inspect all the foxes in the ranch and he was able to gather valuable information that could not be obtained in any other way. He reports that there is an enormous fur wastage in the silver foxes being produced and it is his opinion that if the feeding methods evolved in the experimental ranch were more generally applied this particular loss of revenue, to a great extent, would be eliminated, at least with future generations of the foxes. During his tour the biochemist visited a number of ranches that were feeding according to his instructions and without exception he found a better class of fur in these ranches.

APPENDIX G

Report of Committee on the Deterioration of Concrete in Alkali Soils

The annual report of our committee last year contained a complete review of the organization, objects and early activities of the committee, and any members who may be interested are referred to the report which was published in full in the February issue of the *Journal* of the Engineering Institute of Canada for 1923. This year a brief progress report is presented covering the general activities of the year just passed.

Examination of the test specimens in the field has been carried out, and some new blocks installed, but our main efforts have been confined to the chemical research, in which field much work has been done and results obtained which we have every confidence will make a valuable contribution to science generally and especially towards an understanding and solution of the problem on which we are engaged.

The financial situation as will be seen from the attached statement is very satisfactory and we have now sufficient funds in the bank to enable us to carry on the research work for at least two more years.

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Field Work during 1923

No extensive field work has been undertaken since the original installation of test specimens in the fall of 1921. Additional specimens have been made and installed from time to time as new compounds and treatments which might have merit in prolonging the life of concrete have been brought to the attention of members of the committee. Specimens containing each material have been installed at each of the three exposure sites, Cassils, Alberta; Grandora, Saskatchewan; and Deacon, Manitoba.

Yearly inspections have been made of the condition of the blocks at each site and samples of the alkaline ground water to which the specimens are exposed have been secured for analysis. While some cases of partial and complete disintegration have occurred it is yet too early to attempt to draw definite conclusions as to the relative durability of the different concretes. In general, those concretes in which various integral waterproofing compounds and so-called alkali-proof compounds have been employed have failed to show that there is any advantage to be gained by using them, in fact most specimens so treated show less resistance to the action of the salts in the ground water than similar blocks that have not been treated.

Chemical Work

Dr. T. Thorvaldson, Director of the Chemical Investigation, has continued to co-operate in the field experiments on blocks, analyses being made from time to time of the ground water from the experimental plots as well as some of the water-proofings and integral compounds used in the field work.

The work on the action of sulphate solutions on Portland cement as mentioned in the last report, where intimate contact was affected by shaking the powdered cement with various solutions has been discontinued for the present as the interpretation of the results obtained must depend largely on work with the individual substances present in cement. Further, satisfactory methods for analysing the solid phase after decomposition so as to determine the quantity of each chemical substance present, were not obtained. The work done on the effect of hydrogen-ion concentration on disintegration of cement has given some interesting results, and this method is being used in all the series of experiments where applicable. When large enough samples of the silicates and aluminates contained in cement are obtained we intend to carry on further work on electroendosmosis with membranes of those substances in the pure state with the hope of getting at the fundamental factors in the effect of alkalinity on the deterioration of concrete.

The work on the effect of salt solutions on the contraction and expansion of mortars is still being continued and promises to supply a method of connecting up the microscopic work with the results on briquettes and bars.

The experiments on the pure constituents of Portland cement have got well started. Small quantities of the three compounds tricalcium aluminate ($3CaO.\ Al_2O_3$), tricalcium silicate ($3CaO.\ SiO_2$), and dicalcium silicate ($2CaO.\ SiO_2$) have been prepared using very pure raw materials. These raw materials were white marble, containing 98.8 per cent $CaCO_3$, as the source of calcium; commercial flint, containing 99.5 per cent SiO_2 as the source of silica; and pure alumina made in the laboratory from alum as the source of Al_2O_3.

The preparation of the three above-mentioned compounds involved from eight to ten heat treatments of the mix, the furnace being held at the proper temperature for a period of three or four hours. The resulting clinker was withdrawn and suddenly cooled and then finely ground. This process was continued till microscopic examinations showed that the product was entirely

homogeneous, special tests being made to ensure the entire absence of free lime.

First a series of tests was made with the three constituents of cement and solutions of sodium sulphate and magnesium sulphate. All of the compounds were attacked and decomposed, but the time required for the decomposition varied, being greatest with the dicalcium silicate. Samples of each of the compounds were hydrated and two series of tests made with each of the hydrated constituents. One series was made with solutions of varying concentration of sodium sulphate and one with solutions of magnesium sulphate of similar strengths. All of these hydrated compounds were decomposed by the sulphate solutions, the progress of the decomposition being observed with the petrographical microscope and a record kept of the changes by means of photo-micrographs. These tests are not yet completed.

The aluminates present in the French high-alumina cements are also being prepared and these will be studied in the same way.

The writer took the opportuuity given by a visit to Toronto in May of this year to go to New York in order to have a conference with the members of the committee of the National Research Council dealing with the deterioration of cement in sea water. He spent a day in conference with Wm. G. Atwood, Director of the Committee, and Mr. A. A. Johnson, Assistant to the Director. It is gratifying that the Committee of the National Research Council has come to the same conclusion as your Committee on Deterioration of Concrete came to several years ago, namely, that the only reasonable method of attack is to make an extended study of the fundamental reactions of cement clinker and hydrated cement with salt solutions. This makes their chemical problem identical with ours as far as it is a laboratory problem. The committee of the National Research Council has not progressed further than to plan their chemical work, but we look forward to close co-operation when they begin their work.

Financial

The following summary of expenditures and receipts as to December 1, 1923, is submitted, a detailed and itemized statement of expenditures to December 1, 1922, was sent to the financial supporters of this research last year, and a further itemized statement of all expenditures from December 1, 1922, to December 1, 1923, is being sent this year.

TOTAL EXPENDITURES TO DECEMBER 1, 1923

General—	
Committee meetings, travelling expenses	$ 1,628 66
Miscellaneous, telegrams, office expenses, etc	353 85
	$ 1,982 51
Physical Tests—	
Travelling allowances and expenses	$ 1,123 66
Materials and special equipment	1,696 11
Freight and cartage	325 79
	$ 3,145 56
Chemical Research—	
Travelling expenses	$ 278 45
Salaries	13,828 72
Materials and equipment	4,517 90
	$18,625 07
Grand Total	$23,753 14

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TOTAL RECEIPTS TO DECEMBER 1, 1923

	1921	1922	1923	Total
	$	$	$	$ cts.
Research Council	5,000	5,000	5,000	15,000 00
Canada Cement Co	3,000	3,000	3,000	9,000 00
Saskatchewan	3,000	3,000	3,000	9,000 00
Alberta	1,000	1,000	.....	2,000 00
Canadian Pacific Railway	1,000	1,000	1,000	3,000 00
City of Winnipeg	200	200	300	700 00
Interest on Bank Account	.....	.....	.....	139 41
Total Receipts	.....	.....	.....	38,839 41
Total Expenditures	.....	.....	.....	23,753 14
Balance in Bank	.....	.....	.....	15,086 27

EXPENDITURES YEAR DECEMBER 1, 1922 TO DECEMBER 1, 1923

General		$ 134 64
Physical		22 18
Chemical—		
Salaries	$ 6,794 18	
Materials	595 17	
		7,389 35
Total		$ 7,546 17

From the above statements it will be seen that the financial situation as far as the committe is concerned is quite satisfactory. We have actually received the third payments from all contributors with the exception of the province of Alberta, who have intimated that owing to the stringency of their financial affairs it would be impossible for them to make their third payment.

On the other hand the city of Winnipeg very generously increased their contribution this year by 50 per cent.

The expenditures for the past year as will be noted were expended almost entirely on the chemical work and as salaries constituted the major portion, it will be seen that on the present basis we have sufficient funds to continue our research for another two years without further contributions.

APPENDIX H

Report of Associate Committee on New Brunswick Forest Problems

Acting on representations made by the Department of Lands and Mines of the province of New Brunswick, the Research Council made a grant of $5,000 to determine, if possible, methods and costs of re-seeding recently burned land, old burns not restocking and certain types of cut-over lands. The Research Council arranged for this investigation to be carried on jointly by the Dominion Forestry Branch and the Forestry Service of the province of New Brunswick, the funds for the investigation being furnished by the Research Council. The work is directed by an Advisory Board, consisting of two members of the Dominion Forestry Branch, the Deputy Minister and the Provincial Forester of the province of New Brunswick. Two associate members were elected to this board, viz., a professor from the University of New Brunswick Forest School and the Director of the Dominion Entomological Department for New Brunswick. This board is directly responsible to the Research Council of Canada.

The field work completed to date includes the seeding of sixty acres of recently burned land, forty acres being seeded on the Tabusintac watershed, Northumberland county, and twenty acres on Grog Brook watershed, Restigouche county. The area seeded was divided into six different areas of ten acres each, covering six different conditions, permanent sample plots of one acre each being established on each area by the Dominion Forestry Branch. The seeding was done mainly by the spot method, the ground being scraped with a mattock and the seed lightly covered. One area was seeded in the twitching trails upon completion of a logging operation. This was done by a crew at the same time the sample plots were established. Other methods tried were broadcasting and raking in.

It had been planned to seed one hundred acres, but on account of the ground freezing early and scarcity of certain kinds of seed such as white spruce and red pine, the work was curtailed to a great extent and a total of sixty acres was seeded.

The seed used amounted to fifty-eight and one-quarter pounds, fifty-four being white pine, one pound red pine and one-half pound jack pine. Two and three-quarter pounds white spruce seed was supplied by the federal service. The cones were collected and the seed extracted during the autumn before the seeding commenced. As there was very little white spruce and red pine cones last season, enough white pine cones were collected for the three seasons. A total of 424 bushels of white pine, $8\frac{1}{2}$ bushels of red pine and $19\frac{1}{4}$ bushels of jack pine were secured, the pickers being paid from $1 to $2 per bushels according to species and location.

The cones were extracted in an improvised room at the D.S.C.R. building, 293 pounds of white pine, 6 pounds of red pine, and 17 pounds of jack pine being secured. This yield of nearly three-quarters of a pound per bushel is considered a high average. Samples of the seed were shipped to Ottawa for testing as to germination, and the seed found to be of very high quality.

TABUSINTAC AND GROG BROOK DAM

Reseeding was done in sections burned over during the fire season of 1923 only, the object being to devise a method to give our more desirable rapid growing and valuable species, such as white spruce, white pine, etc., the advantage of a start over the more inferior species which ordinarily form the first reproduction on a large percentage of our burned over lands.

The seeding party was organized at Fredericton on October 11, and departed on the night train for Newcastle. On the 12th, two motor trucks were secured to move the party and supplies to the mouth of the Eskedelloc portage, a point 22 miles north of Chatham. From this point the supplies and equipment were moved by team, over a portage road $4\frac{1}{2}$ miles, to Connell's Club House at the Forks, where the Eskedelloc joins the Tabusintac. The following day was devoted to establishing camp, selecting areas to be seeded, etc. Surveying areas for seeding was commenced on the 16th and the first seeds were planted on the northern end of area number one on the 17th.

These areas contain ten acres each and a boundary is defined around each by squared posts set at intervals of from two to two and one-half chains. Posts are about 4 inches x 4 inches painted white with red caps. Corner posts bear number of area and date of establishment.

This work was carried on in co-operation with the federal government, which established permanent plots of one acre in each ten-acre area. Every third row of seed spots in the permanent acre plots was tagged and numbered, the tags being placed on stakes 2 inches x 2 inches x 18 inches long. The purposes of these lots are for collecting data and recording annual growth of the species under various conditions.

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Four areas comprising a total of forty acres were planted at Tabusintac between October 16 and 31. When the party moved to Grog Brook dam in Restigouche county, a point 35 miles from Campbellton on the International railway, and completed two more areas containing ten acres each, before being compelled to disband on account of the ground being frozen.

Disbandment took place on November 15, after the party had been in the field thirty-six days and established six areas or a total of sixty acres.

With the exception of area No. 4 all planting was done by the spot method, spots about 12 inches by 12 inches being made with a mattock, down to mineral soil where approximately fifteen seeds were dropped and covered lightly with soil. The spots were lined out with pickets and made at intervals of five feet.

DESCRIPTION OF AREAS AND SEEDING

Area No. 1 lies 12.5 chains magnetic north and south by 8.00 chains east and west, severely burned, softwood type, light crown cover remaining, gentle to moderate southeast slope, shallow soil, seeded with white pine. Strip one-half chain wide across south and broad cast, west half raked, east half left as it fell. Permanent acre plot, south half seeded with white pine, south half with white spruce.

Area No. 2 lies 10 chains by 10 chains magnetic north and south and is subdivided, sub-area "A" contains 2 acres, barreny spruce type, severely burned, medium crown cover, flat aspect, damp heavy moss covered soil, seeded with white pine.

Sub-area "B" contains 7 acres, softwood type severely burned, light crown cover, moderate to steep north facing slope, light sandy soil, seeded with white pine. Permanent acre plot lies partly in sub-area A and partly in B, north half is seeded with white spruce, south half with white pine. Strip one-half chain wide across south end of sub-area B broadcast, west half raked, east half left as it fell.

Area No. 3 lies 10 chains N. 3°E. by 10 chains, S. 87°E. subdivided. Sub-area "A" contains four acres, softwood type, lightly burned, heavy crown cover on south half, moderate on north half, moderate north facing slope, shallow, sandy soil.

Sub-area "B" contains five acres, softwood type, severely burned, light crown cover, moderate to steep north facing slope, light sandy soil, seeded with white pine. Permanent acre plot lies in south end of sub-area B. West half seeded with white pine, east half with white spruce.

Area No. 4 lies 10 chains N. 43°E. by 10 chains N. 47°W. This area was selected in a logging operation where cutting had just ceased. Numerous trails occurred as the area had been practically clean cut. Seeding was done on trails only. Area was subdivided. Sub-area "A" contains 4.2 acres, softwood type, chiefly jack pine, severely burned, practically no crown cover, due to cutting, gentle westerly slope, light sandy soil, seeded broadcast on trails with white pine and raked.

Sub-area "B" contains 4.8 acres. Similar aspect seeded with white pine broadcast on trails, left as it fell. Permanent acre plot situated chiefly in sub-area "A" west half seeded with white pine, east half with white spruce.

Area No. 5, located at Grog Brook dam. Lies 10 chains by 10 chains magnetic north and west, subdivided. Sub-area "A" contains 2.5 acres, lightly burned, softwood type, heavy crown cover, flat aspect, moist sandy soil seeded with white pine. Permanent plot of one-half acre located on northern end, seeded with white pine. Sub-area "B" contains 6.5 acres, severely burned and open, mixed-wood type, small percentage white birch, shallow soil, flat

aspect generally, seeded with white pine. Permanent plot one-half acre, three-quarters seeded with mixed white and red pine, one-quarter with jack pine. A strip one-half chain wide across the north side of this area was broadcast and central part raked.

Area No. 6. This area is divided into three sub-areas A, B, and C. Sub-area "A" contains 2.5 acres, lightly burned, heavy crown cover at present, moderate north slope, sandy soil, seeded with white pine.

Sub-areas B and C are severely burned, practically no crown cover, light sandy soil, moderate north facing slope, seeded with white pine. Permanent plot one-half acre in sub-area A, north half seeded with jack pine, south half mixed white and red pine. A strip one-half chain wide across northern side of sub-areas A and B was sown broadcast and left as it fell.

Maps accompanying this report show location of areas and permanent plots. Areas are tied by traverse to permanent land marks. The Tabusintac section is tied to a hub set at N.E. corner of Connell's Club House and the Grog Brook dam section is tied to mile post 30 + 100.

The party consisted of seven men including the cook and chief, while the federal government party, establishing permanent plots, consisted of three men and the chief, and boarded with the provincial party, paying a proportional rate for rations and cooking. Three men comprised a crew, two making spots with mattocks and one following sowing and covering the seed. The work progressed rather slowly on account of a shortage of labour and weather conditions, whereas only two seeding crews were used three or even four might have been, thus greatly reducing the overhead.

Following is a distribution of the time, showing amount devoted to the different phases of the work:—

Time travelling	6 days	or 16·7%	of total
Time lost on account of rain	7 "	19·4%	"
Sundays	5 "	13·9%	"
Time surveying areas	2 "	5·6%	"
Time making posts	3½ "	9·7%	"
Time painting posts	2½ "	6·9%	"
Time planting seed	10 "	27·8%	"
Totals	36 "	100%	

QUANTITY SEED PLANTED

Areas 1, 2 and 3 received	30 pounds of white pine		
Area 4 seeded on trails received	3½ "	"	
Areas 5 and 6 received	20½ "	"	
Total white pine planted	54 pounds,	area	57·13 acres
Total red pine planted	1 pound,	"	·62 "
Total jack pine planted	½ pound,	"	·25 "
Total white spruce planted	2¼ pounds,	"	2·00 "

Omitting area No. 4 an average of 1·06 pounds per acre of white pine was applied.

PLANTING COST

One thousand four hundred and eighty dollars and eighty cents, or $24.68 per acre.

Itemized statement of costs based on percentage of time devoted to various phases of the operation:—

	%
Planting	27·8
Surveying	5·6
Post making	9·7
Post painting	6·9
Travel	16·7
Weather	19·4
Sundays	13·9

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An amount for cost of seed of $3.95 added to $24.68 planting cost per acre makes average cost per acre $28.63. It must be borne in mind that in actual practice much lower priced labour would be used. There would be no cost for surveying or making posts and the seed spots need not be marked, all of which is necessary in the case of the experiment. It is expected that with the experience gained in 1923 this cost can be very materially reduced both in the cost of seed and in planting.

APPENDIX I

Report of Associate Air Research Committee

During the year 1923-24 three meetings of the committee were held—May 25, 1923, November 20, 1923, and February 9, 1924.

Among the subjects which have engaged the attention of the committee, but in connection with which it was not found possible to undertake any experimental work, may be mentioned:—

Difficulties experienced with regard to the reliability of catalytic lamps.
The promising performance of a new type of internal combustion engine, the Attendu engine.
The failure of a metal air screw in service.
Possibilities of washing used lubricating oil for re-use in æro engines.
Use of skis for landing æroplanes in winter flying.
General progress of æronautical research.

As regards the last named, valuable information was brought back and communicated to the committee by Colonel Stedman, after his visit to Washington and various flying fields in the United States in the spring of 1923.

During the year research has been carried out under the auspices of the committee in regard to the following subjects:—

Deterioration of lubricating oil through storage at low temperatures (Professor Watson Bain).
Difficulties arising due to freezing of various types of radiator, and measures to be adopted to minimize this trouble (Professor Robb).
Behaviour of rubber shock absorber cord at low temperatures (Professor Wilson).
Wall effect in wind channels (Professor Parkin).
Use of anti-freeze mixtures (Professor Robb).

Very encouraging reports have been received of the practical utility of the results obtained from investigations carried out under the committee, these having been found of considerable advantage in connection with the programme of winter flying carried out by the R.C.A.F., at High River, Borden, and elsewhere.

During the year the reconstruction of the Toronto Wind Channel has been completed and its calibration and preparation for experimental work has been successfully carried out.

APPENDIX J

Report of Delegate to the Second Pan-Pacfic Science Congress

The second Pan-Pacific Science Congress assembled at Melbourne, Victoria, August 13, 1923, and continued its sessions in that city until August 22, when it adjourned to Sydney, New South Wales, and was in session there from August 24 to September 3. The congress was a representative one including, in addition

to numerous delegates from Australia and New Zealand, representatives from Great Britain, the United States of America, Japan, Java, Malaya, certain of the Australasian island groups and Canada. I cannot at present give the number of delegates in attendance, but it was a goodly number and sufficiently representative to guarantee a highly successful conference. Canada was represented by Dr. C. M. Fraser, Dean Brock, of the University of British Columbia, and Prof. J. P. McMurrich.

As was natural, the interests of the congress centred about Australasian affairs, and so far as the more northerly nations, such as Japan and especially Canada were concerned, the proceedings of the congress yielded only incidental results. The Canadian delegates took part in the work and discussions of the sections in zoology, geology and anthropology, but the chief result of the participation of Canada in the congress was the feeling it aroused that the Dominion appreciated the importance of the congress and was desirous of co-operating in the fulfilment of its purposes. This feeling was very strong, especially on the part of our Australian colleagues and many were the expressions of pleasure (both privately and publicly) that Canada should show an interest and should co-operate in the problems of the Pacific. For this reason alone I am confident that the participation of the Advisory Council and of the Dominion Government in the congress was well worth while. I may state that the next meeting of the congress is to be held in Japan in 1926, and it is to be hoped that Canada will be well and fully represented, that this impression may be maintained and strengthened and since it is probable that on this occasion the problems of the North Pacific will receive greater attention.

Of general results of the deliberations of the congress the following may be mentioned as affecting Canada:—

1. It was recommended that the various countries should establish plant quarantines for protection from plant diseases and insect pests.

2. It was recommended that provisions be made for the teaching of anthropology in the Australian universities, since a sympathetic method of dealing with the governing native races can be developed only on a wide and sympathetic knowledge of native life and thought. This recommendation, though intended only for Australia, is equally pertinent for Canada.

3. It was recommended that steps be taken looking to the speedy erection of wireless stations in all countries bordering on the Pacific, capable of communicating directly with each other, and that such stations shall keep daily records on an approved basis with regard to static, its effect on wireless communication and its relation to meteorological conditions.

4. It was recommended that the Australian National Research Council appoint a committee on the investigation of the temperature, salinity, hydrogen ion concentration and currents of the Pacific ocean, the committee to consist of at least one member of each country represented at the congress in which such investigations of the Pacific ocean are now being carried on.

5. It was recommended that a series of observations be instituted in the Pacific ocean in critical areas of crustal unrest for the accurate determination of latitude and longitude, these observations to be repeated once in every five years.

6. It was recommended that an International Bureau of Animal Health be established.

7. The congress affirmed the desirability of establishing further faunal sanctuaries in Pacific countries where interesting and valuable native animals are in danger of extinction.

8. That it is desirable that the investigation and survey of the terrestrial and marine fauna and flora of countries in and surrounding the Pacific should be proceeded with.

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9. It was recommended that steps should be taken by the Pacific countries concerned for the study and preservation of the various valuable marine mammals such as fur seals, sea otters, whales, elephant seals and dugongs, now in danger of extinction.

10. The congress desired to urge upon all Pacific countries the importance of carrying on researches on all those aspects of oceanography, physical and biological, that are essential to an understanding and proper utilization of the organic productiveness of the Pacific.

In conclusion it may be stated that one of the most interesting events of the congress was the arrival in Sydney harbour of the United States cruiser *Milwaukee* which, equipped with the new Sonic sounding device, had made a traverse from San Francisco to Sydney with the object of showing the applicability of the device to the determination of deep sea topography. It is to be hoped that the device may at an early date be applied to the determination of the topography of the continental shelf on both our coasts.

APPENDIX K

Report of the Analyses of Commercial Salts Used in Connection with the Fishing Industry in the Maritime Provinces

Prepared by J. F. LOGAN, Ph.D., *McGill University, Montreal, Que., under the direction of the Associate Biological Committee of the Research Council*

In studying the table of analyses below, the following facts should be noted:—

1. All analyses were carried out in duplicate, the report in nearly all cases being the mean of two determinations.

2. The salts present are chlorides and sulphates, and the methods of analysis do not permit a determination whether any of the sodium present occurs as sulphate. As, however, the amount of SO_4 present is very minute and as Malagash samples are not hygroscopic it may be safely assumed that the calcium and magnesium present are there as sulphates, leaving a residue of the SO_4 combined with a very minute amount either of the sodium or potassium, or of both. Assuming that this residue is combined with the potassium alone, the sodium chloride will be 98.5 per cent of each sample of Malagash salt.

3. The Malagash salt (with the possible exception of the Liverpool) was by far the least hygroscopic of any sample submitted. This lack of moisture-absorbing quality is certainly a valuable one from the fish-curing standpoint. Fish cured with Malagash salt should remain dryer than those dried with the foreign salts, and therefore should keep much better. The relatively high content in moisture-absorbing calcium chloride or magnesium salts of the imported samples (with the exception of the Liverpool, which has probably been purified) renders them less serviceable from this standpoint.

4. According to Tressler (U.S. Bureau of Fisheries, Document No. 884), the calcium and magnesium are the most objectionable constituents of salts used in curing fish, from the fact that rapid "striking" is prevented by their presence. It will be seen from the table that the Malagash salt is about as good as the Liverpool salt, and much better than any of the others from this standpoint. The Malagash has the least magnesium of any salt analyzed.

5. The only factor which detracts from the value of the Malagash salt is its relatively high percentage of insoluble matter (silica, sand, etc.). This inert matter should have little influence upon the value from a fish-curing standpoint if care is used in frequently cleaning out butts. If purification of Malagash salt were contemplated, this insoluble matter could be very easily removed by settling basins.

6. The Malagash salt, therefore, seems to be a very valuable material in that it is relatively pure in so far as calcium and magnesium are concerned.

—	Malagash	Trapani	Yvizia	Liverpool	Turk's Island
	%	%	%	%	%
SO_4 (of the sulphates)	0·952	1·720	1·142	0·656	1·753
Cl chlorine	59·845	58·935	59·620	59·855	58·745
K potassium	0·195	0·435?	0·292	0·136	0·346
Ca calcium	0·324	0·235	0·306	0·262	0·544
Mg magnesium	0·005	0·660	0·206	0·011	0·480
FeO iron and Al_2O_3 aluminium	none	traces	traces	none	traces
Silica SiO_2, sand etc. insol. in dil. HCl.	0·347	0·141	0·021	0·010	0·039
CO_3 carbonate ion	none	traces	traces	none	traces

APPENDIX L

Nitrogen Fixation

Extracted from Bulletin No. 11 of the Research Council

The effect of the war since its cessation upon most individuals, and upon most nations, has been such as to cause them, of necessity, to give thought to things of the immediate present rather than of the future, so that nitrogen fixation has by no means received that attention which its tremendous importance during the period of conflict showed that it merits.

It is evident from data already presented in this report that Germany's capacity in production of nitrogenous materials is, compared with that of any other country, stupendous. France takes the matter seriously and effort is being made, apparently with some success, to obtain definite action on the part of the Government in regard to the establishment of a nitrogen industry of a size bearing some reasonable relation to the country's requirement, special attention being given to the Haber and Claude processes. Activity in Italy is indicated by the attempts apparently being made to establish the Casale and Fauser processes of ammonia synthesis on a commercial basis. Two or three firms in Great Britain are doing their best to go ahead with fairly large schemes.

In the United States outside of the work being done by the Government's Fixed Nitrogen Research Laboratory, the chief interest at present is centred in the possible disposal of the great Muscle Shoals plant, for which Henry Ford has made an offer of purchase. Some time ago it seemed not unlikely that this offer would be rejected, but the latest news indicates that it is now being given favourable consideration by the United States federal officials subject to certain conditions to be imposed by the Government. In Norway, the great nitrogen fixation plants are in a position very different from that which they occupied before and during the war; some of them are reported as being likely to be permanently devoted to other uses. Denmark is said to be considering the matter of establishing some nitrogen fixation process, but for a year or so now there has been no news of development in Spain, India, Japan, Australia or New Zealand, from all of which countries during, and for a short period after, the war there came reports of certain activities in regard to nitrogen fixation. It should be remarked that even in those countries (exclusive of Germany) mentioned above where the greatest interest in nitrogen is being manifested, the actual progress, so far as construction of commercial plants is concerned, if not negligible, at least is quite small.

Turning now to Canada, the great cyanamide works at Niagara Falls, Ont., is still operating, but the plant of the American Nitrogen Products Company in British Columbia is said to have been disposed of.

It was reported some time ago that a commercial sized plant of the Island (arc process) type was to be established at Niagara Falls, Ont., but so far this has not been done. There is, however, a very recent report in "Canadian Chemistry and Metallurgy" for January, 1924, which states that Dr. Island's company, Electro Chemicals, Ltd., "has secured power rights on the canal at Thorold, Ont." Presumably this is on the Welland canal, in which case the rights were no doubt secured from the Dominion Government.

Canada is undoubtedly well fitted, from the point of view of natural resources, for the establishment of a nitrogen fixation industry on a large scale, by one or more of the existing processes.

The arc process, which is said to be capable of producing nitric acid more cheaply than almost any other known process (see Final Report of Nitrogen Products Committee of Great Britain) and which can be operated by off-peak power, would seem to be peculiarly well adapted to Canada on account of the availability of relatively cheap hydro-electric power. Again, the vast stores of lignite and peat are capable of yielding enormous quantities of nitrogen under suitable treatment.

Such projects as the development of the St. Lawrence river for power purposes, as well as the work of the Dominion Fuel Board which may lead to the establishment of plants for the carbonization of coal, must be looked upon as having a direct bearing on the nitrogen fixation problem in Canada, as it is in these directions that we must look for means of establishing one or other of the various processes.

The yield of grain per acre in Canada is only about one-half what it is in many European countries where fertilizers are used extensively, and since this country is primarily agricultural, and likely to remain so, it must of necessity become more and more dependent on the use of fertilizers, of which the most important single element will be nitrogen. There will also be a large and ever-growing demand for nitrogen for use in many other industries.

APPENDIX M

Fellowship, Studentship and Bursary Graduates

The following is a complete list of persons who have been enabled to secure special post-graduate training in science under Research Council Fellowships, Studentships or Bursaries and who, having completed their work under these awards prior to 1923-24, now occupy the position indicated in each case:—

Name	Present Occupation
F. M. Archibald, B.Sc.	Chemist, Imperial Oil Refineries, Ltd., Sarnia, Ont.
Miss M. Anderson, B.A., M.Sc.	No information.
H. C. Bates, B.A., M.A.	Instructor in Physics, Lafayette College, Easton, Pa.
A. H. Bell, B.A.	Fellow in Geology, University of Chicago, Chicago, Ill.
H. P. Bell, B.Sc., M.Sc., M.A., Ph. D.	Associate Professor of Biology, Dalhousie University, Halifax, N.S.
G. H. Berkeley, B.A., M.A., Ph.D.	Pathologist-in-charge, Dominion Field Laboratory of Plant Pathology, St. Catharines, Ont.
Miss E. L. Bishop, B.A., M.A.	Teacher of Mathematics, Collegiate Institute, Picton, Ont.
H. A. Braendle, B.A., M.A.	Assistant superintendent, Ames-Holden Tire and Rubber Co., Ltd., Kitchener, Ont.
O. C. Bridgeman, B.A., M.A.	Associate Professor of Chemistry, University of Alberta, Edmonton, Alta.
J. W. Burns, B.Sc., M.Sc.	Instructor in Chemistry, University of Western Ontario, London, Ont.
Miss F. M. Cale, B.A., M.A.	Married.
Miss M. L. Clark, B.A., M.A.	Teacher of Mathematics, Collegiate Institute, Sarnia, Ont.
R. J. Clark, B.A.	Demonstrator, Department of Physics, McGill University, Montreal, Que.
Miss L. Corbett, B.A., M.A.	Married.
Miss A. E. Dempsey, B.A., M.A.	Assistant Chemist, Maple Leaf Milling Co., Port Colborne, Ont.
E. P. Dolan, B.Sc., M.A., M.Sc.	Deceased.
V. H. Emory, B.A. Sc.	Research, Abitibi Power and Paper Co., Iroquois Falls, Ont.
T. S. C. Fawcett, B.A. Sc., M.A. Sc.	Research, University of Toronto, Toronto, Ont.
R. E. Foerster, B.A., M.A., Ph.D.	Research, Dominion Government Hatcherics at Cultus Lake and Harrison Lake, B.C.
H. R. Foreman, B.A., M.A.	Assistant Manager, Keith's Electric Refrigeration Co., Ltd. Toronto, Ont.
Miss C. W. Fritz, B.A., M.Sc., Ph.D.	Research, University of Toronto, Toronto, Ont.
W. A. Gale, B.A.Sc., M.Sc.	American Trona Corporation, Trona, Cal.
B. E. Gilbert, B.A., M.A.	Student at Botany Graduate School, University of Chicago, Chicago, Ill.
Miss K. F. Godwin, B.A., M.Sc., (now Mrs. J. W. Pinhey).	Holding Philip Carpenter Fellowship in Zoology, McGill University, Montreal, Que.
C. Greaves, B.Sc., M.Sc., Ph.D.	Junior Chemist in Division of Wood Preservation, Forest Products Laboratories, Montreal, Que.
R. Hamer, B.A., M.A., Ph.D.	Instructor in Physics, University of Wisconsin, Madison, Wis.
R. H. Harris, B.A., M.A.	Chemist, Quaker Oats Company, Saskatoon, Sask.
W. H. Hatcher, B.A., M.Sc., Ph. D.	Associate Professor of Chemistry, McGill University, Montreal, Que.
E. Hearle, B.S.A.	In charge of mosquito investigation, Entomological Laboratory, Banff, Alberta.
G. H. Henderson, B.A., B.Sc., M.A., Ph. D.	Professor of Mathematical Physics, King's College, Dalhousie University, Halifax, N.S.
Miss E. M. Hill, B.A., M.Sc.	No information.
H. J. C. Ireton, B.A., M.A.	Demonstrator and Research in Physics, University of Toronto, Toronto, Ont.
A. B. Jackson, B.S.A.	Assistant Plant Pathologist, Dominion Laboratory of Plant Pathology, St. Catharines, Ont.
W. F. James, B.A., M.Sc., Ph. D.	Assistant Geologist, Geological Survey, Ottawa, Ont.
Miss M. B. Kearney, B.A., M.A.	Instructor in Mathematics and Physics, Converse College, Spartanburg, S.C.
K. H. Kingdon, B.A., M.A., Ph. D.	Physicist, Research Laboratory, General Electric Co., Schenectady, N.Y.
W. A. Lawrance, B.A., M.A., Ph.D.	Stanley Professor of Chemistry, Bates College, Lewiston, Me.
J. F. Lehmann, B.Sc., M.Sc.	Holding 1851 Exhibition Scholarship in Cambridge, Eng.
A. H. Leim, B.A., Ph.D.	Ichthyologist to Biological Board of Canada, Biological Station, St. Andrews, N.B.
G. H. W. Lucas, B.A., M.A., Ph.D.	Research, Department of Chemistry, University of Toronto, Toronto, Ont.
D. G. MacGregor, B.A.	Professor of Physics, Mount Allison University, Sackville. N.B.
C. A. Mackay, B.A., M.A.	Instructor in School of Public Health, Harvard University, Boston, Mass.
A. W. McCallum, B.Sc.F., M.A.	Division of Botany, Department of Agriculture, Experimental Farm, Ottawa, Ont.
W. H. McCurdy, B.A., M.A.	Instructor, Palmer Physical Laboratory, Princeton University, Princeton, N.J.
J. L. McDonald, B.A.	Harvard Medical School ,Cambridge, Mass.
J. W. McKinney, B.Sc., M.Sc., Ph. D.	Chemist, Department of Health, Ottawa, Ont.
H. R. McLarty, B.A., M.A.	Pathologist-in-charge, Dominion Laboratory of Plant Pathology, Summerland, B.C.

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Name	Present Occupation
Stuart McLean, B.A., M.A.	Experimental Engineer, Laboratory of National Lamp Works, General Electric Co., Nela Park, Cleveland, Ohio..
T. C. McMullen, B.A., M.A., Ph.D.	Dean, Albert College, Belleville, Ont.
W. C. McQuarrie, B.A., M.A.	Instructor in Physics, Lafayette College, Easton, Pa.
J. A. McRae, M.A., Ph.D., F.I.C.	Associate Professor of Chemistry, Queen's University, Kingston, Ont.
John Melville, B.A. Sc., M.A. Sc.	Chemist, Powder Point Works of the Giant Powder Company of Canada, Ltd., Nanoose Bay, B.C.
Miss B. K. E. Mossop, B.A., M.A., A.A.A.S.	Assistant Pathologist, Queen Alexandria Sanatorium, London, Ont.
Miss D. E. Newton, B.S.A., M.Sc.	Hudson's Bay Fellowship, University of Manitoba, Winnipeg, Man.
Miss M. Newton, B.S.A., M.Sc., Ph.D.	Associate Professor of Biology, University of Saskatchewan, Saskatoon, Sask.
H. G. Oddy, B.A., M.A., Ph.D.	Lecturer in Chemistry, University of Alberta, Edmonton, Alberta.
Miss M. E. M. Olding, B.A.	Married.
J. F. Phillips, B.A. Sc., M.A.	Teacher, Riverdale Technical School, Toronto, Ont.
H. N. Racicot, B.A.	Pathologist-in-charge, Dominion Laboratory of Plant Pathology, Ste. Anne de la Pocatiere, Que.
P. V. Rosewarne, B.A., M.A.	Chemist in charge, Oil Laboratory, Fuel Testing Station, Department of Mines, Ottawa, Ont.
W. W. E. Ross, B.A.	Assistant Magnetician, Meteorological Service, Toronto, Ont.
J. E. Saunders, B.Sc., M.Sc.	Mining Engineer, South American Gold Areas Ltd., Sao Bento, E. F. C. B. Minas Geraes, Brazil.
D. A. Scott, B.A., M.A.	Associate Director, Insulin Division, Connaught Laboratory, University of Toronto, Toronto, Ont.
W. F. Seyer, B.A., M.Sc., Ph.D.	Associate Professor of Physical Chemistry, University of British Columbia, Vancouver, B.C.
Miss E. Shanly, B.A., M.Sc.	Research in Department of Pathology, McGill University Montreal, Que.
W. W. Shaver, B.A., M.A., Ph.D.	Research Assistant in Department of Physics, University of Toronto, Toronto, Ont.
Miss J. D. Spier, B.A., M.Sc.	Biochemical work in Department of Metabolism, Montreal General Hospital, Montreal, Que.
H. N. Stephens, B.A., M.A., Ph.D.	Instructor in General Inorganic Chemistry, University of Minnesota, Minneapolis, Minn.
O. J. Walker, B.A., M.A., Ph.D.	Associate Professor of Chemistry, University of Alberta, Edmonton, Alta.
E. F. Whyte, B.A., M.A., Ph.D.	Assistant Chemist, Department of Health, Halifax, N.S.
D. Wolochow, B.A., M.A., B.Sc.	Research, Department of Chemistry, University of Saskatchewan, Saskatoon, Sask.
C. A. H. Wright, B.Sc., M.Sc., Ph. D.	A. D. Little Inc., Charles River Road, Kendall Square, Cambridge, Mass.
E. G. Young, B.A., M.Sc., Ph.D.	Professor of Biochemistry, Dalhousie University, Halifax, N.S.
J. F. T. Young, B.A., M.A., Ph.D.	Associate Professor of Physics, University of Manitoba, Winnipeg, Man.....

APPENDIX N

Fellowships, Studentships and Bursaries Awarded, 1923-24

FELLOWSHIPS

Name	Where held	Subject of Research
E. H. Boomer, B.Sc., (Univ. of B.C.) M.Sc., Ph.D. (McGill) (Ramsay Memorial Fellowship).	Department of Physical Chemistry, Cavendish Laboratory, Cambridge University, England.	The forces of molecular attraction in various substances in the gaseous conditions.
F. B. Adamstone, B.A., M.A., Ph.D. (Toronto).	Department of Biology, University of Toronto.	The distribution and economic importance of the organisms constituting the bottom fauna of lake Nipigon.
D. S. Ainslie, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Structure of lithium red line and its relation to atomic structure.
P. G. Hiebert, B.A. (Manitoba) M.A. (Toronto), M.Sc., Ph.D. (McGill).	Department of Chemistry, McGill University.	Vapour pressure of pure hydrogen peroxide.
Miss M. Levi, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	Soft X-rays.
A. D. Macallum, B.A. (Toronto), M.Sc., Ph.D. (McGill).	Department of Chemistry, McGill University.	Synthesis of rubber homologues and characterizing these by comparison with natural rubber.
D. M. Morrison, B.Sc. (Univ. of B.C.), M.Sc., Ph.D. (McGill).	Department of Chemistry, McGill Univeristy.	Molecular compound formation and velocities of reactions at low temperatures and oxonium compound formation in the vapour state.
Miss Irene Mounce, B.A., M.A. (Univ. of B.C.), M.Sc. (Manitoba).	Department of Botany, University of Toronto.	Biology of fomes pinicola and some work in pholiota adiposa.
G. M. Shrum, B.A., M.A., Ph. D. (Toronto).	Department of Physics, University of Toronto.	Metastable helium and band spectra of hydrogen, helium and other gases at low temperatures.
H. G. Smith, B.A., M.A. (Toronto).	Department of Physics, University of Toronto.	The absorption and fluorescence of potassium vapour.
Miss E. M. Taylor, B.A., M.A. (Toronto).	Department of Chemistry, University of Toronto.	Effect of acid on the reproduction rate of yeast.
Miss M. Weinberg, B.A., M.A., M.Sc. (Manitoba).	Department of Physics, University of Toronto.	Spectrum of nitrogen.
R. E. Foerster, B.A., M.A. (Univ. of B.C.), Ph.D. (Toronto).	Department of Zoology, University of B.C.	Resigned.

STUDENTSHIPS

J. C. Forbes, B.A., M.A., (Saskatchewan).	Department of Biochemistry, McGill University.	Isolation of pepsin and the determination of some of its physical characteristics.
Miss M. A. Fritz, B.A. (McGill), M.A. (Toronto).	Department of Geology, University of Toronto.	The stratigraphy and palaeontology of the section exposed on Workman's Creek, Meaford, Ontario.
W. V. Howard, B.A., M.Sc., Ph.D. (McGill).	Department of Geology, McGill University.	Geology of Dalhousie and Campbellton. N.B.
S. Lehrman, B.A., M.A., (Toronto).	Department of Chemistry, University of Toronto.	Scattering of light by dust-free liquids.
F. R. Lorriman, B.A., M.A., Ph.D. (Toronto).	Department of Chemistry, University of Toronto.	Friedel-Crafts' reaction with derivatives of acenaphthene.
D. J. MacLeod, B.A., M.A. (Queen's).	Department of Bacteriology, Queen's University.	The action of hydrogen ion and salt concentration on the activity of bacteria with particular reference to food preservation.
J. H. Mennie, B.A., M.A., (Univ. of B.C.), B.Sc. (Oxford).	Department of Chemistry, McGill University.	Determination of the vapour density of gases under varying conditions of temperature and pressure.
L. A. Munro, B.A., M.A., (Dalhousie).	Department of Inorganic Chemistry, McGill University.	The adsorption of vapours by alumina.
H. C. Bates, B.A., M.A., (Toronto).	Department of Physics, University of Toronto.	Resigned.
E. P. Dolan, B.Sc., M.A., (St. Francis Xavier), M.Sc. (McGill).	Department of Geology, McGill University.	Died.
Miss J. D. Spier, B.A., M.Sc. (McGill).	Department of Botany, McGill University.	Resigned.

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BURSARIES

Name	Where held	Subject of Research
B. S. W. Buffam, B.Sc., M.Sc (McGill).	Department of Geology, McGill University.	The alteration of a mica tinguaite dyke Mount Royal, Que.
G. C. Chamberlain, B.S.A. (Ont. Agric. College).	Department of Botany, University of Toronto.	Life history of venturia inaequalis.
Miss H. D. Chataway, B.A., B.Sc., M.Sc. (Manitoba).	Department of Chemistry, University of Manitoba.	The photo synthesis of p. nitro benzyl bromide.
R. G. Corneil, B.Sc.(Queen's)	Department of Chemistry, Queen's University.	The laws of absorption of vapours in air, by means of liquids (a) absorption of acetone vapour in sodium bisulphite solutions (b) absorption of acetone vapours by water.
J. L. F. Germain, B.A. (Univ. of Montreal), A.R.C.S. (Imp. College, England).	Department of Industrial Chemistry. Royal College of Science, England.	Advanced analytical chemistry.
H. B. Hachey, B.Sc. (St. Francis Xavier).	Department of Physics, McGill University.	Measurement of air velocity with thermo junctions. The use of thermojunctions for the measurement of winter temperatures within trees; and allied problems with thermojunctions.
R. H. F. Manske, B.Sc., M.Sc. (Queen's).	Department of Organic Chemistry, Queen's University.	The mechanism of the condensation of carbony compounds with compounds containing an active methylene group.
J. E. Maynard, B.A., B.Sc. (Manitoba).	Department of Geology, University of Manitoba.	Conditions of deposition of the silts and clays of Lake Agassiz.
Miss A. P. Macdougall, B.A. (McMaster), M.A. (Univ. of B.C.).	Department of Biology, University of B.C.	The aphididae of British Columbia.
S. R. McDougall, B.A.Sc., M.A.Sc. (Univ. of B.C.).	Department of Chemistry, University of B.C.	Effect of various amounts of higher alcohols, esters, fatty acids and unsaturated hydrocarbons on the coefficient of static friction of mineral lubricating oils applied to different metal surfaces.
A. B. McLay, B.A., M.A. (McMaster).	Department of Physics, University of Toronto.	The ultraviolet spectrum with a fluorite spectrograph, starting on the elements boron and beryllium.
Miss A. I. McPherson, B.A., M.Sc. (McGill).	Department of Physics, McGill University.	Absorption of high speed β particles from uranium X.
D. D. Mossman, B.Sc. (McGill), M.A. (Toronto).	Department of Organic Chemistry, University of Toronto.	Dyes formed by the oxidation of a mixture of aluminium chloride and dimethyl-aniline.
Miss M. K. O'Brien, B.A., M.A. (Toronto).	Department of Physiology, University of Toronto.	The identification of insulin and the question of dosage.
H. B. O'Heir, B.A., B.Sc., M.Sc. (McGill).	Department of Geology, McGill University.	Dykes of the Mount Royal tunnel from west portal 3,200′ east.
Miss I. J. Patton, B.A., M.Sc. (McGill).	Department of Chemistry, McGill University.	Comparison of the absorption by charcoal of gaseous hydrocarbons of varying degrees of saturation.
A. L. Patterson, B.Sc., M.Sc. (McGill)	Department of Physics, McGill University.	Energy transformations between X and β radiations.
C. D. Reid, B.Sc., M.Sc. (Alberta).	Department of Physics, University of Alberta.	The ultra sonic beam.
H. L. Robson, B.Sc. (Sask.).	Department of Inorganic Chemistry, University of Saskatchewan.	Western alkali deposits from the standpoint of the phase rule.
D. C. Rose, B.Sc., M.Sc. Queen's).	Department of Physics, Queen's University.	Comparison of intensities of spectral lines of argon and other gases under different exciting potentials.
J. O. G. Sanderson, B.Sc., M.Sc. (Alberta).	Department of Geology, University of Alberta.	Analysis of cretaceous and tertiary sediments in Alberta and their relation to the coal measures.
William Ure, B.A.Sc., M.A.Sc. (Univ. of B.C.).	Department of Chemistry, University of B.C.	The vapour pressure of acetone at low temperatures.
W. H. Vining, B.Sc., M.Sc. (Queen's).	Department of Chemistry, Queen's University.	Preparation of substituted β phenylethylamines.
K. S. Wyatt, B.A., B.Sc. (Mount Allison).	Department of Physical Chemistry, University of Toronto).	The formation of the gaseous phase in a supersaturated solution.
W. S. Yarwood, B.Sc., M.Sc. (Manitoba).	Department of Geology, University of Manitoba.	Colloids in iron ore precipitation with special emphasis on the Black Island exposure of Lake Winnipeg.
C. W. Coo, B.Sc., M.Sc. (Toronto).	Department of Mining Engineering, University of Toronto.	Resigned.
C. S. Hannen, B.S. (McGill).	Department of Chemistry, McGill University.	Resigned.
M. Home, B.A. (Univ. of B.C.).	Department of Physics, McGill University.	Resigned.

APPENDIX O

Assisted Researches Granted During 1923-24

Subject of Research	Grantee	Where carried on	Amount awarded
			$ cts.
Colour vision	Dr. Frank Allen	Department of Physics, University of Manitoba, Winnipeg.	1,100 00
Ultra sonics	Dr. R. W. Boyle	Department of Physics, University of Alberta, Edmonton.	2,500 00
Researches on fungi	Dr. A. H. R. Buller	Department of Botany, University of Manitoba, Winnipeg.	300 00
Economical cultivation of medicinal plants in British Columbia.	Dr. R. H. Clark and Dr. J. Davidson.	Departments of Chemistry and Botany, University of B.C., Vancouver.	500 00
Plant extracts containing Glukokinin: a substance corresponding in plant life to insulin in animal life.	Dr. J. B. Collip	Department of Biochemistry, University of Alberta, Edmonton.	3,000 00
Artificial propagation of the sturgeon	Prof. W. J. K. Harkness	Department of Biology, University of Toronto, Toronto.	600 00
The food relations of certain minute organisms (entomostraca) in the cultivation of fresh water fishes.	Prof. A. B. Klugh	Department of Biology, Queen's University, Kingston.	350 00
Separation of the bitumen of the Alberta tar sands into the chemical substances which it contains.	Dr. A. Lehmann	Department of Chemistry, University of Alberta, Edmonton.	1,000 00
The resistance of plant tissues to low temperatures.	Dr. F. J. Lewis	Department of Botany, University of Alberta, Edmonton.	400 00
The variation with frequency of the power loss in dielectrics.	Dr. H. J. MacLeod	Department of Physical and Electrical Engineering, University of Alberta, Edmonton.	600 00
Researches in the field of low temperature.	Dr. J. C. McLennan	Department of Physics, University of Toronto, Toronto.	2,500 00
The Graham peat process	Department of Mines	Ottawa	300 00
The nature of winter hardiness in crop plants.	Dr. Robt. Newton	Department of Plant Biochemistry, University of Alberta, Edmonton.	2,000 00
Channel interference in wind channel testing.	Prof. J. H. Parkin	Department of Mechanical Engineering, University of Toronto, Toronto.	700 00
Laws governing the sizing of crushed minerals on sieves.	Dr. J. B. Porter	Department of Mining Engineering, McGill University, Montreal.	750 00
Fundamental problems connected with the cultivation of different varieties of Indian corn.	Prof. H. F. Roberts	Department of Botany, University of Manitoba, Winnipeg.	250 00
Interference in radio broadcast reception	Prof. T. R. Rosebrugh	Department of Electrical Engineering, University of Toronto, Toronto.	3,000 00
The constitution of caoutchouc, the deterioration of rubber by oxidation and the nature of the resin present in rubber.	Dr. G. S. Whitby	Department of Chemistry, McGill University, Montreal.	2,000 00
Investigation of certain phases of the destruction of piling by marine boring animals.	Associate Biological Committee.	Atlantic Biological Station, St. Andrews, N.B.	800 00
Artificial propagation of the sturgeon	Associate Biological Committee.	Department of Biology, University of Toronto, Toronto.	800 00
Rust Problems connected with cereal grains.	Associate Committee on grain rust.		5,000 00
Utilization of Canadian Helium resources.	Associate Committee on Helium.	Department of Physics, University of Toronto, Toronto.	5,000 00
Reforestation experiments in cut-over and burnt-over lands in New Brunswick.	Associate Committee on New Brunswick Forest Problems.	Forestry Branch, Interior Department, Ottawa, and Department of Lands and Mines, Fredericton, N.B.	10,000 00
Nutritional problems of the fox-breeding industry.	Associate Committee on Nutritional Problems of the Fox Industry.	Research Station, Department of Agriculture, Hull, Que.	5,000 00
Deterioration of concrete in alkali soils and waters of Western Canada.	Committee of the Engineering Institute of Canada.	Departments of Chemistry and Engineering, University of Saskatchewan, Saskatoon, Sask.	5,000 00

APPENDIX P

Additional Researches in Progress During 1923-24 under Grants Previously Awarded

Subject of Research	Grantee	Where carried on
The reduction of complex silver-lead-zinc ores of British Columbia.	H. Freeman	Vancouver, B.C.
Roentgen rays	Dr. J. A. Gray	Department of Physics, McGill University, Montreal, Que.
Causation of cracks in concrete protective coatings on iron and steel structures.	Prof. Peter Gillespie	Department of Civil Engineering, McGill University, Montreal, Que.
Relation of soil acidity to nitrogen fixing bacteria.	Dr. F. C. Harrison	Macdonald College, Ste. Anne de Bellevue, Que.
Rock crushing with rolls, an investigation of the action of ball mills.	Prof. H. E. T. Haultain	Department of Mining Engineering, University of Toronto, Toronto, Ont.
Surface energy of solids	Prof. F. M. G. Johnson	Department of Chemistry, McGill University, Montreal, Que.
Fog signalling	Dr. L. V. King	Department of Physics, McGill University, Montreal, Que.
(a) The spectrum of infra-red rays	Dr. J. C. McLennan	Department of Physics, University of Toronto, Toronto, Ont.
(b) Explosive pressures which require a high voltage current apparatus (piezo-electric research).		
Action of blood towards toxines in conditions of fatigue.	Dr. J. J. R. Macleod	Department of Physiology, University of Toronto, Toronto, Ont.
(a) Intensity measurements in spectra	Prof. J. K. Robertson	Department of Physics, Queen's University, Kingston, Ont.
(b) The bridging of the gap in the ether waves between those produced by the ultra-violet light and the so-called X-Rays.		
Action of pure salts on the structure and growth of vegetable cells.	Prof. G. W. Scarth	Department of Biology, McGill University, Montreal, Que.
Conductivity and vapour pressure of salt solutions.	Dr. A. N. Shaw	Department of Physics, McGill University, Montreal, Que.
Soil corrosion of iron and steel	Dr. J. W. Shipley	Department of Chemistry, University of Manitoba, Winnipeg, Manitoba.
Acidity and lime requirement of soils in Quebec and New Brunswick.	Dr. J. F. Snell	Department of Chemistry, Macdonald College, Que.
Chemistry and bacteriology of fish curing	Associate Biological Committee.	Department of Biochemistry, McGill University, Montreal, Que.
The isolation of pure vitamines	Associate Food Research Committee.	Laboratory of Food Chemistry, University of Toronto, Toronto, Ont.
Best methods for obtaining accurate results in testing varieties, strains and treatment of grains.	Associate Committee on Grain Yield.	Dominion Experimental Farms.
Problems in industrial fatigue	Associate Committee on Industrial Fatigue.	Department of Physiology, University of Toronto, Toronto, Ont.
Utilization of Canadian iron ores	Associate Committee on Mining and Metallurgy.	Steel Company of Canada, Hamilton, Ont.

APPENDIX Q

Assisted Researches Completed Prior to 1923-24

Subject of Research	Grantee
Ore flotation, particularly the flotation of lead, and zinc ores, using Canadian oils	Dr. J. B. Porter
Extraction of benzene and toluene from coal gas	Dr. H. S. Davis.
Nicotine from tobacco waste	Arthur D. Hone
De-tarring of gas by electrical precipitation	Dr. J. G. Davidson
Canadian waste sulphite liquor as a source of alcohol	Dr. V. K. Krieble
The inheritance of earliness and lateness in wheat	Dr. W. P. Thompson
Reduction of iron ores by gases at low temperature and the electric furnace	Dr. A. Stansfield
Catalytic action of ultra-violet rays	Prof. L. Bourgoin
Water requirements of crops in western soils	E. S. Hopkins
The relation of bacteria to the quality of graded butter	Dr. W. Sadler
Properties and liquefaction of helium	Dr. J. C. McLennan
Method of smelting titaniferous iron ores	Dr. C. W. Drury and A. F. G. Cadenhead.
Microscopic character of cement in relation to its hydration and its physical properties	F. M. Dawson
Surface tension in liquids and emulsions	Dr. J. C. McLennan
Utilization of the milk weed	Dr. A. C. Neish
Apparatus for testing oil shales in the field	Louis Simpson
Research on fungi	Dr. A. H. R. Buller
Constitution of caoutchouc, the deterioration of rubber by oxidation and the nature of resins present in rubber.	Dr. G. S. Whitby
The red discolouration of cured codfish	Dr. F. C. Harrison.
The discolouration, smut, or blackening of canned lobster	Dr. F. C. Harrison

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APPENDIX R

Publications of the Honorary Advisory Council for Scientific and Industrial Research in Canada

Annual Reports for the Years 1917-18, 1918-19, 1919-20, 1920-21, 1921-22, 1922-23

GENERAL REPORTS

1. The Briquetting of Lignites, by R. A. Ross, E.E., D.Sc.
2. The Recovery of Vapours from Gases, by Harold S. Davis, M.A., Ph.D., and Mary Davidson Davis, B.A.
3. The De-tarring of Gas by Electrical Precipitation, by J. G. Davidson, Ph.D.
4. Nicotine and Tobacco Waste, by A. D. Hone, M.A.
5. Canadian Waste Sulphite Liquor as a Source of Alcohol, by V. K. Krieble, Ph.D.
6. An Investigation into the Question of Early Putrefaction of Eviscerated Fish in which the Gills have been left, by Louis Gross, M.D.
7. Survey of General Conditions of Industrial Hygiene in Toronto, by Associate Committee on Industrial Fatigue of the Research Council.
8. A Method of Smelting Titaniferous Iron Ore, by W. M. Goodwin, B.A., B.Sc.
9. Food Requirements of the Ranch Fox, by G. Ennis Smith, B.A.Sc.
10. Fuel Saving Possibilities in House Heating, by L. M. Arkley, M.Sc., and James Govan.
11. Red Discolouration of Cured Codfish, by F. C. Harrison, D.Sc., F.R.S.C., and Miss Margaret E. Kennedy, B.A., M.Sc.
12. The Discolouration, Smut or Blackening of Canned Lobster, by F. C. Harrison, D.Sc., F.R.S.C., and E. G. Hood, Ph.D.
13. Cultural Criteria for the Distinction of Wood-destroying Fungi, by Miss Clara W. Fritz, B.A., M.Sc.
14. On the Utilization of the Low-Grade Iron Ores of Canada, Submitted by the Sub-Committee on Iron Ores of the Research Council, J. G. Morrow. Esq., Steel Company of Canada, Hamilton, Ontario, Chairman.

BULLETINS

1. The Need for Industrial Research in Canada, by Frank D. Adams, Sc.D., LL.D., F.R.S.
2. Researches on Sound Measurement, by Louis V. King, M.A., D.Sc., F.R.S.C.
3. How to Handle Frozen Fish, by E. E. Prince, D.Sc., LL.D.
4. Hints on Frozen Fish, by E. E. Prince, D.Sc., LL.D.
5. Science and Industry, by Prof. J. C. Fields, Ph.D., F.R.S.
6. The Heating of Houses, Coal and Electricity Compared, by A. S. L. Barnes. (Out of print.)
7. The Manufacture of Ethyl Alcohol from Wood Waste, by G. H. Tomlinson, B.A.
8. Some Problems of the Fox-Raising Industry, by Andrew Hunter, M.A., B.Sc., M.B., Ch.B. (Edin.), F.R.S.C. (Out of print.)
9. The Honorary Advisory Council of Scientific and Industrial Research and its Work, by Frank D. Adams, Sc.D., LL.D., F.R.S.
10. A Plan for the Development of Industrial Research in Canada, by R. F. Ruttan, B.A., M.D., D.Sc., F.R.S.C.
11. Nitrogen Fixation, Submitted by the Nitrogen Fixation Committee of the Research Council, J. C. McLennan, O.B.E., Ph.D., D.Sc., LL.D., F.R.S., Chairman.

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Bound after P. 370.
(Report for 1924-25.)

OTTAWA, February 17th, 1927.

The Hon. JAMES MALCOLM,
Chairman, Sub-Committee of the Privy Council on
Scientific and Industrial Research,
Ottawa.

SIR,—I have the honour of presenting to you the Report of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1926.

In accordance with the requirements of the Research Council Act, this report consists of two parts—the report of the President, and a statement of the receipts and expenditures of the Council during the year under review.

Your obedient servant,

H. M. TORY,
President of the Honorary Advisory Council
for Scientific and Industrial Research.

35493—1½

THE SUB-COMMITTEE OF THE PRIVY COUNCIL ON SCIENTIFIC AND INDUSTRIAL RESEARCH—1925-26

Minister of Trade and Commerce, Chairman.

Minister of the Interior and of Mines.

Minister of Agriculture.

Minister of Customs and Excise.

Minister of Labour.

NATIONAL RESEARCH COUNCIL

President: H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S., President, University of Alberta, Edmonton, Alta.

Secretary: S. P. Eagleson, Esq., Ottawa, Ont.

Members:

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A. L. Clark, B.Sc., Ph.D., Dean, Faculty of Applied Science and Professor of Physics, Queen's University, Kingston, Ont.

Hume Cronyn, B.A., LL.B., London, Ont.

A. Frigon, B.Sc., D.Sc., A.M.E.I.C., A.M.A.I.E.E., Dean, Ecole Polytechnique, 1430 St. Denis St., Montreal, P.Q.

Sir George Garneau, B.A.Sc., LL.D., 71 St. Peter Street, Quebec, P.Q.

J. H. Grisdale, B.Agr., D.Sc.A., Deputy Minister, Department of Agriculture, Ottawa, Ont.

A. B. Macallum, Ph.D., Sc.D., LL.D., F.R.S., Professor of Biochemistry, McGill University, Montreal, P.Q.

A. S. Mackenzie, Ph.D., D.C.L., LL.D., F.R.S.C., President, Dalhousie University, Halifax, N.S.

J. M. McCarthy, B.Sc., C.E., Vice-President, Price Bros. and Co., 287 Grande Allee, Quebec, P.Q.

J. A. McClelland, Representative, International Association of Machinists, 798 St. Catherine St. W., Montreal, P.Q.

J. C. McLennan, O.B.E., Ph.D., D.Sc., LL.D., F.R.S., Professor of Physics and Director of the Physics Laboratory, University of Toronto, Toronto, Ont.

W. C. Murray, M.A., LL.D., F.R.S.C., President, University of Saskatchewan, Saskatoon, Sask.

R. F. Ruttan, B.A., M.D., D.Sc., F.R.S.C., Dean of the Faculty of Graduate Studies and Research, Macdonald Professor of Chemistry and Director of the Department of Chemistry, McGill University, Montreal, P.Q.

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NATIONAL RESEARCH COUNCIL

REPORT OF THE PRESIDENT, 1925-26

I. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL

It has been the endeavour of the National Research Council during the year under review to direct its energies mainly toward the co-ordination, stimulation and prosecution of research work in Canada and toward the building up of a well-trained and efficient corps of research workers for service in Canadian industries, and in the scientific departments of our universities and government services, both federal and provincial.

Research Organization

It has been possible for the Council, at a comparatively small cost to the public treasury, to so stimulate research work in Canada as to enable it to build up as active and as effective research organization as it is possible to establish on a voluntary service basis. This has been accomplished through a policy of enlisting the co-operation of existing research organizations and trained scientific investigators and of utilizing fully the equipment which they possess, in the prosecution of co-ordinated researches. The Council has in many cases granted partial assistance to enable these organizations to secure the services of research assistants or necessary special equipment, thus ensuring the prosecution of approved work.

At the close of the year under review, fifteen associate committees were in active operation under the auspices of the Council. The membership of these committees was composed of 228 persons who, without remuneration, gave of their time and experience in furthering the work of the Council. A full account of the duties and activities of these associate committees will be found in a later section of this report. (See page 18.)

During the same period there were also in progress under the auspices of the Council, in various Canadian laboratories spread from Halifax to Vancouver, forty-two specific investigations, each of which was directed, without remuneration, by a Canadian scientist possessing special qualifications to undertake the particular research work entrusted to him.

In addition to the above, during the past year, forty-five persons who had graduated from a university with distinction in science and many of whom had several years experience in post-graduate research work were undergoing further post-graduate training in scientific research in the laboratories of various Canadian universities under National Research Council scholarships. Each of these scholarship grantees worked under the supervision of an approved member of the staff of the university where he was located, who co-operated without remuneration to this end.

The total research organization actively at work under the auspices of the National Research Council during the year 1925-26 numbered 389, of which number 314 persons served without remuneration.

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Assisted Researches

The National Research Council during the past nine years has financially assisted in the prosecution of ninety-two researches, forty of these investigations having been concluded prior to the beginning of the year under review. During the past year fifty-two researches to which financial assistance had been granted by the Council were in progress in twenty-three departments of science. These investigations were carried out at thirteen Canadian universities and in twelve government or industrial laboratories.

The major departments of science in which investigations were in progress were as follows, the number of investigations carried on being given in each case: Departments of Physics, nine researches; Departments of Chemistry, eight; Departments of Botany, six; Departments of Mining Engineering, five; Departments of Biochemistry, four; Departments of Biology, Zoology, Field Husbandry and Electrical Engineering, two researches each; and one investigation was carried out in each of the following departments: Entomology, Bacteriology, Pathology, Plant Pathology, Animal Pathology, Plant Biochemistry, Plant Breeding, General Agriculture, Food Chemistry, Forestry, Geology, General Engineering, Engineering Standardization and Civil Engineering.

These researches were carried out in the following laboratories: University of British Columbia, Alberta, Saskatchewan, Manitoba, Toronto, Western Ontario, Queen's, McGill, Montreal, Macdonald College, Nova Scotia Technical College, Mount Allison and Dalhousie. In addition to the above university laboratories, researches were also in progress at the following places: Queen Alexandra Sanatorium, London, Ont.; Fort Qu'Appelle Sanatorium, Fort Qu'Appelle, Sask.; Steel Company of Canada, Hamilton, Ont.; Atlantic Biological Station of the Department of Marine and Fisheries, Halifax, N.S.; a co-operative investigation carried out by the staffs of the Department of Lands and Mines of New Brunswick and the Federal Forestry Service of the Interior Department, Federal Department of Mines, Ottawa, and four investigations carried out in various laboratories of the Federal Department of Agriculture.

It will therefore be seen that the research activities of the National Research Council were carried on in every province in the Dominion where facilities are available for work of this nature, this being in accordance with the definite policy of the Council to utilize to the fullest possible extent all existing faciilties, both of equipment and of trained research workers in order to stimulate and co-ordinate research work throughout Canada in so far as it may be possible to do so with the facilities and financial resources at the disposal of the Council.

Interesting information as to the cost of this work to date will be found in a later section of this report on finances and also in the appendices. It will suffice here to observe that during the year under review approximately 45 per cent of the total expenditure of the Council was devoted through these grants directly to the prosecution of specific researches.

It is perhaps advisable to draw attention to the fact that research grants are awarded by the Council under very definite regulations, which require, among other things, that no part of any grant may be used to remunerate the grantee for his services in directing the investigation, that all apparatus and materials purchased from the grant are to be regarded as the property of the Council and are subject to recall at the discretion of the Council and that reports on the progress of the investigation are to be submitted at regular intervals or on demand from the Council. Furthermore, no grant is awarded unless the applicant has furnished complete and detailed information on the form provided by the Council, showing the qualifications of the applicant to direct the work proposed, the nature, scope and objective of the investigation, and full details as to the manner in which the grant will be expended, if made. A complete copy of the regulations which govern these grants will be found in Appendix "B" of this report. Under such conditions, it is possible for the Council to derive the maximum benefit possible through these awards.

Training Research Workers

One of the outstanding facts disclosed by the research inventory of Canada which was taken by the National Research Council in 1917 was that the supply of trained research men competent to undertake independent investigation was entirely inadequate to permit of any general application of research to Canadian industrial problems. In order to do its share in overcoming this serious difficulty, the Council established a number of scholarships for post-graduate research work in science, which it awards annually under strict regulation to outstanding graduates of our universities and technical colleges, who have given evidence of the possession of that special capacity which indicates that they are likely to develop into investigators capable of conducting independent research in their chosen field of science.

Three classes of scholarships are awarded by the Council, namely, Bursaries, Studentships and Fellowships, having an annual value of $750, $1,000 and $1,200, respectively. These awards are intended to enable students who have graduated with distinction from a university to continue their training in science until they have qualified for a Ph.D. degree, three years being the maximum assistance granted to an individual candidate under any combination of awards.

These scholarships are awarded to the best qualified applicants therefor. The minimum qualification for a Bursary is graduation with distinction from an approved university. An applicant for a Studentship must have had at least one year of post-graduate research experience, while Fellowships are awarded only to persons who possess very high qualifications and who have demonstrated beyond question their ability to carry on independent research.

During the year under review the Council awarded five Fellowships, seventeen Studentships and twenty-three Bursaries, and it is of interest to note that there were approximately three times as many applications as there were awards available, which ensures that the group of men who held these awards during the past year were of the most desirable type and possessed very high scientific qualifications for the awards which they received.

The forty-five awards during 1925-26 were won by graduates of thirteen Canadian universities, as follows: University of British Columbia, eight; Alberta, two; Saskatchewan, five; Manitoba, three; Toronto, seven; McMaster, two; Western Ontario, two; Queen's, three; McGill, seven; Montreal, two; Laval, one; Bishop's College, one; and Dalhousie, one.

The Council has compiled a "Who's Who" of persons who have won and held a Fellowship, Studentship, or Bursary, showing what has been achieved by each grantee. The latest figures available cover the eight years immediately preceding the year under review. During that period the National Research Council awarded one hundred and nine Bursaries, eighty-six Studentships and forty-two Fellowships. These two hundred and thirty-seven awards were held by one hundred and fifty-one persons in thirteen departments of science, at sixteen Canadian universities. Each grantee worked under the direction of an approved member of the staff of the university where the award was held, who had agreed to co-operate with the Council in the careful supervision of this work. Two hundred and ninety-five scientific papers have been published by these grantees, of whom one hundred and thirty-four have secured the degree of M.A. or M.Sc., and forty-one the degree of Ph.D.

At the end of the period under review, one hundred and thirty-one persons had completed their training in science under these awards. The Council has, therefore, during the past eight years increased to this extent the number of research workers available for service in Canadian industries and universities or in the Government service. Of these, eighty-nine persons held a Bursary, Studentship, or Fellowship for one year, twenty-three persons held awards for two years while nineteen persons took advantage of the maximum assistance available and held awards for three years.

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It will perhaps be of interest to note the present occupation of the one hundred and thirty-one persons who have completed their training under these awards. Of these, fifteen persons are continuing their post-graduate studies, some under scholarships from other sources and some having gone to foreign universities for special instruction or in order to continue their training in some particular branch of science; thirty-four persons are engaged in the teaching profession, thirty of these having received appointments to the staffs of Canadian universities, where the great majority of them will have an opportunity of continuing their scientific training and of engaging in research work. Twenty-four persons are employed in the industries and twenty-two have accepted positions in the technical branches of the Federal and Provincial Governments. One grantee has died and the remainder have failed to furnish the Council with information regarding their present occupation.

It is especially gratifying to note that of the one hundred and thirty-one grantees, only seventeen persons have accepted positions in foreign countries; all of the others, so far as it has been possible to ascertain, are at work in Canada with the exception of eight persons, who are continuing their post-graduate studies in the United States or in England.

A complete list of persons who held National Research Council scholarships during the past year, showing in each case the university from which they graduated, the laboratory in which the award was held and the research work carried on by the student, will be found in an appendix to this report, and also a list of persons who, having been enabled to secure special graduate training in science under these scholarships, had completed their work prior to the year under review.

In concluding this section of the report, it would perhaps be of interest and value to note that in the United States of America there are 2,000 post-graduate scholarships available each year, most of them open to graduates from Canadian universities. In Canada there is at the present time no important group of post-graduate scholarships in science available, apart from those offered by the National Research Council. It is respectfully suggested that Canadian industries would be well advised to establish a number of scholarships for the special training of men to deal with their own technical problems, for, until the number of these awards available in Canada is considerably increased, many of the most brilliant graduates of our universities will be forced to go abroad for their post-graduate training in science, with great risk of their services being permanently lost to Canada.

For convenient reference, the following statement, showing the number of Fellowships, Studentships and Bursaries awarded by the Council in each of the nine years since these awards were instituted and the expenditure incurred in connection therewith, may be found of service.

Year	Fellowships	Studentships	Bursaries	Expenditure
1917-18	3	4		$ 5,550 00
1918-19	3	5		7,150 00
1919-20	5	16	5	20,850 00
1920-21	5	10	8	17,700 00
1921-22	7	9	28	38,575 00
1922-23	3	22	13	35,725 00
1923-24	12	8	25	37,830 00
1924-25	4	12	30	40,101 66
1925-26	5	17	23	40,082 75
	47	103	132	$ 243,563 66

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Organization of Laboratory Investigations on Grain

During the year under review, the Council was asked to advise the Government on the question of the action which should be taken to organize laboratory investigations on grain on a sound and effective basis. This question had come forward through the closing of the grain laboratory at Winnipeg and because of the fact that the new Grain Act requires the establishment of a grain laboratory under the Board of Grain Commissioners.

On consideration of this question, and after consultation with officials of the Grain Board and the Department of Trade and Commerce, the Council decided to convene a meeting of cerealists of the prairie provinces for the purpose of thoroughly discussing all phases of the question and of drawing up a program of research on problems concerning wheat production and grading, and for the consideration as to the way in which the western universities could best co-operate in this work.

This meeting was held at the University of Alberta on January 15, 1926, under the chairmanship of the President of the National Research Council, and a definite program of research was drawn up and adopted. This program which is divided into two main sections, covering (1st) problems to be investigated by the Research Laboratory of the Board of Grain Commissioners and (2nd) problems to be investigated in university laboratories under the direction and with the assistance of the Council, was as follows:—

A Program of Wheat Research for the Prairie Provinces

Adopted by conference under the auspices of the National Research Council at the University of Alberta, January 15, 1926.

PART I.—PROBLEMS TO BE INVESTIGATED BY THE RESEARCH LABORATORY OF THE BOARD OF GRAIN COMMISSIONERS

I. *Problems connected with the grading of grain.*

- A. Annual survey of protein content of wheat and analyses of samples sold on protein content.
- B. Annual survey of frosted, rusted, sprouted, immature, weathered or damaged grain, with appropriate analyses.
- C. Tests of new varieties for which there is no established grade.
- D. Supervision of moisture testing.
- E. The effects of mixing on the value of grades.
- F. To conduct such additional control work as may be required by the Board.

II. *Preparation and dessimination, for the use of the grain trade, of information on the Canadian grain crop.*

III. *Co-operation with the universities in the investigation of problems connected with the storage and shipment of grain.*

- A. Moisture limits for sound and damaged grain.
- B. Deterioration in storage and shipment.

PART II.—WHEAT RESEARCH BY UNIVERSITIES

I. *Methods.*

Co-operative standardization, particularly of such important empirical tests as milling and baking.

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II. *Nature of Wheat Quality.*

A. *Gluten.*

1. Chemical nature of gluten proteins, including molecular configuration and optical properties.
2. Colloidal properties:
   (*a*) Methods of measurement: viscosity, plasticity, water-binding capacity, etc.
   (*b*) Effect of lipoids.
   (*c*) Effect of electrolytes.
   (*d*) Effect of mechanical treatment: heavy grinding, etc.
3. Index combining gluten quality and quantity factors.

B. *Starch.*

1. Physical properties: gelatinization points, colloidal behaviour, etc.
2. Size and structure of grains.
3. Effect on colloidal properties of dough.
4. Speed of hydrolysis by diastase.

C. *Lipoids.*

1. Nature and quantity.
2. Effect on colloidal properties of gluten and dough.

D. *Electrolytes.*

1. Nature and quantity of electrolytes in flour.
2. Effect of natural and added electrolytes on colloidal properties.
3. Effect of natural and added electrolytes on enzymes and yeast.

E. *Enzymes.*

1. Diastase.
   (*a*) Quantity and activity.
   (*b*) Effect of size and nature of starch grains on activity; possible importance of cytase.
   (*c*) Effect of method of grinding flour on apparent activity.
   (*d*) Effect of conditions of fermentation, presence of electrolytes, etc., on activity.
2. Proteases.
   (*a*) Activity in different flours.
   (*b*) Effect on colloidal properties of gluten and dough.
   (*c*) Control of activity by conditions.

III. *Environmental Effects.*

A. Climate.
B. Soil.
C. Irrigation.
D. Differential reactions of a series of varieties.

IV. *Methods for improving quality.*

A. Use of varieties adapted to particular environmental complexes. (See III D.)
B. Production by plant breeding methods of new varieties with superior special adaptations.
C. Nitrogen manuring.
D. Legume vs. non-legume rotations.
E. Control of time and amount of irrigation.

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V. *The Baking Process.*
   A. Validity of using for tests flour produced in small experimental mills.
   B. Investigation of physical, chemical and biological factors.
      1. Special investigation of yeast.
         (*a*) Standardization of cultures used.
   C. Methods of handling strong and weak flours.
   D. Methods of handling or utilizing special flours, such as flours produced from sprouted or weathered wheat.

Biological Research on Problems Underlying Crop Production in the Prairie Provinces

As the result of a request received from the Canadian Universities Conference, that the Council convene certain conferences to consider a program of graduate studies in the biological sciences, the Council authorized the calling of a meeting of biologists and agronomists of the three western universities for this purpose. The conference was held at the University of Alberta on January 16, 1926, and the questions discussed included problems which should be contained in a program of biological research, changes which might be made in courses in biology offered at Canadian universities and arrangements which might be effected for graduate work.

As a result of this conference, the following definite program of biological research on problems underlying crop production in the prairie provinces was drawn up and adopted by the conference.

Program of Biological Research on Problems underlying Crop Production in the Prairie Provinces

Adopted by Conference under auspices of National Research Council at University of Alberta, January 16, 1926

I. *Survey of climatic and other important features of various zones in relation to crop production.*
   A. Temperature.
   B. Rainfall.
   C. Wind.
   D. Evaporation.
   E. Relative humidity.
   F. Sunshine.
   G. Physiography.
   H. Natural vegetation, including forest cover, wind-breaks, root-systems, etc.
   I. Average crop yields.

II. *Cultural methods in relation to crop production.*
   A. Crop sequences.
      1. Effects of various crops on those which follow, with reference to yield, quality, disease and insect infestations, and soil factors.
   B. Use of soil moisture by various crops.
   C. Nurse crop studies.
   D. Tillage methods in relation to:
      1. Conservation and utilization of moisture.
      2. Weed control.
      3. Preservation of tilth.
      4. Prevention of soil drifting.
      5. Nitrification.
      6. Other phases of soil biology.

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III. *Crop adaptions.*

A. Nature of resistance of plants to unfavourable conditions of environment, e.g., drought, frost, alkali, and disease.

B. Survey of local adaptations of crop varieties in relation to soil and climatic conditions.

IV. *Botanical characters which distinguish a high yielding from a low yielding variety.*

V. *Agricultural and industrial uses of crops.*

VI. *Crop pests.*

A. Plant diseases.

1. Survey of prevalence of various crop diseases and losses therefrom.
2. Pathology and methods of control.
3. Disease resistance and physiology of parasitism.

B. Insects, rodents, and other animal pests.

VII. *Genetics and plant breeding.*

A. Improvement of crop plants for particular areas by the application of modern plant breeding methods.

B. Problems in the principles of genetics and in the practice of plant breeding.

C. Cytological problems in connection with plant genetics.

D. Tree breeding, with special reference to hybrids.

VIII. *Agricultural botany.*

A. Economic plants: botanical relationships, morphology, reproduction, ecology.

B. Survey of native vegetation in relation to ecological conditions, with particular reference to the native grasses.

C. Collection of comprehensive herbaria, and preparation of flora of the prairies.

IX. *Muskegs.*

A. Survey of regional distribution.

B. Depth, vegetable composition, and relation to superficial deposits.

C. Reclamation and agricultural utilization.

International Activities

The National Research Council of Canada is an important link in an Empire and an international organization for the co-ordination and development of scientific research throughout the civilized world. The Council was established in 1916 by the Canadian Government, acting on the request of the British Government, which had not only established a similar organization in Great Britain, but had also petitioned each of the British dominions to take like action, with the object of developing scientific and industrial research within their own borders and with the expressed hope that in due course an Empire scheme for scientific and industrial research which would be of great assistance in maintaining the industrial position of the Empire would evolve.

In Great Britain this work has grown to such magnitude and is recognized to be of such importance that a separate Government Department of Scientific and Industrial Research was created several years ago, while organizations similar to the National Research Council of Canada have been established in practically every important unit of the Empire. The National Research

Council of Canada keeps in close touch with the activities carried on by each of these organizations and particularly with the Department of Scientific and Industrial Research in Great Britain.

It will of course be recognized that the national problems peculiar to any unit of the Empire depend to a large extent on geographical location. The problems of major importance to Canada are not, as a general rule, the problems which are most pressing in South Africa, India, or Australia, for example, and consequently each country must make up its mind that unless it tackles its own national scientific problems in a businesslike way, most of them are likely to remain unsolved. Nevertheless, there are many important problems in which several units of the Empire have a joint interest and a considerable volume of scientific work has already been carried out, especially in Great Britain, which is of very definite value to Canada. The development of an effective organization through which all scientific research carried on throughout the British Empire can be closely co-ordinated is therefore a duty of very great importance.

The Council is also the official Canadian representative in the International Research Council, of which organization practically every important commercial country in the world is a member. The International Research Council constitutes a focal point through which the views, on important scientific questions of general interest, of the most important scientific organizations and of the leading men of science throughout the civilized world can be reviewed and disseminated.

Under the International Research Council, there have been organized a number of International Scientific Unions, each of which confines its activities to questions relating to some particular department of science. Up to the present time the National Research Council of Canada has organized Canadian committees in five of these International Scientific Unions, as follows:

International Union of Pure and Applied Chemistry.
International Union of Pure and Applied Physics.
International Mathematical Union.
International Union of Geodesy and Geophysics.
International Astronomical Union.

Through the International Research Council and its various unions, the National Research Council of Canada is enabled to keep in close touch with the development of scientific thought and progress throughout the civilized world.

The National Research Council is the official adviser of the Federal Government on Scientific questions, and is frequently called upon through the Department of External Affairs, to pass judgment on important international questions of a scientific nature, such as, for example, communications from the League of Nations regarding a proposed Convention on the Protection of Scientific Property, a communication from the World's Metric Standardization Council regarding a scheme for world metric standardization, a report from the Colonial Research Committee of Great Britain, a report from the Imperial Economic Conference regarding research, a request for financial assistance in the publication of the International Tables of Constants and Numerical Data of Chemistry, Physics, and Technology, and several requests for co-operation in finding qualified candidates for British Scholarships available to Canadians for post-graduate work in Great Britain.

Meetings and Personnel

Five meetings of the National Research Council were held during the year under review, all of them at Ottawa. At the commencement of the year, fourteen of the fifteen members of the Council authorized by the Research Council Act,

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had been appointed by the Governor in Council. All of the above gentlemen were reappointed members of the Council, by the Governor in Council, for a further term of three years expiring March 31, 1928. In addition to the above appointments, Mr. J. M. McCarthy, Vice-President of Price Brothers & Company, Limited, Quebec, was appointed a member of the Council for a period of two years expiring March 31, 1927, in accordance with the schedule for the retirement of members by rotation. At the close of the year under review, therefore, there were no vacancies in the membership of the Council.

Finance

The total revenue which the National Research Council received from all sources during the fiscal year 1925-26, was $138,573.74. Of this amount $135,000 was voted by Parliament for the work of the Council, $1,191.25 was received from the British Empire Exhibition Scholarship Trustees, London, England, for transmission to the Canadian research worker selected by the National Research Council as the best qualified applicant for this scholarship which is tenable at an approved University in Great Britain, and $1,342.49 was refunded to the Council from various sources. The last figure represents mainly unexpended balances of research grants remaining on hand on the conclusion of the investigations.

During the year under review the total expenditure of the National Research Council was $138,573.74. The amount expended on post-graduate scholarships in scientific research was as follows: Fellowships, $5,100; Studentships, $16,554; Bursaries, $16,928; and the British Empire Exhibition Scholarship, $1,500, the total expenditure on all scholarships being $40,082. During the year $61,931.65 was expended on grants in aid of approved researches, $1,539.84 was expended on the Library of the National Research Council, the printing of the reports and bulletins issued by the Council, including the annual report, totalled $621.43, and the fee for Canadian membership in the International Research Council was $23.75.

The total cost of administering the Associate and Advisory Committees of the Council was $1,072.15, and the travelling expenses of these committees amounted to $3,104.46. The travelling expenses of members of the Council and the headquarters staff totalled $6,463.50, salaries and honoraria amounted to $19,243.36, and $4,488.21 was expended on general administration of the work of the Council.

Government salaries are usually provided under a vote separate from the appropriations for the work of a department. If the salary item in the above figures be disregarded, it will be seen that more than 85 per cent of the money expended by the Council during the year under review was applied directly to research work, and less than 15 per cent was expended on all administration including travelling expenses of the Council and all committees. This figure is remarkably low considering the nature and extent of the organization which has been established by the National Research Council on an honorary basis, especially since the various co-operating organizations and individuals are spread across Canada from coast to coast which obviously increases the cost of convening meetings of committees. It will be obvious to anyone who gives thought to the question that it would be impossible to reduce the administration expenses of the Council appreciably, even if the total expenditure were very much less than at present. In other words, the Council has kept its administration expenses as close as possible to the irreducible minimum, and has applied as large a proportion of its funds as was possible, directly to the prosecution, promotion, and co-ordination of research work.

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Publications

The National Research Council issues two series of publications in addition to its annual report. These are numbered in sequence according to date of publication and are known under the general titles of "Reports" and "Bulletins."

The difference between these two classes of publications is that a report embodies the result of an original investigation carried out under the auspices of the Council, whereas a bulletin is usually a compilation of present knowledge on some subject considered to be of sufficient importance to justify the preparation and publication of the information. The series of reports are for the most part of a technical nature. On the other hand, the bulletins issued by the Council are usually prepared in non-technical language, in so far as this may be possible, as bulletins are designed to furnish authentic information on important scientific questions in a manner which may be readily understood by persons without scientific training.

The results of the majority of the researches carried out under the auspices of the Council have been published in scientific and technical journals, but from time to time the Council has selected certain reports which it considered should be published under its own auspices in the reports series.

With reference to the distribution of Research Council publications, it may be of interest to note that, in addition to a list of scientific organizations with which the Council exchanges publications, it maintains a general mailing list covering libraries, scientific organizations, individuals and industrial firms engaged in or specially interested in scientific research. When any publication is available for distribution, notice is sent to each name on the above list, but publications are sent only to those who return the reply section of the notification card, thus preventing the distribution of any publication to persons not specially interested in the particular subject dealt with.

It will also be realized that in connection with technical and semi-technical reports, there is generally a special group of scientific organizations, individuals, or industries, which are interested in the particular subject dealt with. A special mailing list is consequently prepared by the Council in connection with each report issued, to cover this particular field, care being taken to avoid duplication with the general mailing list.

At the close of the year under review, eighteen reports and eleven bulletins had been published by the Council. A list of the titles of these publications will be found in Appendix "J" of this report.

II. SUMMARY OF THE ACTIVITIES OF ASSOCIATE COMMITTEES

Foreword

Two classes of Associate Committees have been established by the National Research Council. The first class consists of committees appointed, one in each of the major departments of science, with the main object of keeping the Council constantly in touch with important research problems requiring attention and with advances made from time to time in the particular department of science which they cover. These committees also provide the Council with a valuable source of scientific advice in each of the sciences which they represent in connection with any problem which may arise during the progress of work carried on under the auspices of the Council. In some cases, of course, research work is carried on under the auspices of these Advisory Committees, although that is not their main function.

Another group of Associate Committees has been appointed by the Council for the specific purpose of undertaking the co-ordination, organization and prosecution of research work on some main problem or group of problems. These committees differ from the first group in that their first duty is to undertake the direction of research work specifically assigned to them, but they also serve, of course, in an advisory capacity in their own field.

Fifteen Associate Committees of the National Research Council were in existence at the close of the year under review. Of these, the following seven might be considered to be Advisory Committees: Associate Committee of Chemists, Associate Committee on Mining and Metallurgy, Associate Committee on Physics and Engineering Physics, Associate Biological Committee, Associate Library Committee, Associate Committee on Nitrogen Fixation, and Associate Committtee on Engineering Standards.

In the majority of cases, it is customary for Advisory Committees to meet once a year at a time and place most convenient to the majority of the members concerned, to discuss the work of the Council, the manner in which the committee can most effectively co-operate therein and to make such recommendations to the Council as may be deemed necessary or advisable. Reports covering the activities of these committees during the year under review will be found beginning on page.... of this report.

In addition to the seven Associate Committees of an advisory nature, there were in existence at the close of the year under review seven Associate Research Committees, as follows: Associate Committee on Accurate Plot Work in Agricultural Research, Associate Committee on Aeronautical Research, Associate Food Research Committee, Associate Committee on New Brunswick Forest Problems, Associate Committee on Helium, Associate Committee on Tuberculosis Research, Associate Committee on Cereal Grain Rust, and Associate Committee on Magnesite.

A synopsis of the activities carried on by each of the above committees during the year 1925-26 follows and perusal of this section will afford a general idea of the nature and extent of the work in progress under the auspices of the National Research Council during the past year. It is obviously possible for the Council to carry on such a volume of work with the limited appropriation at its disposal only through the unselfish co-operation of the members of the above committees and other research workers who give freely of their time and experience without remuneration.

A complete list of the Associate Committees of the Council is given beginning on page 91 of this report.

Associate Committee on Magnesite

Magnesite, the natural carbonate of magnesium, was discovered in 1900 near Grenville, P.Q., but on account of the amount of lime and silica associated with it—chiefly as the minerals dolomite and serpentine—there was no large development of these deposits until 1914, when supplies from Austria were cut off. Active mining was then begun, and in 1918 the shipments were valued at over $1,000,000. Most of the magnesite was used as a refractory furnace lining.

When the war was over, the United States market, to which most of the Canadian magnesite had been shipped, was once more supplied from Europe, as the manufacturers of refractories were financially interested in the Austrian deposits, and ocean freight rates were low. Moreover, the duty on magnesite entering the United States was increased, to protect their own industry developing in Washington and California.

Under these conditions the companies operating the Canadian deposits found their most important market practically cut off, and even in a part of the Canadian field the competition of Austrian magnesite was felt, as freight rates to the Atlantic seaboard were higher than the ocean rates from Europe. The Canadian companies succeeded in curtailing expenses by close co-operation, and then they requested the National Research Council to undertake an investigation of their technical problems.

As a result of this request the Council formed an Associate Committee on Magnesite, with Dr. H. M. Tory as chairman and Drs. Adams, Camsell and Clark as members. Under their direction a study of the technical problems in connection with the utilization of Canadian magnesite was made, and it was found that there were at least two directions in which action by the Council appeared to be warranted.

(1) So much lime and silica occur with the magnesite of the Grenville district that a large proportion of the rock quarried has to be discarded. The selection of the good rock is difficult, as the magnesite and dolomite are similar in appearance and are quite intimately associated. Consequently, in order to secure a product sufficiently low in lime and silica for metallurgical purposes, much magnesite has to be discarded with the dolomite and serpentine. A cheap and efficient method of separating the magnesite from the associated impurities is therefore urgently needed.

(2) During the war an effort was made to use Canadian magnesite in the manufacture of refractory brick, but the methods which had been worked out for Austrian magnesite proved to be unsatisfactory. In view of the large tonnage of magnesite annually used for this purpose, however, it would be of great value to the Canadian industry if their product could be utilized.

As the National Research Council has no laboratories of its own, Dr. Camsell generously offered the facilities of the Department of Mines. The Council gladly accepted this offer, and two investigations were soon started.

A chemist has been engaged to work in the ore-dressing laboratory of the Mines Branch in an effort to solve the purification problem. To date this investigation has been confined to small-scale tests, but these indicate that the proportion of magnesite recovered from a given tonnage quarried can be greatly increased. The cost of the proposed treatment would not be high.

A ceramic engineer is working on the problem of magnesite brick in the ceramic laboratory of the Mines Branch. In the first tests trouble was encountered in the cracking of the bricks and in the formation of numerous soft spots. The causes of these failures have now been definitely determined, and it is hoped that methods can be developed for overcoming them.

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If opportunity offers, further investigations will be undertaken in an effort to develop new uses for Canadian magnesite. The Canadian deposits are known to be large, and there appears to be good reason to believe that a thriving industry can be established.

Associate Committee on Engineering Standards

In July, 1925, the work previously carried on by the Canadian Engineering Standards Association was brought under the jurisdiction of the National Research Council. The organization of the Association was not altered in any way except that under the Council it constitutes the Associate Committee on Engineering Standards. The Association has been in existence since 1919, and at present has a membership of 425. It has investigated a large number of projects which are of interest and value to the commercial and industrial life of Canada. A number of these investigations have been published in the form of standard specifications, and their value as a guide in designing, manufacturing, etc., is becoming more and more recognized.

The work of the Association is carried on voluntarily by technical committees, the personnel of which includes representatives from every branch which may have a direct interest in the project under review. There are 53 active technical committees and panels.

In addition to the technical committees, there are seven sectional committees, representative of the following branches: Civil Engineering and Construction, Mechanical Work, Electrical Work, Automotive Work, Railway Work, Ferrous Metals and Mining Work. These committees investigate and approve the various projects which have been studied and approved by the technical committees, each one dealing only with its own particular subject.

The Main Committee, with the executive officers of the Association, in addition to approving of the various projects which come from the sectional committees, constitutes the governing body of the Association. Meetings are held semi-annually for the presentation of reports and the transaction of such business as may require attention.

As this is the first report of the Associate Committee on Engineering Standards to appear in an annual report of the National Research Council, attention is called to the publication which have been issued by the Association to date. A complete list is given on page of this report. The publications are numbered consecutively, the letter appearing before the number denoting the class of work to which the specification belongs, and the final number giving the year of publication.

At the present time the following projects are under review. Some of them have reached an advanced stage and should be ready for publication in the near future. A brief sketch of some of the most important projects is given along with their present status.

Canadian Electrical Code

This project represents an attempt to secure uniformity in practice in electrical installations throughout Canada, and in addition it is hoped to attain working standards in electrical fittings and devices. National standardization in this regard is desirable, both from the standpoint of safety and economy, and should prove of great value to the electrical industry as a whole. The first draft of the proposed rules and regulations was prepared in 1925 and since then has undergone minute study and criticism by the various provincial committees organized especially for this work. In the near future a meeting of the Electrical Code Committee, representative of all the provinces, will be held in order to advance the work another step towards completion.

Road Construction

In order to keep pace with the ever-increasing motor car traffic, we have been compelled to spend annually tremendous sums of money on the building and maintenance of our highways. The different provinces have been greatly assisted in their road building programs under the federal aid scheme. It was felt that the time had arrived when a study of existing practices in road construction would be of great benefit to provincial governments, municipal bodies, contractors, etc. This important project is divided into a number of sections, each of which deals with a specific phase of the undertaking. The various panels are:—

Block Pavements, including brick, wood, granite and asphalt
Bituminous Roads.
Broken Stone or Macadam Roads.
Concrete Roads.
Earth Roads.
Road Foundations and Sub-Grade Preparation.
Gravel, Sand and Sand-Clay Roads.
Road Structures (not including bridges).
Definition of Highway Terms.

A publication entitled "Standard Classification of Highway Expenditure" is now being printed and will shortly be ready for distribution.

Cast Iron Pipe

The specification on cast iron pipe issued some years ago by the Canadian Society of Civil Engineers is now out of print, and the Association has undertaken the work of preparing an up-to-date edition. The first draft will be ready for the Committee very soon. On account of the large amount of this commodity which is manufactured in Canada, this project should have a particular interest for Canadian industry. The specification will embody dimensioned drawings of all standard fittings, methods of manufacture, tests, etc.

Traffic Signals for Highways

This project is of special interest not only to motorists, but also drivers of horse-drawn vehicles and pedestrians using the highways. It is hoped to ultimately secure uniformity in traffic signals in all the provinces of Canada and also with the United States. The specification will cover standard road signs, location of signs, lights on moving vehicles, and signals for railway crossings. The work on this project has reached an advanced stage.

In addition to the above, the following projects are being investigated and studied:

General revision of Specification A1-1922, Steel Railway Bridges.
General revision of Specification A6-1922, Steel Highway Bridges.
Standard Specification on Movable Bridges.
Revision of Specification A16-1924, Steel Structures for Buildings.
Investigation of Reinforcing Materials for Concrete.
Investigation of Machine Screw Thread Situation in Canada.
Investigaiton of Sheet Metal Gauges and Wire Gauges.
Study of Rating and Testing of Electrical Machinery.
Investigation and Report on Heavy Steel Castings.
Specification on Silicon Steel.
Standard Specification on Western Cedar Poles.
Standard Specification on Power Transformers.
Standard Methods of Sampling for Check Analysis for Rolled and Forged Steel Products.
Forging Quality Bar Steel.
Sherardizing and Galvanizing of Iron and Steel.

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Through an arrangement with foreign standardizing bodies, the Association is kept constantly in touch with progress which is being made in other countries. This applies particularly to the British and American standardizing bodies. In preparing a specification on a particular product, we are compelled to view it not only from a national but also from an international standpoint, for if we expect to interchange our products with those of other countries, we must consider those matters relating to the products which are of mutual concern.

Where a branch of industry or representative technical organization desires to avail itself of the services of the Association, it is ready to assist and co-operate to the fullest extent.

Associate Committee on Cereal Grain Rust

It seems scarcely necessary to further emphasize the great losses occurring from grain rust. Those losses speak with an eloquence more forceful than mere words could possibly be.

Our whole economic structure is increasingly dependent upon the success of the country's wheat crop. Its condition is the business barometer, and stocks rise or fall, industry is stimulated or depressed, almost directly in proportion to the estimated yield. Of the factors which go to make those estimates uncertain, rust is perhaps the greatest. The solution of the rust problem is therefore of the utmost importance, not only to the grain growers of the West, but also to the manufacturers of the East, whose markets depend upon it, and to the railroads which haul the crop.

The summer season in Western Canada in 1925 was an unusually favourable one, from the point of view of rust. Grain got off to a good start, grew rapidly, and was quite far advanced by the time rust came up from the south. Only the late crops suffered severely, but some damage was done over much of Southwestern Manitoba and Southern Saskatchewan.

During the past season, surveys of the disease were made to ascertain the extent and degree of the infection. In addition, aeroplanes were used to some extent in securing information as to spore flights in the upper atmosphere.

Eradication work in connection with the barberry and buckthorn was continued. So successful has been the effort to destroy these promoters of grain rust that it is now practically certain that no barberry or buckthorn plants are to be found over most of the area noted above.

Activities in plant breeding are being continued on a large scale in connection with the newly established rust laboratory on the grounds of the Manitoba Agricultural College at Winnipeg. Many resistant or partly resistant strains are being studied, and further breeding work with these strains is being carried on. One rather promising feature in connection with this breeding work is the experimentation in connection with Garnet wheat, a variety of hard spring wheat about equal in productivity and milling quality to Marquis, but nearly two weeks earlier. The importance of earliness lies, not only in the ripening of the crop before damage by frost begins, but in the fact that crops which mature early stand a much better chance of escaping damage by rust.

An interesting experiment has been the spraying of grain with sulphur dust. Some wheat was purposely sown late at the Manitoba Agricultural College, in order to ensure infection. When sprayed a sufficient number of times it was found to be practically free from rust, and a smaller number of sprayings reduced rust damage proportionately.

A new laboratory is being built at Winnipeg, and it is hoped that by next season the staffs working on this problem will be provided with first-class accommodations and adequate facilities for the prosecution of their work. Extensive greenhouses are already in use, providing the means of carrying on the investigation all the year round.

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A large number of skilled investigators are at work on various phases of the rust problem. Of these a number have been directly assisted by research grants from the National Research Council. Reports of several of these investigations are summarized below.

Cereal Breeding

The cereal breeding work at the Manitoba Agricultural College had its beginning in 1917, but it was not until 1922 that this developed into a comprehensive plan of attack. In that year fourteen crosses were made of wheats possessing satisfactory resistance to stem rust with wheats of good milling quality. By the end of 1925 these crosses had increased to forty-three.

From these forty-three crosses there has been obtained a large amount of good hybrid material from which new wheat strains may be selected. The technique of making crosses is comparativly simple and inexpensive, but the process of sorting out desirable strains after crosses have been made is exceedingly tedious.

The average wheat grower treats a field of several acres as a unit. The unit of the plant breeder, on the other hand, is an individual plant. He may grow and examine 50,000 plants, and find that only ten are of value, yet the critical examination of the whole number was essential. The plants which upon examination appear to give promise are subjected to further tests, and a period of five or ten years may frequently elapse before the breeder can definitely pronounce a cross a success. But, whether successful or not, each new cross adds to our knowledge, and opens the road to new avenues of research.

In 1922 Kanred and Kota wheats were crossed. These are two bread wheat varieties, the former being a winter wheat resistant to twenty rust strains, and the latter a spring wheat resistant to five rust strains to which Kanred is susceptible. It was hoped to secure a cross which would be resistant to twenty-five of the forty or more varieties of stem rust. This appears to have been accomplished.

A relatively important cross was that of emmer, a non-shattering grain highly resistant to rust, with Marquis, the present standard wheat. Not once in the past twelve years has emmer suffered appreciably from rust, and if its resistance to rust could be combined with the well-known good qualities of Marquis, the result would be of the highest value. From this cross fifteen plants of merit were produced in 1925, these generally resembling Marquis in appearance but being much more resistant to stem rust. Several other promising crosses have been produced.

Sometimes the plant breeder faces a difficult task. An example is the crossing of Khapli and Marquis. Khapli is an Indian emmer which is highly resistant to all forms of rust found in Canada, but it is a shaggy little plant only about eighteen inches high, that one would ordinarily discard as worthless. On attempting to cross Khapli with Marquis it was found that the seeds produced would not germinate. Dr. Hayes, of St. Paul, crossed Khapli with Mindum, however, and the progeny was crossed with Marquis in this investigation. It is yet too early to estimate the probable value of the new varieties, but they are now in their second year, and represent a combination, which at first appeared to be impossible, of two varieties possessing desirable characteristics.

—(Investigation under the direction of Prof. W. T. G. Wiener, Manitoba Agricultural College.)

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Cereal Breeding

This investigation is similar to that of Professor Wiener, but has been confined to different varieties of wheat, in order to avoid duplication. The problem is essentially to produce one or more varieties of wheat highly resistant to black stem rust and otherwise equal to Marquis in all important agronomic qualities.

Iumillo is a highly resistant variety of durum wheat. It was crossed with Marquis by Dr. Hayes, of St. Paul, the hybrid being called Marquillo. This variety is also highly rust resistant, but unfortunately its flour is yellowish. Marquillo was therefore chosen to cross with Marquis.

The original cross of Marquis with Iumillo was repeated on a larger scale, in the hope that a variety might be produced better than Marquillo. A third cross was of White spring emmer and Khapli, another emmer variety, both highly resistant.

Experimental crosses were also made of a considerable number of varieties in order to study the comparative fertility of the second generation of hybrids from widely different crosses. Some interesting results were obtained. There was observed a marked difference in fertility, depending upon whether the male or female parent was of given variety. In one case the cross in one direction gave only one-fourteenth of the fertility obtained by the reciprocal cross.

The experimental work was carried on throughout the year, this being made possible by the use of greenhouses and artificial light. In the summer a muslin canopy was constructed over the experimental plots in order to avoid possible damage from hail.

Many thousands of individual crossings have been made, and it is aimed to have over 100,000 plants of the second generation for examination. This will require an enormous amount of detailed work, but the object in view is so important as to make the effort well worth while.

—*(Investigation under the direction of Professor J. B. Harrington, University of Saskatchewan.)*

Cereal Breeding

In 1922 the breeding of wheat and other cereals was undertaken at the University of Manitoba. A number of valuable crosses were made including Marquis with Khapli (the most rust-resistant member of the wheat series to date) and with Acme, a tolerably resistant durum wheat. One Marquis-Khapli cross survived and proved fertile. By 1925 this had been continued to the fourth generation and had segregated into several different types, of which the principal were:—

(1) A bearded type resembling Monad wheat.
(2) A bearded type resembling Khapli.
(3) A bearded type, but otherwise resembling Marquis.
(4) A beardless type, resembling Marquis.
(5) A beardless type, otherwise resembling Khapli.
(6) A Khapli type of head in which, however, the grain threshes out free, unlike Khapli, in which, as in all the emmers, the grain does not thresh out, but is retained in the chaff, an undesirable characteristic.

Of the Acme-Khapli and the Acme-Marquis crosses originally made, a number are now in the fourth generation. In all, out of 34 segregations from crosses made in 1921 and 1922 between Acme and Khapli, Acme and Marquis, and the reciprocal crosses of these, and of Monad by Marquis and a few others, there are now on hand nearly 25 pounds of seed.

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In 1924 with the formation of the Associate Committee on Cereal Grain Rust, co-operation with that organization began, this investigation being continued along the lines originally undertaken.

A very large number of crosses were made, using Khapli, Iumillo and several resistant durums, the crosses being mostly upon Marquis; but to some extent also upon Kota, Garnet and Reward. In all, in 1925, 170 crosses succeeded, using 14 different parental combinations. In 81 out of the 190, Khapli constituted one of the parents. In 35 crosses, Iumillo, a rust-resistant durum, second only to Khapli in general rust resistance, formed one of the parents. In all, 492 seeds were produced in the 170 crosses, an average of about 3 seeds to the cross. It may be stated that in crossing or hybridizing a head of wheat, an average of about 20 flowers—10 each side of the head—are left, the remainder being cut away. The apparently low percentage of seed set per head of twenty flowers pollinated, is due to the use of Khapli in making the crosses. Khapli is not a true wheat, but an emmer (*Triticum dicoccum*), and crosses with some little difficulty with ordinary wheat, and the hybrids tend quite generally to be sterile.

In addition to the crosses made in 1925, 26 back-crosses were made, chiefly with Khapli as the pollen parent, upon various crosses previously made, mainly Khapli x Marquis. Out of these 26 back-crosses, 220 seeds were obtained.

Crosses were also made between Khapli, and Monad, Pentad and Reward. A number of heads of the Khapli type, found in plots of hybrid No. 85 (a Khapli-Marquis cross), were recrossed or back-crossed with Marquis,—seeds to the number of 38 resulting from these crosses.

It is believed that substantial progress has been made in the production of hybrids between Marquis and several important rust-resistant types in the wheat group. The wheat of all these hybrids will be sown this season.

—(Investigation under the direction of Professor H. F. Roberts, University of Manitoba.)

Crown Rust of Oats

The crown rust of oats (Puccinia coronata) often causes serious damage in Canada. No adequate study of this disease has yet been made. This research was undertaken primarily to determine the degree of susceptibility to crown rust of the varieties of oats grown in Canada, and in other countries as far as possible. It included a study of the grass hosts of the form of crown rust on oats and their importance in its spread. A study was also made of the forms of crown rust on grasses and their relation to the form on oats and their aecial hosts.

Over two hundred varieties of oats contained in Canada and the United States were inoculated in the greenhouse with urediniospores of crown rust collected at Saskatoon. Of these, ten varieties showed resistance. Of thirty-two varieties obtained from Australia nine showed marked resistance. One of these was practically immune. While this variety is not of satisfactory quality it may be of great value for hybridization.

Over one hundred species of grasses were inoculated with crown rust in the greenhouse, but most of these were not markedly susceptible. Field study indicated that grasses are not an important factor in the spread of crown rust, the only grass showing marked infection being wild oats.

Many inoculations were made on oats with aeciospores from both the cultivated and native buckthorn. Heavy infection followed every inoculation of the former, but the latter was clearly of little importance in the spread of crown rust of oats.

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The inoculation of ninety varieties of oats with a collection of rust made at Macdonald College, Quebec, showed different reactions from those obtained with western rusts. This is an indication that different strains exist, as in the stem rust of wheat.

There has also been undertaken a study of the entrance, development and reproduction of crown rust on susceptible hosts. The study so far indicates that the development of the parasite within the host tissues is, in general, very similar to that of stem rust on wheat, although there are numerous minor differences.

—Investigation under the direction of Professor W. P. Fraser, University of Saskatchewan.)

Nature of Resistance and Susceptibility to Stem Rust in Wheat

The breeding of resistant wheat varities seems to present the best hope of solving the stem rust problem. Our knowledge of the real nature of resistance is so deficient, however, that the plant breeder is forced to depend on empirical methods. The investigation and elucidation of the factors involved should enable him to proceed directly to secure the factors desired.

A review of previous work on disease resistance in general enables us to classify the factors involved as mechanical or structural, and biochemical or physiological.

In most diseases investigated the entrance of the parasite into the host is a mechanical process, and the nature and thickness of the cuticle, and closing or plugging of the stomata, are important. Spread of infections within the host may also be governed by structural features, such as the composition and toughness of the cell walls, the isolation of susceptible tissues, the deposition of cork layers, etc. Growing conditions may influence morphological susceptibility at least slightly.

Substances diffusing from the host tissues into the infection drop may either stimulate or inhibit spore germination. A similar effect has been secured with some simple chemical substances.

After entry has been effected the parasite may disintegrate the tissues by enzyme action or destroy them by the introduction of toxins. These actions have been found to be retarded by the juice of certain plants, indicating a chemical basis of resistance.

Substances toxic to fungi occur in plants, but those investigated have not been found sufficiently constant in quantity to account for direct physiological resistance, since this is relatively constant under all conditions.

Resistance may be due to the presence in the host of a substance toxic to the fungus, or to the absence from the host of the substance required by the fungus, or to the excretion by the fungus of a toxin which kills the host cell and leaves the parasite to starve. Any of these factors would destroy the balance between the metabolism of host and fungus, upon which parasitism depends. While in general those conditions which promote the vigour of the host also increase the severity of infection, it has in certain instances been found possible by controlling conditions to so modify the metabolic balance of the host as to render it unfavourable for the development of the parasite.

A program of biochemical investigations on wheat stem rust has been outlined. This covers (*a*) the physiology of the host; (*b*) the physical and chemical properties of host-cell contents; (*c*) inhibiting or accessory substances; (*d*) the physiology of the parasite.

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For this investigation, reference series of wheat varieties and rust forms have been selected to represent a wide range of rust reactions. A start has been made on the work outlined in sections (*a*) and (*c*) of the foregoing program, and it is planned to begin that called for in section (*b*) during the coming summer. A statement of the results obtained will be postponed until the investigation has made greater progress.

—*(Investigation under the direction of Professor R. Newton, University of Alberta.)*

Crosses between Wheat and Rye

A number of investigators have succeeded in crossing wheat and rye, but only with the greatest difficulty. A variety of wheat has been obtained from South America, however, which crosses readily with rye, as high a proportion of pollination proving successful as in crosses between any two varieties of wheat.

By using this variety as the female parent a large first and small second generation have been produced. From these and from back-crosses a great many plants of later generations have been raised. This material, particularly the F_1, has been studied cytologically.

The wheat used has the typical 21 haploid chromosomes of *Triticum vulgare* and the rye has the typical 7 of *Secale*.

At the first reduction division in F_1, 28 univalent chromosomes usually appear. These move without dividing to opposite poles, nothing like an equatorial plate being formed and the division figure appearing highly irregular. Often 1 or 2 and rarely 3 bivalents appear and divide in characteristic fashion. Supernumerary nuclei are formed from lagging chromosomes; these may fuse with the principal nucleus or may become enclosed in cells of their own, or may remain unfused in the same cell as the principal nucleus.

The prophases of this division appear from preliminary observations to be normal, both contractions occurring, and some parallelism of chromatin strands being evident though not expected on the parasynaptic interpretation.

The second division is usually much more regular than the first, but may be quite as irregular. An equatorial plate is usually formed on which nearly all the chromosomes become oriented and divide, though lagging chromosomes are common. "Tetrads" usually have from 4 to 8 cells but may have more or fewer.

From back crosses plants with more than 21 chromosomes have been secured.

In tetraploid and hexaploid species of wheat each chromosome has a single mate; random mating amongst duplicated chromosomes does not occur normally, but may occur abnormally. It is probable that there is among wheat chromosomes no mate for any rye chromosome.

Conclusions regarding economic results must not be too hastily drawn from a consideration of chromosome numbers. It appears that some of the chief advances in wheat breeding depend on a crossing of different species. This presents great difficulty because of the difference in chromosome numbers. It is clear that very different results may be expected when different varieties of the same species are crossed with a different species. In the present investigation we have a large number of lines in late generations with a preponderance of wheat characteristics but also retaining certain definite rye characteristics. Judging from chromosome numbers and experience with other attempts to cross wheat and rye, this would be impossoble.

—*(Investigation under the direction of Professor W. P. Thompson, University of Saskatchewan.)*

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Chromosome Behaviour in Triploid Wheat Hybrids

At the heterotypic division of the hybrid between *T. monococcum* and a variety of *T. turgidum* 3 to 7 bivalent and 15, 13, 11, 9 or 7 univalent chromosomes appear. After the bivalents have divided the univalents all arrange themselves on the plate and divide equationally. At the homeotypic division a number lag, fail to divide and wander at random to the poles. Their number corresponds to that of the univalents of the first division.

This behaviour is similar to that in pentaploid hybrids except in regard to the variable amount of mating. It is very different from that in another cross between these same two species, investigated by Sax, in which 7 bivalents and 7 univalents appear and in which the univalents divide at the second division instead of the first. Nevertheless it is similar to that in *T. monococcum* x *T. Dicoccum,* except that in the latter a number of univalents fail to divide at the heterotypic division.

Since the original duplication which produced 14 chromosome species, such differentiation has occurred as to make mating between chromosomes of the two types difficult.

The chromosomes of two varieties of *T. turgidum* appear to be differentiated as judged by their behaviour in hybrids, though those of one behave normally in crosses with entirely different species of wheat.

—*(Investigation under the direction of Professor W. P. Thompson, University of Saskatchewan.)*

Chromosome Conditions and Plant Characters in Hybrids between Emmer and Bread Wheat

In crosses between 14– and 21–chromosome wheats the F_2 show chromosome numbers and combinations of characters which approach those of the parents much more closely than is to be expected if all gametes are functional and all zygotes viable. In results hitherto reported the conditions of the 21–chromosome parent were represented nearly as frequently as those of the parent with 14 chromosomes.

A cytological examination was made of 28 F_2 hybrids between *T. dicoccum* (14) and *T. vulgare* (21). Twenty-four plants had 14 bivalent chromosomes and 0–4 univalents; only 1 had as many as 17 bivalents; only 3 plants had more than 34 single chromosomes, and the greatest number was 37. The great preponderance of low numbers approaching that of the *dicoccum* parent and the absence of those approaching the *vulgare* number, are evident. F_3 results were similar.

Twenty pairs of characters which distinguish the parents were studied in these 28 and in 49 additional F_2. On the basis of genetic behaviour the characters fall into two classes: (1) those found in the *dicoccum* condition in all or nearly all the segregates, (2) those found frequently in the *vulgare* or intermediate as well as in the *dicoccum* condition. The characters in Class (1) prove to be those which must generally distinguish *dicoccum* varieties taxonomically from *vulgare* varieties. Most of those in Class (2) are not of general taxonomic value but happen to distinguish the varieties used in this investigation. The great majority of individual plants were *diccoccum*-like in species-distinguishing characters; the remainder were intermediate.

The numerous *dicoccum*-like plants were those which had 14 bivalent chromosomes; the few intermediate plants were those with 15-17 bivalents. *Vulgare*-like combinations of characters and chromosome numbers are alike absent. The presence of 1-4 univalents in addition to the 14 bivalents has no effect in making the characters *vulgare*-like or intermediate. The presence of additional bivalents has some effect in this respect.

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The primary 14 as well as the extra 7 *vulgare* chromosomes are concerned to some extent in the determination of *vulgare* characters. The extra 7 are also concerned to some extent in determining non-specific characters.

Several possibilities were investigated to account for the missing type expected.

(1) The proportion of visibly bad pollen is insufficient to account for the difference between actual and expected results or for the difference between *dicoccum-vulgare* and other hybrids.

(2) Twenty-five per cent of F_1 flowers in a favourable position for setting seed failed to do so. These may represent missing types, but cannot account for the differences between this and other 14×21–chromosome crosses for *durum-vulgare* F_1 showed as great sterility.

(3) Fifty per cent more F_1 seed failed to produce mature offspring than is the case in pure races, whereas in the *durum-vulgare* cross the percentage was only 25.

(4) About 50 per cent of young F_1 pollen grains showed lost chromosomes. This would probably reduce the number of F_2 zygotes with 36 or more chromosomes to less than one-quarter of the whole. Though *dicoccum-vulgare* hybrids show a somewhat greater loss than *durum-vulgare* the difference is not sufficient to account for the results.

(5) The taxonomic differences between *dicoccum* and *vulgare* are greater than between other 14–chromosome wheats and *vulgare* and may indicate greater chromosome incompatibilities.

The difficulty of combining, through breeding operations, desirable qualities of *dicoccum* with those of *vulgare* will be very great because of the correlation of *dicoccum* characters and particularly because of the rarity of *vulgare*-like segregates.

—*(Investigation under the direction of Professor W. P. Thompson, University of Saskatchewan.)*

Associate Committee on Tuberculosis

For several years past there has been a steadily growing conviction that sufficient attention has not been paid, in Canada, to the solution of tuberculosis problems through research.

To put the matter on no higher plane than that of financial values, it is obvious that bovine and avian tuberculosis are responsible for an enormous annual loss in the live stock and dairy industries.

It is also obvious that apart altogether from the untold suffering and misery directly attributable to the ravages of this disease among humans, there is each year an appalling economic loss arising from the illness of those suffering from it and through the premature death of thousands of the most desirable type of citizens.

In the past, researches on tuberculosis have been carried out at various centres in Canada. Scattered investigations relating particularly to human tuberculosis have been undertaken principally in university and sanitarium laboratories, while the most important Canadian researches to date on bovine tuberculosis are those which have been undertaken by the Federal Department of Agriculture at Ottawa and at the University of Alberta at Edmonton.

Action Taken

Recognizing the importance of this problem and the necessity for the co-ordination and stimulation of all tuberculosis research work which is carried out in Canada, the National Research Council appointed a small committee of scientists, who in the past have taken a keen interest in this subject, and who

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are eminently qualified to express an opinion thereon, to consider and report as to the manner in which the Council could co-operate in the solution of problems arising from tuberculosis.

This committee met at Ottawa on March 18, 1925, and its deliberations were crystallized in the following report to the Council:—

Preliminary Report

"The committee wishes to highly commend and strongly endorse the work which has for several years been conducted in the Biological Laboratory of the Health of Animals Branch of the Department of Agriculture in research in the problem of bovine tuberculosis under the direction of Dr. E. A. Watson.

"Because of the essential unity of the problem of tuberculosis, whether affecting man or lower animals, it will be necessary to broaden the scope of the inquiry to include a study of certain phases of human tuberculosis.

"It is the judgment of the committee that the present plant of research in tuberculosis should be greatly expanded and additional financial support be made available at the earliest possible moment for increasing the facilities for such research and enlarging the personnel necessary for the work.

"It is therefore recommended that the National Research Council appoint a representative permanent committee to consider this matter and evolve a plan which will give effect to the proposals contained herein."

Committee Appointed

This report was approved by the National Research Council and steps were immediately taken to give effect to its recommendations.

In accordance with its fixed policy in dealing with such major problems, the Council appointed an Associate Committee on Tuberculosis Research, representative of all organizations known to be actively working on, or which are directly interested in, the problems of this disease, such as the Federal Departments of Agriculture and Health, the universities and agricultural colleges, the Canadian Tuberculosis Association and the Sanitaria, and the stock breeders.

The personnel of the committee is given at the close of this bulletin and the first eleven persons named compose an executive committee which is responsible for the planning and direction of all research work carried out under the auspices of the committee and for the allocation of financial assistance.

The Committee at Work

The first meeting of the committee was held in Ottawa on May 26 and 27, 1925, under the joint chairmanship of Dr. H. M. Tory, President of the National Research Council, and Dr. J. H. Grisdale, Deputy Minister of Agriculture.

Twenty-six members of the committee were in attendance.

In opening the meeting, Dr. Tory explained that the National Research Council had assigned to the committee the duty of thoroughly canvassing the situation in connection with all phases of this disease, of evolving a detailed research program and of taking such steps as may be necessary to give effect to that program.

Dr. E. A. Watson, Chief Pathologist, Federal Department of Agriculture, then presented a paper on the Present Situation in Canada with Respect to Bovine Tuberculosis.

Dr. Oskar Klotz, Professor of Pathology and Bacteriology, University of Toronto, addressed the Committee on Researches in Canada on Human Tuberculosis.

The point of view of the stock breeders was presented by Mr. George H. Hutton and Mr. W. A. Dryden and several other members also spoke briefly on various phases of the problem.

Prolonged general discussion ensued and the question was reviewed from many different angles.

When the whole situation had been thoroughly canvassed, a sub-committee was appointed to draft a specific research program in the light of the discussion which had taken place. The report subsequently presented by this sub-committee was carefully reviewed by the main committee and a complete program of researches on tuberculosis which should be carried out in Canada, was finally adopted by the main committee.

Revised Research Program—Associate Committee on Tuberculosis Research

The Tuberculin Question

1. Research on the chemical nature of tuberculin, both human and bovine.

2. A comparative study of the tuberculin reaction and immunological reactions in tuberculous infection in both human and animal and especially in determining the state of activity of tuberculous lesions and to correlate these questions with the transmissibility of infection.

Diagnosis

3. A specific diagnostic test for bovine infection in human as distinguished from infection with the human type of bacillus, other than bacillary differentiation.

4. That the literature concerning X-ray examination and diagnosis be made available together with an expert's advice regarding this method of examination in connection with humans and animals, especially in research, including the correlation of tissue pathology with radiographic opacities.

The Vaccination Question

5. The employment of living tubercle bacilli:—

(*a*) Research to ascertain the ultimate fate of living tubercle bacilli inoculated into an animal for vaccinating or prophylactic purposes.

(*b*) Research to ascertain the fate of tubercle bacilli introduced into an already vaccinated animal either by a natural channel of infection or by experimental infection.

(*c*) Research to ascertain whether living tubercle bacilli attenuated by artificial means (or bacilli of weak virulence) and employed for vaccinating purposes are able, by passage through animals or other means, to recover their former or original virulence.

(*d*) Repetition of the vaccination experiments made by Calmette and Guerin, and the determination of the duration of immunity.

(i) without modifications;

(ii) with such modifications as the individual investigator may desire.

6. The employment of dead tubercle bacilli and various derivatives of tubercle bacilli.

(*a*) Investigation of the claims made for the raw vaccine.

(*b*) Investigation of the claims of any other vaccine and the preparation of new vaccines or vaccinating substances.

Chemo-Therapy and Sero-Therapy

7. A study of the Sanocrysin method of treatment (Moellgaard.)

8. Investigation of other claims of chemo-therapeutic agents.

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Bacteriology and Pathology

9. Comparative study of bovine, human and avian strains of tubercle bacilli, in respect to—

(*a*) Type of infection and disease in various hosts.

(*b*) Kochs phenomenon, especially when re-infection is made with a strain of a different type to that of the primary infection.

(*c*) Differences in receptivity, susceptibility and pathologic anatomy in man and in different species of animals, and whether these differences are referable to the bacillus itself or to the animal host.

(*d*) Action of the bacillus on the host and the reaction of the host to the parasite.

(*e*) Variations, adaptations, and possible transmutation of types of tubercle bacilli, human, bovine, and avian, their relation to each other.

(*f*) Comparative study of bovine, human and avian strains of tubercle bacilli and a few non-pathogenic acid fast bacilli in respect to the possibility of cultivating the filtrate virulence of that same filtrate, to ascertain the relations of the Much's granules.

Biochemistry of Tuberculosis

10. A further study of the biochemistry of the blood and tissues in tuberculosis.

Epidemiology

11. Epidemiological study by way of actual application, in a given area, of known efficient health methods.

12. Field and laboratory experiments to determine methods by which and especially ages at which tuberculosis infection both human and bovine occurs in humans.

13. Gathering of data pertaining to the incidence of bovine infection in children by means of isolation of the infecting bacilli and a study of the pathological lesions.

Ottawa, October 21, 1925.

Complete Information

Having established a definite research program, the next step was to determine how this program could be put into effective operation.

The committee decided that before proceeding further, complete information should be secured as to the research work at present in progress in Canada and the facilities both as to men and equipment which are now available in Canadian laboratories and which might be utilized in the prosecution of the research work contemplated by the committee.

Questionnaire Distributed

With the object of securing this information, a special questionnaire was prepared and distributed to fifty-three Canadian laboratories and institutions which were known to engage in tuberculosis research, or which it was thought might possibly be in a position to effectively undertake such work.

By closely following up this questionnaire, returns were secured from practically every laboratory and organization which was approached by the committee.

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Second Meeting of Committee

As a result of the information received through the questionnaire, it was possible to compile a complete summary of tuberculosis research activities at present existing in Canada and of the facilities available for such work.

With this information at hand, the committee was in a position at its second meeting, which was held on October 21, 1925, to allocate its research work and also to determine the most effective channels through which the necessarily limited financial assistance at its disposal could be distributed.

In this connection, it may be stated that it is not the policy of the committee to establish and equip new laboratories, but, rather, to stimulate work in laboratories where adequate facilities for tuberculosis research and its proper supervision already exist.

The replies to the questionnaire distributed by the committee clearly indicate that there are at present very few laboratories in Canada which are actively engaged in tuberculosis research.

Every laboratory approached by the committee, however, realizing the importance of co-ordinating and stimulating all researches to be carried out in Canada in future on this subject, endorsed the action taken by the committee and expressed its willingness to co-operate in any way which might be possible in this work.

One of the main objects of the committee—the co-ordination of all tuberculosis research work in Canada—was therefore assured.

Allocation of Work

It was the judgment of the committee after carefully considering the whole question, that the main part of the work on human tuberculosis should be carried on in the two chief centres of population located at Montreal and Toronto, especially as at each of these points a number of laboratories had united in a local organized group and were prepared to work in the closest co-operation as a single unit under the committee.

The work of the Montreal group will be centred at the University of Montreal and the work of the Toronto group at the University of Toronto.

In addition to these centres, researches will also be carried on under the auspices of the committee during the coming year at Queen's University and at the Queen Alexandra Sanatorium at London, Ont., and at Fort Qu'Appelle Sanatorium in Saskatchewan.

With reference to bovine tuberculosis, in addition to the work already mentioned much of which has a direct bearing on this phase of the problem, the committee has arranged with the Federal Department of Agriculture and a committee appointed by the Department of Health of the province of Alberta, from officers of that department and the University of Alberta, to continue and to enlarge their research programs.

Both of these organizations are working in the closest co-operation with the committee, the former without financial assistance and the latter with a comparatively small grant.

It should be emphasized, however, that every organization to which assistance is granted by the committee is itself making a substantial contribution to the work which it is carrying on.

Pasteur Institute Delegate

As a general principle, the committee will not grant assistance toward the salary of a director of research in any laboratory. The policy is rather to provide necessary assistance and equipment in laboratories where provision has already been made for adequate supervision and general equipment.

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When, however, the committee was informed by the group of laboratories centred at the University of Montreal, that it would be possible to secure the services of a colleague of Professor Calmette's from the Pasteur Institute at Paris, for such time as required by the committee, it was decided that the exceptional qualifications and knowledge of this problem which such a research worker would possess would be of great value to all investigators working under the auspices of the committee.

Arrangements are therefore being made to bring Professor Calmette's colleague to Canada in connection with this work, and, at the request of the Montreal group, to place him in charge of the investigations to be carried out in the laboratories centered at the University of Montreal.

While it is clearly recognized that the effectiveness of the anti-tuberculosis vaccine developed by Professor Calmette has not been fully demonstrated, it is regarded as a most hopeful advance toward the prevention of tuberculosis, and it is the purpose of the committee to thoroughly investigate its merit in connection with the bovine phases of its research program.

Progress Achieved

The progress on this problem which has been achieved by the National Research Council during the past year may therefore be summarized as follows:—

(1) An Associate Committee on Tuberculosis Research has been appointed and is in active operation.

(2) This committee has succeeded in enlisting the co-operation of all existing agencies for tuberculosis research in Canada, thus ensuring thorough co-ordination of the research work carried out under its auspices.

(3) A definite, detailed program for tuberculosis research in Canada has been established.

(4) Complete information has been gathered as to Canadian activities and facilities with respect to tuberculosis research.

(5) An aggressive tuberculosis research program to be carried out during the year 1926 has been definitely organized and is now in active operation.

It is obvious that several years will be required in order to complete most of the problems which are being attacked by the committee, but it is hoped that by means of thorough co-ordination, constant and careful supervision, and through the careful allocation of the financial resources at the disposal of the committee, it will be possible to make very substantial progress on the problems of tuberculosis within the next five years.

Associate Committee on New Brunswick Forest Problems

As anticipated in the last annual report, Canada has become the world's leading producer of newsprint. The pulp and paper industry as a whole is now second only to agriculture in the value of its products, and its development is proceeding on an ever-increasing scale. These are facts for national gratification, but equally for serious consideration of the problem of replenishing the supplies of pulpwood, which are being rapidly depleted.

The question of forest renewal is one to which the National Research Council has given careful attention, and the year under review is the third in which, co-operating with the Forestry Branch of the Department of the Interior and the Department of Lands and Mines of the province of New Brunswick, it has carried out re-seeding experiments in the province mentioned.

Two methods of seeding have been tried—broadcasting and the seed-spot method. The former requires less labour, but six or eight pounds of seed per

acre compared with less than a pound for the latter. The seed-spot method is the cheaper, and it has the additional advantage that the likelihood of germination is much greater, since the seed are always brought into direct contact with the soil.

The primary object of the 1925 studies was to determine the relative value of spring and autumn seeding. To obtain this information, spring planting was done on lands adjoining the 1924 autumn-made plantations in the various localities. During the season 560 acres were seeded, distributed over eight localities, and representing non-reproducing, burned-over lands of seven different periods, and one hardwood cut-over area. Permanent sample plots were surveyed and recorded, so that regular examinations will be possible. All of the field work has been done by a field party of the Dominion Forest Service.

During September, the areas which had been reseeded during the seasons of 1923 and 1924 were examined. Some were only partly successful, but the results showed that older burns, already reproducing to intolerant hardwoods which could act as a nurse crop, or areas with a dense stand of dead trees, had done remarkably well. Thus the Tabusintac areas, seeded in 1923 under a dense stand of dead trees, show 75 to 90 per cent germination and survival, while areas at Weaver's Siding, seeded under intolerant hardwoods, show 90 to 100 per cent.

If operations of this character are to be a commercial success it is obvious that costs must be kept at a low figure. In experimental work, where the chief aim is to develop successful methods, and much supervision is necessary, costs are bound to be relatively high. The total cost of labour, including the preparation of spots, seeding, meals, wages of cook and assistant, lost time in bad weather, and the supervision of one forester, was $3.68 per acre. The cost of seed, at $3.78 per pound, was $1.17, making a total of $4.85 per acre, exclusive of travelling expenses and the scientific part of the investigation. In commercial work, with large, well-organized parties of trained men, it should be possible to do considerably better than this.

Trees normally take from 50 to 100 years to grow to a merchantable size. It is obvious, therefore, that in the short space of three years one cannot come to any definite conclusion as to the success of the work. But it is important that these and other methods of reforestation should be further developed, until the best means of providing for the continued prosperity of the industries dependent upon Canada's forests can be definitely determined.

Associate Committee on Food Research

Recent work by this committee has been along two main lines, (1) studies of phosphotungstic acids; (2) picric acid precipitation from the gum of rice polish.

(1) The most satisfactory method so far tried for the purification of antineuritic vitamine from rice polish is that of Funk, the precipitation by phosphotungstic acid. This method, nevertheless, often gives uncertain results, possibly due to the indefinite nature of what is called phosphotungstic acid.

Miss Burwash found that the duodeci acid was a good precipitant of vitamine but the luteo acid was of little value for this purpose. She prepared the acids by laboratory methods which appeared to give pure materials. The commercial preparations are costly and of uncertain composition. In order to carry on this investigation, large quantities of duodeci acid were required, and therefore a simpler method of preparation was adopted—that recommended by Wu. With this new acid great difficulty was experienced in obtaining a satisfactory separation of the vitamines and it was soon evident that methods of comparing the different samples were particularly needed. Simple qualitative

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tests were lacking. Quantitative analyses of these materials are slow and unsatisfactory, but micro-chemical examination seemed to offer possibilities of usefulness.

There has consequently been made a microscopic examination of a number of phosphotungstic acids which were available. This examination has shown that in certain respects the duodeci acid prepared by Miss Burwash was different from that obtained by Wu. The latter can be purified by repeated crystallization and then shows optical properties very similar to those of the other. The optical method seems to provide a simple and accurate means of detecting the presence of particular forms of these acids.

(2) An attempt has been made to purify the vitamine from rice polish by precipitating the active substance with picric acid, as does Eddy with extract of yeast. The method proceeds quite easily and much diminution of volume occurs, but so far the residues have not been found to contain the quantity of vitamine which might be expected. It is possible that the correct degree of acidity has not yet been found, as this is known to be a very important point. This will be thoroughly investigated.

Associate Committee on Physics and Engineering Physics

The Eighth Annual Meeting of the Associate Committee on Physics and Engineering Physics was held in Ottawa on May 21 and 22, 1925, fifteen members of the committee being present.

The committee had under consideration the problem of retaining the best trained men for service in Canada, and of closer co-operation between the universities in regard to appointments to their respective staffs. After full discussion, it was the consensus of opinion that this question should be thoroughly discussed at the next conference of Canadian universities.

With regard to a recommendation which had been made by the committee at a previous meeting, that the fellows, students, and bursars of the National Research Council should be required to hold their awards at Canadian universities, but that a limited number of fellows who had obtained their Ph.D. should be allowed to proceed overseas, and a limited number of fellows should be brought to Canadian universities from Great Britain or from other parts of the Empire, Dr. Tory informed the committee that their recommendation that the scholarships awarded by the National Research Council should be held at Canadian universities only, was accepted in principle, but that the recommendation to send abroad a limited number of fellows who had obtained their Ph.D. and to bring in a limited number from Great Britain or other parts of the Empire to study in Canada could not be carried out at present.

In this connection, attention was called to the fact that the scholarship tenable by a Canadian at the Imperial College of Science and Technology, London, was for one year only, and was given with the hope that the scholarship would be made permanent from Canadian funds. It was the general view of the committee that reciprocity should apply, and that if Canada founded fellowships for tenure in Great Britain, the authorities in Great Britain should establish similar scholarships tenable in Canada.

It was decided that the committee recommend for consideration by the National Research Council, the establishment of one or more competitve advanced travelling Fellowships in Physics and Engineering Physics, open to all Canadians whether university graduates or not.

On consideration of a recommendation made at the seventh annual meeting of the committee, that the Research Council should pay the national contributions required for Canadian membership in the International Unions of Physics and Engineering Physics, Geodesy and Geophysics, and Astronomy, it was reported that the National Research Council had paid the contribution necessary

to maintain Canadian membership in the first-named union, and that as the Department of the Interior is directly concerned, it has assumed responsibility for the payment of the fees to the other two unions named above.

On consideration of the resolution passed at a previous meeting of the committee, on the question of the publication of scientific papers in Canada, it was reported that the National Research Council had granted the sum of $750 to the Royal Society of Canada to cover the deficit incurred by that Society in publishing the scientific sections of its transactions for the year 1924-25. It was further reported that the Council and the universities were being asked to guarantee a sum of $4,500 to the Royal Society so that it would be in a position to publish all papers presented in its scientific sections during the year 1925-26.

Considerable discussion took place as to the function that the committee could fill in order to be of maximum service to the National Research Council. The president of the Council pointed out that the committee had been established for the specific purpose of securing the best kind of judgment on problems of physics and engineering physics, and in order that the National Research Council might be advised with regard to the problems in this field, the solution of which should be undertaken. The president further suggested that conferences should be held in local communities with other physicists interested in the work, in order to encourage the application for grants for bona fide problems on the part of those who otherwise might not make application.

When the question had been fully discussed, it was unanimously agreed that the committee, by presenting definite well-thought-out subjects of research for the development of our natural resources and industries, giving as much detail as possible as to what would be involved in the investigation, would thereby enable the Council to decide more effectively which investigations should be supported.

It was also agreed that in order to stimulate research activities in all parts of Canada, the members of the committee should make it known in their districts that the Council would sympathetically consider applications for research assistance, and that competent investigators should be encouraged to submit proposals for research.

It was also the consensus of opinion that the committee could render a very useful service if all such applications or proposals in the field of physics and engineering physics were submitted to the committee for a report before final action was taken thereon by the National Research Council.

It was thought too, that the members of the committee or groups of members might, by getting in close touch with the research organizations in the different sections of Canada where they are situated, assist them in the formulation of their research programs, and in the utilization of the opportunities offered through the National Research Council.

This policy was approved by the committee, and it was suggested that a further meeting of the committee should be held some time in the autumn to consider the lists of research problems to be prepared in the meantime, prior to the submission to the National Research Council of definite recommendations thereon.

The chairman introduced Dr. J. A. Ruddick, Commissioner, Dairy and Cold Storage Branch, Federal Department of Agriculture, and informed the committee that he had invited Dr. Ruddick to address the committee on refrigeration. Dr. Ruddick stated that it is his duty to administer the Cold Storage Act. He called attention to the fact that refrigeration is used for many purposes other than cold storage—for example, the Eastman Kodak Company, Rochester, possesses the largest single artificial refrigeration plant in the world. Refrigeration is also used in the manufacture of chocolate and confectionery and in many other industries. Dr. Ruddick called attention to the wide gap between the information possessed by refrigerating engineer and that possessed by the

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average architect designing a plant and also to the fact that there is an amazing lack of efficiency in domestic ice refrigeration units, which is even worse in larger units, such as those used by grocers, butchers, etc. He emphasized the fact that there is great need to educate the general public as to the value and methods which should be adopted in utilizing the cooling power of ice.

Dr. Ruddick expressed the opinion that if dwelling houses were properly insulated, it would probably be possible to cut the fuel bill by half. He pointed out that the difference in temperature maintained inside a dwelling and that which prevails outside it during the winter season in Canada is as great as the difference in temperature inside a cold storage plant and that which prevails outside it during the summer months. No one would think of erecting a cold storage plant without insulating the walls, but few people as yet realize that there is equal necessity of insulating the walls of their homes, depending instead on an over-sized furnace and a double supply of coal. Dr. Ruddick expressed the opinion that if houses were properly insulated it might be possible to make better use of central-heating schemes.

Considerable discussion ensued, in which the question of the use of carbon dioxide as a substitute for ice and the use of various gases as preservatives for fruit were discussed. At the conclusion of the discussion, it was moved by Professor Allen, seconded by Professor Price, and resolved that the committee recommend that the National Research Council take steps to investigate the literature on refrigeration and, if necessary, issue a popular pamphlet embodying this information. It was also suggested that an investigation be undertaken with reference to the comparative refrigerating values of carbon dioxide and ice.

The committee had under consideration a report prepared by Dr. Eve, Chairman of the Sub-Committee on Radio, and entitled "On Recent Advances in Wireless Propagation both in Theory and in Practice." On consideration of this paper, the committee discussed the effect of the aurora on wireless transmission and reception, and considered whether it was advisable to send a spectrograph to Fort Simpson and to make arrangements to have observations taken there during the coming year. The question of the penetrating radiation of lightning flashes was also considered. As a result of the discussion which followed, it was unanimously agreed that a preliminary investigation should be arranged during the coming year at some western university.

A report prepared by Professor Rosebrugh, covering his investigations on "Interference in Radio Broadcast Reception," was presented to the committee. When this report had been carefully considered, it was moved by Mr. Patterson, seconded by Mr. Price, and resolved that the report be transmitted to the National Research Council, and that the committee express its satisfaction with the progress achieved.

Mr. Patterson introduced the question of the enormous loss which occurs annually in Canada through forest fires. He pointed out that forest débris is hygroscopic in character and that the seriousness of the fire is usually determined by the climatic conditions which precede it. He pointed out that if the humidity is down to about 30 per cent, the moisture dries out of the débris so thoroughly that no preliminary heating is required to start a fire and that under such conditions it spreads with such rapidity that it is soon uncontrollable. Mr. Patterson suggested that if some means of co-ordinating the forest activities of all governments could be perfected, this would be of enormous advantage to Canada. Dr. Shaw suggested that it might be of advantage to carry out a general research on the effect of humidity on hygroscopic substances.

Major Steele made a brief statement as to the results which had been achieved during the last few years from the use of aircraft in connection with forest protection. He pointed out that in this way it was possible to detect many fires in their initial stages and also to transport men and equipment to

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the scene in time to extinguish fires which might otherwise cause serious damage. He also pointed out that aircraft serve as a valuable check on careless campers and settlers.

The chairman raised the question of the advisability of taking steps to establish in Canada a gas research station. He pointed out that the general object of such a station would be the synthetic production of materials such as carbon black, formaldehyde, etc., and requested suggestions as to other materials in the production of which such a station could be utilized. It was suggested that as a basis for a decision on this question it would be necessary to catalogue all known uses of natural gas in the production of synthetic products.

The secretary reported that the term of appointment of Dr. J. S. Plaskett, Prof. R. W. Boyle, Prof. Frank Allen, Prof. T. C. Hebb, and Mr. H. O. Keay expired immediately following this meeting in accordance with the rotation schedule adopted by the committee. Discussion ensued as to the policy which should be followed by the committee in selecting a list of nominations to such vacancies, for submission to the National Research Council. It was the general consensus of opinion that the membership of the committee should consist of the best available men in physics and engineering physics, and that a retiring member should be replaced on the committee only when there was an equally strong man available to succeed him so that such action could be taken without weakening the committee. It was therefore unanimously agreed that the committee should recommend to the National Research Council that Dr. Plaskett, Professor Boyle, Professor Allen, Professor Hebb, and Mr. Keay be reappointed members of the committee for a further term of three years.

It was further agreed, on a suggestion made by President Murray, to recommend the appointment of Prof. E. L. Harrington to the vacancy created through the death of the late Dr. McGougan.

Subsequent to the annual meeting of the committee, sectional sub-committees were organized for the purpose of gathering within their own territory suggestions as to important research problems awaiting solution in Canada. Each of these sub-committees was under the chairmanship of a member of the Committee on Physics and Engineering Physics.

In order to collate the information collected, a meeting of the chairmen of the various sectional committees was held on February 25, 1926, in Montreal, at which meeting the reports presented by each sectional committee were reviewed in a preliminary way.

It was found, however, that the number of problems submitted by the various sectional committees was so large that only a very small proportion of them could be given immediate attention. It was therefore agreed that a list of all the problems presented should be prepared in accordance with a classification laid down by the committee and that a copy of this list should be forwarded to each of the sectional chairmen in order that each of them, either alone or in consultation with others, might carefully review this list, noting the problems which they considered most urgent. This would enable the committee to make definite recommendations to the Research Council as to problems in Physics and Engineering Physics which should be investigated.

Associate Committee on Helium

The National Research Council on consideration of representations received from the Department of National Defence suggesting the continuation of investigations initiated and partly carried through by Professor J. C. McLennan at Calgary in the years 1917 to 1920 on the extraction of helium from the natural gases of Canada, constituted in January, 1924, an Associate Committee on Helium. This committee is comprised of representatives of various organizations interested in this subject, including the Department of National Defence, the

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Federal Department of Mines and the Ontario Department of Mines. The activities of the committee up to the beginning of the year under review are fully set forth in the Annual Report of the National Research Council for the year ending March 31, 1925.

The fourth meeting of the Associate Committee on Helium was held in Ottawa on December 18, 1925, seven of the nine members of the committee being in attendance. At this meeting the chairman of the committee, Professor J. C. McLennan, reported that the National Research Council had decided that the helium recovery plant, formerly built and operated at Calgary, should be made available for the establishment of a helium recovery station, and, in addition, that the council was prepared to provide a sum of $5,000 toward the establishment of a gas research laboratory with a further sum not exceeding $5,000 annually for a period of three years toward the conduct of such researches on helium as might be approved by the National Research Council.

The chairman further reported that acting on authority given by the National Research Council, the committee had secured an option on certain natural-gas areas near Inglewood, Ont., known to contain gas rich in helium, and that as a result of representations made by the committee the Ontario Government had subsequently taken up this option and had purchased the gas rights in these areas. The chairman also reported that the scheme for the establishment of a helium experimental station had been considered at a meeting of representatives of the committee with the Finance Committee of the University of Toronto and that at this meeting a three-year preliminary scheme of research had been drawn up involving provision for the following expenditures:—

(1) To erect the station, install pipe lines and equipment.. ..	$25,000 00
(2) To carry on research for the purpose of lowering the cost of helium produced during a period of three years at $7,500 per year	22,500 00
(3) To sink three new wells	6,000 00
	$53,500 00

On consideration of the sources from which the necessary funds might be secured to meet this expenditure, it was thought by those present at the above meeting that the National Research Council might agree to contribute $5,000 for the installation of plant and $5,000 per year for three years, that the Federal Department of Mines might contribute $5,000 for one year, that the British Air Ministry and the Department of Scientific and Industrial Research in Great Britain might contribute £1,000; that the University of Toronto might contribute $7,500 per year for three years. These contributions would make available for this scheme approximately $52,500. The idea was that if all of the bodies indicated above became contributors to the scheme the University of Toronto would temporarily finance the undertaking and be reimbursed by the parties mentioned for the amounts cited.

The committee was also informed by the chairman that at a subsequent meeting of the National Research Council it was decided that the control of the plant made available by the National Research Council in connection with the above scheme should remain with the Council, that the method and regulations for the disposal of the surplus helium produced, after the needs of the laboratory of the University of Toronto had been supplied, should be determined by the National Research Council on the recommendation of its Associate Committee on Helium, and that the proceeds of the sale of this surplus helium should be set aside as a fund for further helium research.

Mr. McLeish, Director of the Mines Branch of the Federal Department of Mines, informed the committee that there was contained in his departmental estimates for the current year the sum of $5,000 to be devoted to a helium investigation and that he was now prepared to recommend that this sum be

made available for the scheme of the Helium Committee, provided it was understood that the direction of the research would be in the hands of the Associate Committee on Helium of the National Research Council, on which committee his department was represented. It was the unanimous opinion of the members of the committee that the direction of the helium research work undertaken should be in the hands of the Associate Committee on Helium of the National Research Council, but that the University of Toronto should be offered representation on the committee either by the Chairman of the University Finance Committee or by such person as the university might choose to nominate.

The committee was agreed that, if the Finance Committee of the University of Toronto decided that they had ample warrant for financing this scheme, Dr. McLennan, Mr. Patterson and Colonel Harkness should be a sub-committee with power to draw plans and formulate details for presentation at the next meeting of the Council. It was further agreed that two other members of the committee, Dr. Ruttan and Mr. McLeish, should, if possible, attend a meeting to be held in Toronto for the purpose of discussing the details of this plan with the Finance Committee of the university.

Information presented to the committee indicated that the British Air Ministry and the Department of Scientific and Industrial Research in Great Britain were favourable to co-operation in the work of helium extraction and were particularly interested in obtaining helium for research and in securing additional information on the cost of helium extraction.

The committee arranged that the representatives of the Federal and Ontario Departments of Mines should co-operate in testing the gas of certain wells in Ontario with the object of securing further information as to the extent of the Inglewood field. The Chairman informed the committee that he had received inquiries regarding the possibility of obtaining a supply of helium from various organizations in the United States, from the German Reichsanstalt and from various scientists and scientific bodies in Canada, Great Britain and Ireland.

At a meeting of the National Research Council held toward the close of the year under review, the position of the Council in connection with the proposed establishment of a helium recovery station was carefully reviewed and the decision of the Council in the matter was finally crystallized in the following resolution: "Resolved that for the purposes of establishing a helium recovery station at Inglewood, Ont., where the Government of that province has secured certain gas wells rich in helium, the National Research Council request the British Air Ministry to grant permission for the transfer to the University of Toronto of the helium plant formerly at Calgary, Alta., and now in the keeping of this Council, on the undertaking of the University of Toronto to establish and operate such station for helium research. On its part the Council agrees to grant a sum of $5,000 towards the establishment of such gas research laboratory, and to contribute a further sum not exceeding $5,000 per annum for three years after the plant is ready to operate towards the conduct of such researches in respect to helium as may be approved by this Council from time to time on recommendation of its Associate Committee on Helium. These grants are to come into effect when the Council has been informed that the University of Toronto has undertaken the establishment and management of such station on the following conditions: (1) to dispose of the helium produced in a manner to be arranged mutually between the President of the National Research Council and the President of the University; and (2) to set aside for further scientific research on helium, or for such other purposes as may be mutually agreed upon by the President of the National Research Council and the President of the University of Toronto, the proceeds of the sale of such helium."

At the close of the year under review negotiations were still in progress with the object of setting up the helium extraction and gas research station near Inglewood, Ontario, in accordance with the scheme outlined in this report.

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Associate Committee on Accurate Plot Work

The problem of securing standard methods of testing cereals is a very difficult one, owing to the almost endless variety of conditions found in different localities. It is nevertheless of great importance, since only by the use of standard methods can comparative results be obtained in testing varieties of cereals. New varieties are being produced in great numbers, and it is obviously a marked advantage if their commercial value can be determined in the shortest possible time.

The work of this committee during 1925 was carried on at six different points: the Experimental Farms at Ottawa, Ont., Charlottetown, P.E.I., Cap Rouge, Que.; and Scott, Sask.; at Macdonald College, P.Q.; and at the University of Alberta, Edmonton. Of these, the Central Experimental Farm alone received no financial assistance from the National Research Council.

The work involved in this project is being carried on with the greatest possible care. The plots are laid out and the seed are sown with almost mathematical accuracy. The method employed, including, as it does, sixteen replications for each rate of seeding, will reduce experimental error to the absolute minimum.

The most exact records are being kept of all work done and results obtained. When full data have been accumulated these will be analyzed and a complete statement of results will be available.

Associate Biological Committee

Destruction of Marine Piling by Borers

In the last annual report the importance of this problem, particularly in Europe and the United States, was outlined. Up to the present the damage along the Canadian coast line has not been serious, but in view of the possibility of greater destruction in future it is strongly advisable that the habits of the borers be definitely determined, and that methods of control should be worked out.

Throughout this investigation the committee has enjoyed the hearty co-operation of the National Research Council of the United States, which has been conducting a similar investigation in that country. The work in Canada has been carried out under the direction of Dr. A. G. Huntsman, Director of the Atlantic Biological Station of the Biological Board of Canada.

It has been found that while the adult borers (*Teredo navalis*) can survive through wide variations of temperature and salinity, there is a period of crisis in the development of the embryos. This is probably about the time of shell formation, between the sixtieth and eightieth hours, depending on the temperature.

Temperature is a very important factor in influencing the rate of growth of this very destructive mollusc. A temperature of 7.5° C. (46° F.) is unfavourable, while at zero ° C. (32° F.) only 33 per cent of the animals in a piece of wood were found to survive for seven days. Laboratory experiments indicate that a temperature of 15° C. (59° F.) is about the lowest necessary for successful development, while 22.5° C. (73° F.) appears to be the optimum temperature.

Salinity is also an important factor. Boring activities were found to be suspended at as low as 1 per cent salinity, although a lower figure might be tolerated if a good supply of oxygen could be maintained. At the other extremity a salinity of 4 per cent was found to be definitely unfavourable.

It is interesting to compare the results obtained in experiments with conditions found in different parts of the world. The question has not been much

studied in Europe, but in one case it has been noted that the borer was absent in a normal salinity of 0.615 per cent, but when in a dry year it rose to 1.27 per cent a very serious attack developed. A moderate temperature was also found to be favourable. In the United States much damage has been done in San Francisco bay, with a temperature range from 6° to 19° C. (43° to 66° F.) The salinity was from 0.908 per cent to 1.93 per cent. On the Atlantic coast damage is greatest where the average summer temperature is about 22° C. (72° F.) and the salinity is 2.4 per cent. In the cooler waters of Canada it may therefore be expected that attacks will be slight, and this is normally the case. The borers were not found in waters cooler than 13° C. (55° F.) and where found at this temperature there were adjacent bodies of water in which development probably took place. It was most active in water at a temperature of 18° C. (64° F.) and at a salinity of 2.1 to 3 per cent. It does not occur in the Bay of Fundy, where the average temperature in summer is 12° C. (54° F.)

It may therefore be said that in so far as the laboratory investigation has gone the results obtained corroborate those factors of temperature and salinity, which in nature limit the distribution of the borer. Once the critical stage of development has been passed, the animal is not as susceptible to unfavourable influences.

The results of the preliminary investigation were published in Report No. 15 of the National Research Council, and details of the second investigation will be issued as Report No. 20. Further work should, however, be done to determine more accurately the life history of the mollusc.

The Chemistry of Fish Muscle

The method to be adopted in fish curing depends to a large extent upon the nature of the material handled. Up to the present empirical methods have been the rule, but it is highly desirable that an effort be made to determine the chemical nature of the protein found in fish muscle in order that the methods of treatment may be developed on a more scientific basis. The chief advance now recorded over the results reported previously is the discovery that there is a difference between the muscle protein which dissolves in water and that soluble in a dilute solution of common salt. The former precipitates best at a pH of 6, whereas the latter comes down best at approximately a pH of 5. This has provided a means for the separation of two soluble proteins from the muscle of haddock. This method has been utilized for the separation of a large amount of protein which is being used in a further study of their characteristics.

An attempt was made to correlate two of the factors which effect the solubility—the concentration of salt used as solvent and the degree of acidity. Temperature is a third factor, but this was eliminated by keeping the material, apparatus and reagents at zero centigrade, all the work being carried on in an ice box. Different concentrations of salt were used to extract equal portions of muscle from the same fish. Precipitation was brought about by acetic acid of varying strengths; the liquid was centrifuged and aliquot parts of the resulting clear liquid were taken and analyzed for nitrogen.

An attempt was made to get a protein solution of fairly homogeneous character for testing. An experimental machine was designed and built for the purpose of carrying out dialysis to remove phosphates and other salts native to the muscle tissue. The dialyzed muscle was extracted with a very large volume of distilled water, with occasional stirring, and was then filtered. Precipitation was then effected by adding acid. The precipitated material was separated and preserved in alcohol. The preserved material will be subjected to further study.

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Associate Committee on Nitrogen Fixation

Two meetings of the Committee were held during the year, one in Ottawa on December 18, 1925, and one in Montreal on February 25, 1926.

At both the above meetings the general policy of the committee was discussed. It was the general feeling that the possibility of establishing a large nitrogen fixation industry in Canada was still remote, and that the general situation was not such as would justify the National Research Council in undertaking any definite investigation, particularly in view of the fact that intensive research was being prosecuted in several other countries, and much of the information obtained would be available to the committee. It was nevertheless considered important that the committee should keep in touch with progress in the nitrogen industry and compile information for distribution as might appear advisable.

Professor McLennan stated that in spite of the rapid progress that had been made in nitrogen fixation in England the Nitrogen Fixation Committee in Great Britain was no longer active. The death of Dr. Harker had removed a correspondent from whom much valuable information had been obtained in the past. There would consequently be increasing difficulty in securing information as to the progress of the British nitrogen industry.

The committee secured the services of Mr. A. S. L. Barnes for the preparation of the 11th Report. Dr. F. T. Shutt prepared for inclusion in it two reports on the fertilizer situation in Canada. There was also appended to this report a bulletin by F. E. Lathe on Nitrogen in Industry. This bulletin, dealing in three sections with sources and production of nitrogen, fertilizers, and urea, respectively, was recommended to the Council for publication.

The committee was strengthened during the year by the inclusion of Mr. H. W. Matheson and Dr. F. T. Shutt.

Associate Committee on Aeronautical Research

Only one meeting of the committee has been found necessary during the year, although substantial progress has been made with a number of investigations carried on under the auspices of the committee.

Of these, the most important has been the work of Prof. J. H. Parkin on the pressure distribution over a U.S.A. 27 aerofoil with square wing tips, which has now been completed, and the results of which are being published. It gives a complete scheme of pressure distribution on an aerofoil of this well known section, both when used as a monoplane, or in various biplane combinations with varying amounts of stagger. This information will be found of great value for aircraft designers using this wing section, which has excellent aerodynamic characteristics. The investigations were made in the four-foot wind channel at the University of Toronto.

A grant having been made by the Department of National Defence, in connection with the Turnbull variable pitch propeller, the final designs and specifications have been completed, and a contract let to Canadian Vickers Limited, and it is anticipated that the propeller will be ready for test very shortly.

One of the principal difficulties in carrying on the work of the Associate Air Research Committee has been that of obtaining and paying experimenters as assistants. Representations are now being made to the National Research Council which it is hoped will lessen this difficulty in future.

Among the tests now in progress are: Prof. C. M. McKergow on the behaviour of oil for oleo shock absorbers; Prof. R. S. L. Wilson on the behaviour of rubber shock absorbers at low temperatures; Prof. Vickers on magneto noises; Prof. Parkin on the wind channel at the University of Toronto; Dr.

Eve on the position in the electro-chemical series of various metals and alloys, with special reference to corrosion effects.

During the year, Colonel Stedman has been good enough to furnish the committee with information regarding recent developments in aviation work. The following notes deal with the more important of these topics:—

Racing

A member of the Air Research Committee was able to be present at the Pulitzer races held in New York and at the Schneider Cup race held in Baltimore in the fall of 1925. These races have some considerable importance in aeronautical research as indicating the highest possible speed that can be attained under certain conditions by aircraft at the present stage of development.

The Pulitzer race was a disappointment in so far as actual speed was concerned, but this may have been affected by the course over which the race was flown. The average speed over the course of 200 kilometers was 248·99 miles an hour for the winning machine with a fastest lap of 249·97 miles per hour. The second machine made an average speed of 241·7 miles an hour with a fastest lap of 243·7 miles per hour.

The relation between this maximum speed attainable and the speed of a service aircraft developed from the knowledge obtained from racing aircraft can be seen from the fact that in the second heat of the Pulitzer race service aircraft were used with an average speed of about 169 miles an hour.

The Schneider Cup race is a speed race for aircraft capable of operating from the water, and this year caused a good deal of interest in aviation circles because Great Britain entered two machines.

The race was won by an American machine with an average speed over a distance of 350 kilometers of 232·57 miles per hour, whereas the second machine was a British machine with a speed of 199 miles per hour. The American machine on the day following made a world's record for a straight away flight over a 3-kilometer course at a speed of 245·7 miles per hour. This is the fastest speed yet made by a seaplane.

Engine development

One of the most interesting features of the year has been the success attained in the air-cooled 12-cylinder V-type engine. In the past, aviation engines have usually developed into the V-shaped water-cooled engine, or the air-cooled radial engine.

The radial engine has a number of very useful features, but has an outstanding disadvantage in that it is rather difficult to fair it into the body of the aircraft cleanly.

The air-cooled V-type engine, particularly when inverted, can be installed very neatly in aircraft, and it is anticipated that more development along this line will be seen in the near future.

Superchargers for all types of military aircraft have reached a stage where they can be considered as an essential part of up-to-date equipment, and this development of the power unit is of considerable interest for other purposes, as it will enable comparatively low-powered aircraft to operate at greater heights, and immediate application can be made to aerial photography.

Light alloys

Interesting developments have taken place in light alloys, particularly in the use of magnesium-aluminum alloys, which are becoming more and more general, and alloys of beryllium and aluminum. These latter alloys are now being investigated, and it is anticipated that valuable results will be obtained in the very near future.

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All these and other developments in air-craft that are being made in other counrties are being closely followed by members of the Air Research Committee, although funds do not permit any very active part being taken in the more expensive research work in aeronautics.

Channel Wall Interference

The wind channel is one of the principal sources of information required for the development of aerodynamics and the design of aircraft. In the wind channel a small-scale model of the complete aircraft is supported in a moving current of air and the forces exerted upon it are measured. The conditions of the wind channel test differ materially from those of the full-sized aircraft in free flight and hence the results obtained in experiments are subject to various corrections before being strictly applicable to full-scale free flight conditions.

The modifying influences which must be taken into consideration when using data obtained in wind channels operating at atmospheric pressure, are as follows:—

(1) Those due to the size and nature of surface of the model.
(2) Those due to the support of the model.
(3) Those due to the wind channel itself, whether open or closed, and the shape and size of its cross section.
(4) Those due to the air current, considering both speed and turbulence of flow.

Some of these, notably those due to model, model support and air speed, have been much investigated, and considerable information has been obtained. On others but little experimental work has yet been done and our knowledge is still far too limited. This particular research has been undertaken to obtain experimental data regarding the necessary corrections due to the wind channel.

In wind channels the air stream is of limited extent and restrictions are thereby imposed on the air-flow past the model. In order therefore to enable the results of wind channel tests to be applied to aircraft in an unlimited air space, the nature and magnitude of the influence exerted by the boundaries of the stream on the air flow, and resulting forces on the model, must be known.

Modern theory has provided a basis for estimating the effect of channel walls on air flow and the present study was made primarily with the object of securing experimental confirmation of the effects predicted by theory. Experimental work was confined to an investigation of wall interference in wind channels of the closed-tube type with square and rectangular cross sections.

The results obtained show: (1) that the presence of channel walls results in an increase in the drag on any symmetrical body; (2) that experimental data agree with the theoretical corrections with channels of reasonable size; (3) the extent and nature of the wall interference effects in greatly restricted streams beyond the limits of applicability of the theory.

—*(Investigation under the direction of Prof. J. H. Parkin, University of Toronto.)*

Associate Committee on Mining and Metallurgy

The committee met early in March at the time of the Annual Meeting of the Canadian Institute of Mining and Metallurgy in Montreal.

Reports from several sub-committees which had been at work during the year were presented.

The Chairman of the Sub-Committee on Electro-Metallurgy stated that a complete report covering the results of its investigations would be ready for presentation to the Research Council at an early date.

The sub-committee appointed to consider whether it would be possible by further investigation to devise some practical method for the removal or material reduction of the sulphur content of Nova Scotia coal, reported that a large amount of information had been collected with reference to the work which had already been done, both in Canada and in England, with reference to the purification of coals high in sulphur, but that the sub-committee had not as yet completed its studies. In connection with this problem it was reported that the difficulties to be overcome did not lie so much with the removal of the sulphur which was present in the form of pyrite as with the elimination of that which was present in the form of organic compounds containing sulphur, and whose separation was a problem of much greater difficulty. The sub-committee was requested to continue its work and to present, at as early a date as possible, a report on this subject, with such recommendations and suggestions as it might consider advisable.

The chairman reported the action taken by the Research Council in connection with the proposal that it should undertake an investigation into the concentration of telluride ores in the Kirkland Lake district. It had been found that investigations into this matter had already been carried out in the laboratory of the Mines Branch of the Dominion Department of Mines and also in the laboratories of Queen's University and of McGill University. Inquiries made from the managers of three of the principal mines in the district in question brought replies from these gentlemen to the effect that they did not consider that such an investigation would be of value. Mr. Lathe informed the committee that an investigation recently carried out by Professor Müller at Ohio State University for the Wright-Hargreaves Mines Company had succeeded in solving the problem of the concentration of telluride ores to the satisfaction of that company by the utilization of a floating process followed by roasting and cyanidation of the concentrate. The committee therefore agreed unanimously that the Research Council had taken the proper course in deciding not to make a grant for the purpose of undertaking further investigations on the concentration of these ores at the present time.

Dr. Sexton reported that the investigation into the extraction of oil from the oil shales of Nova Scotia, which had been carried out by the aid of a grant from the Research Council, by Prof. A. E. Flynn, of the Nova Scotia Technical College, had been completed and the results of the investigation had been forwarded to the Research Council. The chairman informed the committee that the results would be published by the Research Council in the immediate future.

Dr. Porter gave an account of the progress of the investigation into the relative efficiency of various types of screens employed in connection with ore dressing, which he was undertaking by the aid of a grant from the Research Council, and stated that his final report to the Council would be ready in the near future.

Mr. Lathe gave an account of the important results which have already been obtained by the Magnesite Committee, which is engaged under a grant from the Research Council in an investigation into the purification of Canadian magnesite and its utilization for various purposes. The results obtained so far have been most satisfactory and promise to lead to the employment of Canadian magnesite in industry to a much larger extent than heretofore.

Mr. Morrow, Chairman of the Sub-Committee on the Utilization of Canadian Iron Ores, presented a report on the present situation in Canada with respect to the utilization of Canadian ores, and also the manuscript of a History of Iron Mining and Iron Making which had been compiled under the direction of his sub-committee. The publication of this history will be considered by the Research Council. As the large bodies of iron ore in Canada are, almost without exception, low in grade, this sub-committee has been devoting its attention

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almost exclusively to the study of the beneficiation of low-grade ores. "Our object," the report states, "has been to obtain direct and definite data on the work of beneficiating low-grade iron ores wherever attempts are made and to follow their use in the blast furnace. The sub-committee early recognized the impossibility of obtaining sufficient funds to carry out extensive experiments on a semi-commercial or commercial scale. It has therefore made careful observation of the work accomplished by those concerns, either private or governmental, outside of Canada, and expects to be in a position to provide the National Research Council with definite information as soon as successful commercial beneficiation is demonstrated."

It was suggested by Dr. Sexton that the question of the best method of storing coal was a subject which might be investigated with great benefit to the public. Owing to the fact that Nova Scotia coal mined in winter must for the most part be banked till spring when it can be shipped by water—and that while banked it undergoes a certain deterioration—it thereby suffers in competition with coals from the United States which can be shipped all the year round. After a full discussion of the question, Dr. Sexton was requested to prepare a memorandum on the subject for the consideration of the committee, and in order that, if advisable, it might be forwarded to the Dominion Fuel Board for action.

It was decided that arrangements should be made whereby approximately one-quarter of the membership of the Associate Committee on Mining and Metallurgy shall retire by lot each year, but shall be eligible for reappointment.

III. ANALYSIS OF REPORTS ON ASSISTED RESEARCHES

Many detailed reports have been received during the year of researches carried out both by Associate Committees of the National Research Council and by specialists to whom the Council has made grants for the purchase of apparatus or the securing of technical assistance. Most of these papers have been printed in technical periodicals or in the transactions of technical societies, but to reproduce them in full in this report would be out of the question. In order, therefore, to give a general idea of the work performed, there is presented in this section a short summary of the principal researches conducted during the year under review with a brief explanation of the main problems involved. A complete list of the researches to which financial assistance has been granted will be found in Appendices "D", "E", and "F".

The Nature of Winter Hardiness in Crop Plants

The ability of plants to overwinter successfully appears to depend upon a series of chemical changes which give the protoplasm stability. A comprehensive study has been completed of the changes occurring in winter wheat plants during the fall and winter months. This constitutes a contribution to pure science as well as to practical agriculture.

By analysing the press-juice as well as the entire tissues at progressive dates it has been possible to study the distribution of the most important constituents between the fluid cell contents and the inert supporting framework. Most previous studies of changes in plant composition have been confined to analyses of the entire tissues, whereas it is the tissue fluids which are mainly concerned in physiological activity.

The view has been advanced by Dr. D. T. MacDougal and other well-known physiologists that plant protoplasm probably consists of a protein-pentosan complex with pentosans predominating in some cases. Present analyses seem to make this view untenable in relation to wheat plants, in which the pentosans are confined almost entirely to structural parts, and proteins predominate in the fluid cell contents. The soluble sugars are, however, very important from the point of view of this investigation. Fat seems relatively unimportant in winter wheat, although in certain trees it has been found by other workers to accumulate in winter.

The fluid proteins, then, are the colloids which give to hardy wheat plants the power of retaining the water content of the cells against the force of ice crystallization in the intercellular spaces. Further experiments on the " bound water " content of the wheat plants during the winter have, however, not confirmed the existence of any simple and consistent relationship of this property to winter hardiness, thus serving to illustrate again the great complexity of the problem.

Considerable progress has been made in elucidating the mechanics of the disorganization of protoplasm by frost. Existing theories hold that this is due to the precipitation of the proteins, and this can be demonstrated experimentally. However, the cause of the protein precipitation has been in doubt. It has been shown in this investigation that both "salting-out" and acid-precipitation play a part, and that sugar is probably the most important single factor in protecting the protoplasmic proteins from disorganization by these agencies.

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By the use of juice dialyzed free from electrolytes an attempt was made to study separately the salting-out and acid-precipitation effects, uncomplicated by the action of acids and salts naturally present in the juice. This gave the surprising result that small concentrations of salt exerted a protective effect, and the point has been reserved for further investigation.

The naturally-occurring sugar concentrations in wheat plants during the winter have been studied for a number of seasons, and it has been found by experiments *in vitro* that the protection afforded by sugar increases with its concentration, at least up to the maximum concentrations normally found in the juice of winter-hardened plants. It is not surprising therefore to find that in general the hardiest varieties contain the largest amount of sugar throughout the entire winter.

By low-temperature respiration experiments an attempt has been made to explain the disappearance of sugar from wheat plants during the winter. The results obtained show that at temperatures close to 0° C., the respiratory activity is directly proportional to hardiness, and also to catalase activity as previously reported.

One of the greatest limitations to precision in biological work is the plastic, almost fluid, nature of the experimental material. Changes in environment are quickly reflected in the physiological and chemical condition of the plants. Samples collected at different times are never exactly comparable. Conditions have been standardized as far as possible in relation to age and condition of experimental plants, and it is hoped in the near future to have greenhouse space with close temperature and humidity controls.

The ultimate object of all this work is: (*a*) to discover the fundamental nature of frost-resistance, and thus to place the problems of breeding varieties resistant to winter-killing on a sound, scientific basis; (*b*) to develop reliable methods by which the plant breeder may estimate accurately the hardiness of a new strain in one season, rather than be forced to test it in field plots for five or more winters.

—*(Investigation under the direction of Prof. R. Newton, University of Alberta.)*

1925-26

The Deterioration of Concrete in Alkali Soils

In the eastern part of North America concrete and steel construction is generally considered as the standard for permanence. On the western prairies, however, there are many localities where concrete structures are found to deteriorate rapidly, often requiring extensive repairs or replacements in from three to five years. It was early noticed that very rapid deterioration frequently took place in districts where the surface water contained "alkali," this term being generally used to denote a high content of soluble salts, usually of sodium and magnesium sulphates.

The problem early came to the attention of Professor Thorvaldson, of the University of Saskatchewan, and in 1920 he began an investigation in an effort to determine the cause of the deterioration and to devise means for its prevention. When, the next year, the Engineering Institute of Canada and the National Research Council decided to make a thorough study of the problem, it was natural that they should select Professor Thorvaldson to take charge of the chemical investigation. The work was seen to be of such importance that the Governments of Saskatchewan and Alberta, the Canada Cement Company and the Canadian Pacific Railway all agreed to share in the expense with the National Research Council.

A number of papers have been published giving details of the results so far obtained. In outline, it may be said that the action of sodium sulphate was

found to be due to double decomposition with the free lime always formed in the hydration of cement. Since the calcium sulphate formed is relatively insoluble it is largely precipitated, and it therefore continues to be formed, that is, the hydration of lime and the disintegration of the cement can continue. With magnesium sulphate or any other soluble sulphate the action is similar in that calcium sulphate is formed, but when magnesium is present the reaction is further stimulated due to the insolubility of the magnesium hydrate concurrently formed. In some cases the action of frost is sufficient to destroy concrete—this is due to the formation of ice from the water in the pores.

It will be noted that in all these cases the rapidity of the action will vary directly with the permeability of the concrete, for unless the water and solutions can penetrate the latter, action will be confined to the surface and will be correspondingly slow. Impermeability is a requisite of permanence under severe conditions.

It is often important to be able to determine in any particular case to which of several causes disintegration is due—to sulphates, frost or acid attack. Laboratory methods of doing this have been perfected. When destruction is due to sulphate action the insoluble sulphates are found in the concrete. Acid action varies according to the nature of the acid. Frequently the lime salt formed is soluble and is leached away, and some of the acid radical always remains, even though the salt be soluble. Frost leaves the disintegrated cement practically unchanged in composition. Careful analysis therefore reveals the cause in every case.

It has been claimed that the new cements high in alumina would resist the action of sulphate waters. An investigation extending over three years shows this to be partially true. Bars of high-alumina cement were found to resist the action of waters containing magnesium sulphate, but were only partly resistant to sodium sulphate. When both sulphates are present, conditions are favourable to disintegration, as this proceeds more rapidly with low alkalinity, and the insolubility of magnesium hydrate prevents the solution from becoming appreciably alkaline.

One difficulty which has greatly prolonged the investigation has been the necessity of determining the rate of action of solutions upon test pieces. This difficulty has now been overcome by the development of an accurate method of measuring the expansion of pieces under test. This opens up the possibility of studying the effect of remedies and of drawing conclusions as to their usefulness long before any changes in the test pieces are visible. This new method is now being used for the study of various factors on sulphate disintegration as well as to test out a number of possible remedies.

—(Chemical investigation by Prof. T. Thorvaldson, University of Saskatchewan, under a Committee of the Engineering Institute of Canada—Dean C. J. Mackenzie, Chairman—in co-operation with the National Research Council.)

The Horseflies of Western Canada

The investigation of this important family of bloodsucking flies was undertaken because of the possibility of their association with the transmission of the disease known as swamp-fever. This affection of horses is prevalent in certain regions of the prairie, and recurs annually, causing severe losses. Observations appear to indicate that there is some association of a seasonal character between the incidence of the flies and that of the disease. Under experimental conditions the disease has been successfully transmitted from sick to healthy animals by certain species of horseflies. This work has been carried out in Wyoming and in Minnesota.

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The *Tabanidae* (horseflies) of the prairie had not previously been studied, and this investigation so far has been concerned with the study of the life-histories and habits of the several species that inhabit the plains. It thus became essential to devote a large part of the time to the acquirement of specimens for rearing in the laboratory, so that as complete information as possible could be obtained of the various phases of the early stages of development of the different species. The insects were studied in the field and observations made on their breeding habits and the duration of their life-cycle. In the course of this phase of the investigation it was found that the early stages of many species, including the egg, larva, and pupa, had not been previously described, and for the favourable progress of the work it became essential to describe these accurately and to illustrate them carefully. This has now been done for eighteen distinct species, but certain gaps still remain to be filled.

It was found that in the great majority of cases the horseflies deposit their eggs on the leaves of aquatic plants in sloughs during the summer and that the larvae on emergence drop into the water and passing through their early stages of development in the underlying mud they gradually pass to the margins where they are found in the early summer of the following year. In the drier soil they pupate, and after about two weeks as pupae, the adult flies emerge and the cycle is again renewed. In the case of a few species there are indications that the normal life-cycle of one year may be extended to two years if the conditions prove unfavourable.

Lack of previous knowledge of the early stages made it necessary that the larvae collected in the field should be reared in the laboratory to the adult condition, so that exact determinations of all stages could be obtained. The cannibalistic habits of many of the larvae necessitated the treatment of each specimen individually in a series of breeding-jars and for successful rearing much time had to be devoted to maintaining the optimum conditions for the different species.

As a result of the rearing experiments much valuable information was acquired concerning the parasites of the eggs, larvae and pupae which will prove useful in any consideration of the natural control of these pests of live stock. One new species of parasite of the pupa was discovered and this has been described.

It has not been possible in the case of some species to obtain their eggs under field conditions. Specially devised rearing cages were therefore constructed and adult flies collected in the open were placed in the cages under conditions approximating those of the known habitats of the different species in nature. In a few cases oviposition occurred, but in many cases no success was achieved. It was believed that failure was due to the fact that the flies had not previously obtained a blood-meal from their hosts. Specimens were then captured feeding on cattle and horses either fully engorged with blood or in the process of becoming engorged, but no greater degree of success was obtained in the case of these individuals. It is therefore desirable that more time should be devoted to the study of the conditions that are favourable to oviposition especially in the case of these species the oviposition habits of which in nature are unknown.

It is hoped as the investigation develops to prosecute more particularly those phases of the work which are concerned with the hypothesis of transmission of swamp fever by horseflies and to investigate likely methods of controlling the numbers of these pests. The widely scattered nature of the breeding places, sloughs that are distributed far and wide throughout the prairie, presents many difficulties. It was originally supposed that advantage might be taken of the peculiar habit, which the various species possess, of skimming the surface of the water in rapid flight. A film of mineral oil sprayed on the surface of a pond was found to be fatal to these flies. The oil adheres to the bodies of the insects and

causes their death by suffocation. In the great majority of cases, however, only the males develop the habit of skimming, and so the females are free to deposit their eggs, which may have been previously fertilized by the males.

—(Investigation under the direction of Prof. A. E. Cameron, University of Saskatchewan.)

The Onion Maggot in the Montreal District

The onion maggot is one of the most serious pests in the important truck-gardening area which supplies Montreal and the neighbouring cities and towns. So insistent have been the complaints, and so frequent the requests for advice on the control of this insect, that an investigation was begun to discover the biology of the onion maggot and to work out methods for its destruction.

The first season's work was confined chiefly to the securing of accurate data on the life-history of the insect, and to the making of tests and comparisons of the " poison pan " and " trap crop " methods of control.

In subsequent work the habits of the adult were carefully studied, with the object of devising more effective measures of control. A study of infested and non-infested soils was made, the important relation of adult flies to flowers was investigated, and experiments in control were carried out.

The onion maggot is the larva of a small fly somewhat resembling the house-fly. It is found to-day wherever onions are grown in Canada, although not native to this country. The onion is practically its only food, although closely related plants such as garlic, leeks and shallots are sometimes attacked. Eggs are laid at any time after the first of June, close to the onion plants, and just beneath the surface. The eggs hatch in about four days, when the maggot emerges and immediately attacks the onion, in the bulb of which it lives and feeds. Small onions are destroyed and large bulbs are severely injured. The maggot changes to the pupa stage in about two weeks, and after another similar period the fly emerges and the life cycle begins anew. There are from two to three generations in a season.

The adult flies feed on flowers, chiefly those of the dandelion, and, strange to say, the eggs will not develop unless the flies have access to flowers. The discovery of this fact made possible the working out of the life history in control cages, and the establishment of the preoviposition period, which proved to be 13 to 17 days. This is of importance, since the principal method of control now in use aims at destroying the flies during this period. Sunlight proved essential to mating and egg-laying.

In field experiments carried out on a large scale the combined poison-bait-trap-crop method of control resulted in a material reduction of loss, and this method of control is now recommended to growers.

Tests of a number of baits are in progress. The usual one consists of a gallon of water sweetened with a pint of molasses, to which is added a quarter of an ounce of sodium arsenite. The substitution of sodium cyanide for the arsenite increased the attractiveness of the bait, but reduced its destructive power.

The dependence of the adults on flowers for food indicates that the removal of all flowering weeds from the onion field would tend to reduce the infestation.

—(Investigation under the direction of Prof. E. M. DuPorte, Macdonald College.)

Biological Origin of False Wild Oats

Oat plants which appear in many respects to be intermediate in character between the common cultivated oat species and the wild oat are frequently found growing in crops of ordinary commercial oats, and also in strains of oats which

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have undergone severe breeding refinement. These intruding forms are in general regarded as weeds and have been commonly called false wild oats, because of certain characteristics which they possess in common with true wild oats. Their origin has been a matter of uncertainty and dispute for many years. The evidence has supported two theories, one that these forms arise as a result of natural crossing between the cultivated oats and wild oats, that is, the natural crossing theory; and the other, that they occur as a result of some spontaneous change in the genetical constitution of individual plants of the cultivated variety, that is, the mutation theory.

The object of this investigation was to secure further evidence relating to this problem, particularly by cytological studies of the chromosome phenomena, just previous to the fertilization of the flowers in false wild oats as compared with that in cultivated and in wild oats. The problem has also been studied by breeding methods. As the research progressed it became evident that it would be necessary to enlarge the cytological investigations to include all species of oats. The genetical studies, as well as certain phases of the cytological studies, will take several years to complete.

The most significant findings to date are the irregular chromosome behaviour in the false wild oat, as compared with the cultivated and wild oats. The normal behaviour in the latter indicates stability of species characteristics, and probably species types of long standing, while the chromosome irregularities of the false wild oat suggest a lack of stability of chromosome behaviour and consequently a new and as yet rather unstable adjustment of chromosomes to each other. The indications are that this confused chromosome situation quite frequently found in the false wild oats is brought about by some fortuitous change in the chromosomes of the cultivated oat forms, which change also brings about new genetic factor relations and character relations which results in the origination of the false wild oat form. The evidence points strongly to this and consequently lends support to the mutation theory of the origin of false wild oats.

Scientifically the findings respecting these chromosome irregularities contribute something to that now rapidly growing field of biological study of the relation of chromosome phenomena to biologic forms of organisms.

Economically it has been found that the false wild oat has no lineal relationship with the wild oat, neither does it ever revert to this dangerous form. The false wild oat is rather to be regarded as a distinct variety of oat, and not at all the serious menance to agriculture it has been supposed to be.

—(Investigation under the direction of Prof. J. R. Fryer, University of Alberta.)

Glucosides of Plants Native to Western Canada

These plant compounds, which can be readily converted to glucose or other sugars, are frequently of great pharmacological value. No thorough study of those found in Canada has yet been made, but in view of their importance it is highly advisable that this work should be carried out.

The object of this investigation is—first, to ascertain whether in species of corresponding orders to those examined by French scientists, the same glucosides are present; and second, to determine the presence of new glucosides, with a view to their isolation and possible utility.

The method extensively used by French biochemists and pharmacists for the last twenty-five years has been adopted throughout. It is known as Bourquelot's biochemical method, in which the fresh plant tissue is boiled in 85 per cent alcohol, extracts being made with successive portions to remove all the glucosides. The alcohol is evaporated under reduced pressure and the residue is taken up in thymol water. If highly coloured, it needs to be clarified, and

is then ready for test with a polarimeter. The rotation and reducing power of the extract are determined. It is then subjected to the influence of invertase for a week, and the rotation and reducing power are again determined. These are also redetermined at the end of a further period of a week during which it is subjected to the action of emulsin.

Since fresh plant tissue is required for this test it is in this climate essential to collect the material and subject it to the initial treatment between May and October. This limitation of the collecting period determines the procedure, it being scarcely possible to do more than make the preliminary observations in one year. The results obtained determine the nature of the attack during the following summer.

During the summer of 1925 fourteen species of plants were collected for this preliminary survey and the initial treatment was carried out to the stage at which the extracts could be preserved without decomposition. Selection of these species was governed by consideration of the plants already studied in France, so that some comparable results might be available.

The application of Bourquelot's method has been made to eleven of the fourteen species collected. Of these, evidence of one or more glucosides has been found in eight species. In three species the glucoside present appeared to be that previously discovered in other species of the same genera; and in seven, possible evidence of glucosides not previously isolated has been obtained.

The work so far done therefore confirms the utility of the method and has already indicated a number of plants which may repay more detailed study as to the nature and properties of the glucosides present. It is desirable to extend the list of plants studied to include all those easily obtainable species which might possibly yield glucosides of medicinal value; and where their presence has been revealed to collect sufficiently large amounts of the plants to permit isolation of their glucosides and subsequent purification, with the determination of their pharmacological properties.

—(Investigation under the direction of Prof. A. T. Cameron, University of Manitoba.)

The Inheritance of Spore Size in Fungi

Spore size has been generally regarded as a valuable character in the classification of various species of fungi, and in most modern works on mycology the length and breadth of the spores are recorded for each species. It has been shown that in the higher plants specific variations due to environmental factors are not inherited, but up to the present no experiments have been made to determine the nature of spore size and other variations so common in many species of *Hymenomycetes*. It is important that we should know whether such variations are inherited or are purely fortuitous.

The fungus chosen for these experiments was *Coprinus sterquilinus*, a species which can readily be grown in either summer or winter, and fruits readily. Since it has been proved that this species is homothallic, the progeny of a single spore may be regarded as a pure line.

Monosporous cultures were made from spore deposits by the dry needle method, the spores being placed for germination in nutrient gelatine. Each spore was carefully measured before being placed to germinate. Spore deposits were later collected from the fruit-bodies which appeared on the monosporous mycelia, and the mean size of the spores in each spore deposit was compared with the size of the mother spore from which the particular monosporous mycelium had originated.

The mean size of the spores from a fruit-body was determined by measuring the lengths of 100 dry spores with the Poynting plate micrometer. This was

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done with the spores from each of 50 fruit-bodies so that a total of 5,000 spores was measured. These varied in length from 11.2 to 22.8 microns, with an average of 17.8. No appreciable relation was found between the sizes of these spores and those of the mother spores.

To further check this point, large spores were chosen for five successive generations, and the same for small spores. In each case the average spore length was almost the same, indicating that the size of the spores was not modified by inheritance.

In view of these results it seems justifiable to regard spore size as a stable character for purposes of classification, provided always that sufficient consideration is given to variability in the sizes of spores from individual fruit-bodies.

—(Investigation under the direction of Professor A. H. R. Buller, University of Manitoba.)

The Use of Ultra-Violet Light in the Poultry Industry

Canada's poultry industry has in recent years increased rapidly in importance. Not only has Canada won an enviable position through her international exhibits, but in egg-laying competitions she has proved that a cold climate and long winters do not prevent the establishment of excellent records in egg production. Her position in this regard is due in no small part to the work of the Poultry Division of the Dominion Department of Agriculture.

Several investigators in other countries have tried the effect of ultra-violet light upon chicks, and some have claimed remarkable results, particularly in the prevention and cure of rickets in chicks reared indoors in cold weather. In view of the facts that in this country it is often necessary to hatch chicks in the late winter or spring, before they can be let out in the sunlight, and most of the vital rays are absorbed by window-glass, it seemed highly desirable that experiments should be tried here to determine what effect ultra-violet light would have under conditions prevailing in this country. There are several possible ways in which ultra-violet light may be beneficial:—

1. Uuon hens, in increasing the production of eggs and their fertility.
2. Upon eggs, in improving the hatch.
3. Upon brooder chicks, in increasing growth and vigour.

Up to the present only the first of these has been tried, and that for but a short time. So far no marked effect has been observed, but the experiments will be continued and broadened to include all three possible influences.

—(Investigation under the direction of F. C. Elford, Dominion Poultry Husbandman.)

Ultra Sonics

This is the science which deals with sound waves so rapid that they are not perceptible to the human ear. And, as ultra-violet light is found to be radically different from that which is visible to the human eye, so ultra-sonic vibrations possess certain properties quite distinct from those of ordinary sound. They open up an entirely new field in the domain of physics, one alike of the highest scientific interest and of possible practical application.

Ultra-sonic waves are generated by applying an alternating difference of potential of high frequency to a quartz plate, the latter alternately contracting and dilating and sending out into the surrounding medium a wave of the same frequency of vibration as the electrical impulse. A quartz plate is thus an essential part of the ultra-sonic transmitter.

Ultra-sonic waves differ from ordinary sound in that they can be sent out, like light, in beams which travel in straight lines. One of the most important possibilities of an ultra-sonic wave is the detection of a distant object by means of a beam impinging upon and being reflected from it. Experiments have shown that different materials reflect these beams with widely varying intensity, and one part of this investigation has therefore been directed towards the determination of the reflecting powers of various substances and the comparison of the experimental results with those indicated by theoretical considerations. The latter are based upon the density of the medium and the velocity of sound in it.

In a previous report, giving the results of tests carried out at sea, it was stated that steel was an excellent reflector of ultra-sonic waves, rock was moderately good, and ice was very poor. The following table gives the comparative reflecting powers of these three materials as determined in the laboratory and calculated from theory:—

Substance	Relative Reflecting Power	
	Determined	Calculated
Steel	1.00	1.00
Granite	0.76	0.84
Ice	0.31	0.29

Another problem to be investigated was the relation of the velocity of ultra-sonic waves in a liquid to the frequency of vibration in such waves. Determinations of velocity of ultra-sonic waves were made over a range of frequencies from 40,000 to about 600,000 cycles per second. The results show that the change of velocity with frequency, if existent at all, is very slight. All the velocities obtained checked, practically within the limits of experimental error.

The formation of a partial vacuum within a body of liquid, as by the too rapid revolution of a propeller, is termed cavitation. From what has already been said of the transmission of ultra-sonic waves in liquids it will be seen that cavitation, due to alternate compression and tension, is a possibility. If vibration is extremely rapid and its amplitude is great the transmitter cannot maintain contact with the liquid. The result will be a cavitation or partial vacuum, made evident by the appearance of bubbles. Owing to the low vapour pressure of water at ordinary temperatures the production of such a phenomenon with this liquid has not been accomplished, but it has been done with toluol, benzol, xylol, acetone, ether, gasoline, and ethyl, methyl and denatured alcohols. Using a frequency of 80,000 cycles per second cavitation was produced at from 1,850 to 5,700 volts, depending on the liquid. In most cases bubbling was obtained not only at the transmitter but also at nodal points throughout the liquid.

An ultra-sonic beam, like that of light, is in the form of a cone with its vertex at the source. Both show the phenomenon of "side-beams", these coming off the main beam at angles progressively increasing with the distance from the source. Reflection of these "side-beams" may interfere with the observance of the behaviour of the main beam, and an effort has therefore been made to eliminate this trouble by obstructing the path of the beam by an object with a vertical aperture. It was found, however, that this resulted in a serious loss of intensity in the main beam, while the disturbance on the side of the aperture away from the transmitter was fully as great as that of the original beam. No advantage was therefore found in the use of the aperture.

—(Investigation under the direction of Dean R. W. Boyle, University of Alberta.)

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The Preparation of Metallic Barium

Metallic barium is very difficult to prepare owing to the enormous amount of heat generated by its combination with other elements. It oxidizes rapidly in the air and reacts vigorously with water, alcohol and other liquids. All the early attempts to prepare barium were unsuccessful in producing the metal, lower oxides and halogen compounds being ordinarily obtained. In 1901 Guntz distilled a 3 per cent barium amalgam, produced in electrolysis, until the barium content was increased to 10 per cent. This was subsequently heated in an atmosphere of hydrogen, and later *in vacuo* to 950° C., and metal of 98 per cent purity was obtained. He later prepared moderately pure metal by heating barium oxide *in vacuo* with aluminum.

None of these methods were successful in producing a pure metal. This investigation was therefore undertaken in an effort to isolate pure metallic barium preparatory to a study of its physical constants. Its heat of solution and the heats of formation of its salts should be redetermined with care and its action in the field of organic chemistry should be further studied.

The method adopted in this research is that proposed by Guntz—the reduction of barium oxide *in vacuo* with metallic aluminum. The best method of producing barium oxide is to decompose the carbonate above 1,250° C., by heating in an electric resistance furnace. It is difficult to secure porcelain tubes which will withstand such a temperature but this has finally been done and a quantity of pure barium oxide has been prepared.

The experiments in the production of metallic barium from the oxide have not yet proceeded far but a small quantity of a white crystalline metal has been obtained and the prospects for the preparation of pure metalic barium in considerable quantity appear to be good. When this object has been attained the investigation will be extended to include heats of formation and organic compounds of barium.

Since this work was begun a fellow of the National Research Council of the United States has, by a modification of Guntz' apparatus, succeeded in producing a small quantity of pure barium. It is hoped, however, that the present investigation will be successful in producing the larger quantity which will be required if the program outlined is to be followed.

—(Investigation under the direction of Prof. H. E. Bigelow, Mount Allison University.)

The Alkaloidal Content of British Columbia Goldenseal and Deadly Night-Shade

Goldenseal (Hydrastis Canadensis)

For the past twenty years a wide interest has been shown in the cultivation of this plant, owing to the increasing demand, to the greater knowledge of its usefulness for medicinal purposes and to the gradual depletion of the natural sources of supply. The present wholesale price of the root is about $6 a pound, while the extract, alkaloidal hydrastine, at present sells for about $25 an ounce.

The early settlers in America learned of the value of goldseal from the Indians. At present it is used as a remedy for certain digestive disorders, for catarrhal affections of the mucous membrance and as a bitter tonic. Until about 1900 sufficient goldenseal occurred naturally to satisfy the market demand. It grows chiefly on hillsides, where it receives natural drainage, and in woods, which supply the necessary shade. As the roots of this herb are the parts required for drug extraction, most of the natural sources of supply have been destroyed by drug collectors.

Goldenseal is a perennial, reaching maturity in four or five years. It cannot be grown successfully in an open field and consequently natural conditions have to be imitated. This may be done by growing the herb in the shelter of trees or by providing artificial shade. In this investigation the latter method was adopted. A shed, constructed of laths, provided 75 per cent shade. A light, sandy loam was used and the beds were raised above the level of the ground to provide good drainage.

The result obtained indicated that the growing of this plant in British Columbia is commercially feasible. In British Columbia there are doubtless many favourable locations with proper drainage and shade for growing goldenseal under natural conditions. The prospective grower should bear in mind that it requires five years for the crop to reach full development and the initial outlay for preparing the soil and the upkeep for labour and fertilizers would be considerable. The yield obtained indicates a possible return of $14,000 per acre at present prices, but it is naturally impossible to forecast what the producer would receive for his crop five years hence.

Deadly Night-Shade (Atropa belladonna)

Preparations from this plant have a wide application in pharmacology, both for their midriatic property and their paralytic effect on the muscles and central nervous system. The chief alkaloids of *atropa belladonna* are hyposcyamine and atropine, and a small quantity of hyoscine.

Belladonna is a perennial, a native of southern Europe and Asia, but widely naturalized in most civilized countries. It is a beautiful spreading plant sometimes obtaining a height of six feet. In British Columbia plants were grown from seed on light, well-drained, sandy loam. Growth was very luxurious and the yield excellent. Two crops are usually gathered with the exception of the first year.

British Columbia possesses some natural advantages for the cultivation of belladonna. There is comparatively little winter killing, a trouble frequently encountered in the United States. A marked advantage is the absence of the potato beetle, which is unknown in British Columbia, but which greedily attacks the foliage of belladonna wherever grown in the East.

—(Investigation under the direction of Professors R. H. Clark and J. Davidson, University of British Columbia).

The Essential Oil Content of Some British Columbia Mints

Various members of the mint family are cultivated extensively in Great Britain, United States and other countries as the source of essential oils, which are widely used as flavouring and therapeutic agents. Several varieties of mint grow wild in abundance in British Columbia. The object of this investigation was to determine the oil content of such plants when grown under conditions approximating those of commercial fields in other countries.

The plants used for this investigation were with one exception imported from Europe and were grown on a well-drained, sandy loam in the botanical gardens of the University of British Columbia. The location was on the east side of forest land so that the plants were afforded partial shade. The crop, outside of being weeded, received no special cultivation or watering.

Peppermint (Mentha piperita)

The so-called black variety of peppermint was imported from England. The growth of the plants was disappointing, possibly due to the fact that they had not been acclimatized. A rust fungus stripped the lower leaves from the stems before the plants were in full bloom. The plants were distilled while in

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early flower. The percentage yield found was reasonably good but the yield per acre was not more than one-fourth of the normal yield obtained in the United States.

The price of peppermint oil during the last two years has been very high, due to the extensive spread of rust in the United States. Owing to the low yield in British Columbia, however, the financial returns per acre would be low.

Spearmint (Mentha viridis)

These plants were also badly affected by rust before maturity, with consequent loss of foliage. The percentage yield of oil was good but the amount per acre was only one-third of an average crop. The price of spearmint for the last two years has also been high due to the prevalence of rust and the large requirements of the chewing-gum industry.

Horsemint (Monarda fistulosa)

These plants showed a good growth and were free from disease while the yield of oil was well up to the average obtained elsewhere. The oil contains a high percentage of thymol which is extensively used in medicine as an antiseptic. The market requirements are comparatively small.

Pennyroyal (Mentha pulegium)

These plants had an excellent growth and the yield of oil was considerably above the average. The oil is used in medicine and in the flavouring of confectionery.

Thyme (Thymus vulgaris)

The plants showed a good growth but the yield of oil was low. Normally, however, the yield from a plant of this species increases for several years. This herb, often used for flavouring, yields oil of thyme, which has well recognized medicinal properties.

Tansy (Tanacetum vulgaris)

Tansy is a perennial plant now found as a weed in various parts of British Columbia. On cultivation it showed an excellent growth and the yield of oil was well above the average. Oil of tansy is exceedingly poisonous and is used in medicine as a vermifuge. It also finds some use in perfumery. The market requirements are small.

In view of the fact that the prices of some of the above oils have been subject to great fluctuations, and that the market for the others is decidedly limited, it does not appear advisable at the present time to attempt to cultivate these plants in British Columbia.

—(Investigation under the direction of Professors R. H. Clark and J. Davidson, University of British Columbia.)

The Wireworms of the Canadian Prairie

From the earliest days of grain production on the Canadian prairies farmers have suffered loss owing to the destruction of newly seeded grain by wireworms. In the last ten years this loss has become very serious, especially on fields that have been continuously in cultivation for fifteen years or more. In some sections of the country wireworms are now considered the most serious menace that the grain producer has to face, and as the damage increases with the period of cultivation even greater losses may be anticipated in future unless methods are promptly adopted to check this increase.

It is recognized that there are found on the prairie a considerable number of varieties both of true and false wireworms. Up to the present no serious study

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has been made of the damage caused by the different varieties, but this is exceedingly important since their habits differ markedly and it may be expected that radically different methods of dealing with them will have to be developed.

A preliminary survey showed that in many districts in central Alberta and Saskatchewan the most widespread damage is undoubtedly attributable to the larvæ of *Ludius aeripennis*. In the more northern part of Alberta, including the Peace River district, where losses have been particularly severe, this appears to be the only wireworm of any economic importance in grain fields. This investigation has therefore been largely confined in its early stages to a study of this particular variety of wireworms, although it will later be extended to include a number of others.

The black click-beetles, which develop from wireworms, may live for several years, but it appears improbable that the pest is rapidly spread by these adults, since they have never been observed to fly and are otherwise non-migratory. The damage appears to be done almost entirely by the larval or wireworm stage. Careful records of the past history of cultivation in severely infested fields strongly indicate that deep cultivation early in the season has alone been responsible for the prevalence of *Ludius aeripennis*. This appears to hold good for all types of soil. Careful observation of the habits of the wireworms shows the reason for this. The eggs are deposited in the early part of the season in loose soil containing 5 per cent of moisture and upwards. Deep cultivation loosens the soil to a depth where this percentage of moisture can be readily secured. If shallow cultivation is practiced either the eggs will not be deposited or they will be destroyed by the higher temperature and low moisture prevailing near the surface.

It is recommended that summer-fallowing be practiced in those fields which are badly infested, and that prior to July 15 the surface soil be frequently cultivated to a depth of not more than two-and-one-half inches. This will destroy weeds, conserve moisture below the depth of cultivation and confine the deposition of eggs to the warm, dry surface soil. If then the fields be ploughed to a depth of not less than six inches during the latter part of July this will kill practically all of the helpless pupae, thus destroying two generations of the wireworms in a single season, under favourable climatic conditions. It is improbable that such treatment will entirely exterminate the pest since the adult beetles may live several years. It is believed, however, that the occasional practice of this treatment will keep them under control.

These recommendations have been issued as a result of only one season's field work, supplemented by laboratory experiments, but the evidence secured appears to be so conclusive that farmers are strongly recommended to practice these corrective measures. Advantage has been taken of the radio to broadcast the information thus secured and present indications are that the farmers of the western prairies will immediately proceed to take advantage of the information which has been secured.

—*(Investigation under the direction of Prof. E. H. Strickland, University of Alberta.)*

The Inheritance of Sugar and Starch in Corn

One of the chief advantages of dent over flint varieties of corn is that the former do not require grinding before being fed to stock. Unfortunately, when dent corn is grown in northern latitudes, it shows a strong tendency to revert to the flinty character. If it be possible to develop a dent variety which will mature in the short summer of the Canadian West and not revert to flint corn it will be of great value to the prairie farmers.

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This investigation has been undertaken in co-operation with the United States Department of Agriculture. It was felt that duplication of some of the work in the two countries would greatly increase its chances of success, and bring results more quickly, especially in view of the fact that early frosts in Manitoba are in any season likely to injure the crop before it reaches maturity.

In crossing varieties of corn advantage is being taken of the working of Mendel's law of inheritance. When a variety with a "dominant" characteristic, such as a high content of starch, is crossed with one possessing a "recessive" characteristic, as sweetness, all of the first generation of hybrids have high starch and low sugar. If these are again crossed there are produced on all the ears mixed starchy and sweet kernels in the proportion of three to one. The sweet kernels are pure sugar varieties and will breed true, one-third of the starchy kernels are also pure (but only trial will reveal which ones are pure and which hybrid) and the remainder are hybrids like the parents. It thus becomes possible to produce crosses which will breed true and which may retain certain desirable characteristics of the parents.

In this case it is aimed to eliminate the possibility of reversion to the flinty character by producing a corn without the zein protein which appears to cause it. A series of typical dent, flint and sugar varieties was first carefully analyzed by Professor Geddes, of the Manitoba Agricultural College, to determine which would be most suitable for the parent stock. The four varieties chosen—two each of dent and sugar corn—were then carefully crossed by Mr. M. T. Jenkins, of the Iowa Experiment Station. The hybrids were analyzed to determine the effect of the crossing on the sugar and starch content, and the zein protein content will also be determined. They will then be grown for two seasons in order that the true-breeding varieties may be selected and the most promising of the crosses given a trial.

Paralleling the above experiments there is being carried out at Winnipeg the crossing of Northwestern Dent, the only variety of dent corn capable of ripening in Manitoba, with three early varieties of sugar corn, the object being to increase the earliness of Northwestern Dent and obtain a variety upon which experiments for the elimination of the flinty factor may be carried out in Manitoba. This work has been carried on for three years and a gradual reduction in the percentage of flinty ears has been secured. At present there are being tried out twenty-six different crosses of the purely dent type, all derived from the Northwestern Dent.

This investigation, it is believed, is the first to make use of accurate chemical analysis instead of mere visual examination in the crossing of varieties of corn.

—*(Investigation under the direction of Prof. H. F. Roberts, of the University of Manitoba.)*

The Clays of the Lake Agassiz Basin

Towards the close of the Glacial Period, Lake Agassiz covered almost the whole of southern Manitoba and parts of North Dakota and Minnesota. The site of the present city of Winnipeg was then over five hundred feet below the surface of the lake. As the ice sheet retreated the level of the lake was lowered, but the receding of the water was finally stopped by the ridges of the Pre-Cambrian rocks between Winnipeg and Hudson Bay. Lake Winnipegosis, Lake Manitoba and Lake Winnipeg are the present-day representatives of this great inland fresh-water sea.

The basin of lake Agassiz forms an excellent opportunity for the study of sand and clay deposits of an unusual kind. Owing to the low temperature of the water the character of the deposits was radically different from those found

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in ordinary lakes. There was a marked contrast between conditions prevailing in summer and winter and an annual banding is therefore frequently found.

Fairly complete sections through the clay deposits of lake Agassiz have been exposed by excavations near the city of Winnipeg and by erosion along the banks of the Red river.

The lake clays consist of two series of finely laminated beds separated by thin but well-marked sandy beds. The upper series is between two and three feet thick, has imperfect lamination and tends to break on drying with definite cubical parting. The lower series is very uniform throughout the whole section so far examined and is built of laminae from one-fiftieth to one-fortieth of an inch thick, these representing the seasonal deposits. Separating the two series is a sandy bed from four to eight inches in thickness which represents a period during which the lake was comparatively shallow and the water was moving northward at a rapid rate.

The clays of the upper beds have been of some industrial value but the lower clays are practically useless in the natural state. Although they slake rapidly and are of a good colour they are exceedingly difficult to work, and form a tough, sticky mass, which on drying checks and warps badly and shows an excessive air shrinkage. Experiments indicate that this is due to the amount of colloidal material which they contain and an effort has been made to work out methods which would make these clays suitable for brick making at a cost which would not be prohibitive. On heating the clay to a temperature of 200° C. the colloids are found to be partially destroyed, and at 1000° C. the conversion to non-colloidal material is complete. The change is irreversible, but whether it is caused by an aggregation of colloidal particles has not yet been determined.

The work has developed into a study of the characteristics of seasonal deposits of clays, particularly in glacial lakes, in order that data may be secured from which the character of the banding of the clays of the Winnipeg basin may be correctly interpreted. This may also be of importance in revealing the history of older rocks, such as the Cobalt argillite.

The erosive action of the Red River on the clays through which it flows has been studied throughout the whole year, from the standpoint both of the dissolved material and the suspended matter which the river carries. For comparison, samples of the water in Lake Winnipeg and of the sediments now being deposited there have also been included.

This work will be continued for the purpose of obtaining additional data necessary to the utilization of the clays and information which may be of value to the geologist.

(Investigation under the direction of Prof. R. C. Wallace, University of Manitoba.)

The Condition of Evergreen Leaves during the Winter

The behaviour of evergreen leaves during the winter has been a source of frequent discussion, but practically nothing has been definitely learned about it until the present. It is evident that the action of frost upon them is very different from that upon ordinary vegetation, and if the full significance of these differences can be determined it may be of considerable commercial importance.

For some years observations and experimental work have been carried on in Alberta on the changes taking place in evergreen leaves during the winter season. It has been found that there are two outstanding changes in the organization of the cells. In the first place, the strach present so abundantly during the summer disappears and its place is taken by fat. In the second place, the chloroplasts lose their identity during at least a part of the winter. This is partly dependent

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upon the temperature. Further, there is always a very distinct change in the green colour of the leaf so that there is a very strong contrast between the yellowish green of the winter and the vivid green to be observed during the summer months. These observations were first made on coniferous leaves from Alberta and the observations have since been extended to trees growing at sea level on the Pacific coast. These are naturally never exposed to extremely low temperatures. Laboratory experiments have also been carried on to determine whether under greenhouse conditions the formation of fat and the changes in colour would be prevented. Attention has also been directed to the question whether the green cells in winter could respire and assimilate carbon.

The observations and experiments carried out indicate as follows:—

(1) The conversion from starch to fat in the cells during winter months presents the same general features on the Pacific coast as is found in coniferous trees east of the mountains. The disorganization of the chloroplast is in general far less complete, and proceeds only as far as the initial changes which occur in Alberta.

(2) In material kept at constant temperature in greenhouses during the winter, changes in the nature of food reserve from starch to oil occurred in the same way as in control material kept under natural conditions. The disorganization of chloroplasts in the leaf cells was not so complete, and resembled the change occurring in coniferous trees along the Pacific coast. This indicates that the changes from summer to winter organization in leaf cells is not primarily dependent on temperature changes but more resembles a rhythmic change.

(3) Starch, which is usually the indication of photosynthetic activity in green leaves, forms equally well and at the same time in leaves of branches kept in darkness and in those in the light.

(4) By experimental means there was measured the amount of carbon dioxide given off from leaves of Alberta spruce in light and in darkness. The amount produced from the same material under similar conditions of temperature was always greater in darkness than in light, indicating that the chlorophyll mechanism of the leaves was still capable while in the winter condition of utilizing carbon dioxide and thus building up carbohydrates in the leaf.

These results are important inasmuch as they throw light upon the vital processes of leaves of plants which are capable of withstanding very low temperatures. There is found a rhythmic change in the nature of the food reserves which appears to be independent of experimental control as far as temperature is concerned.

—(Investigation under the direction of Prof. J. F. Lewis, University of Alberta.)

The Tar Sands of Northern Alberta

Alberta has recently come into prominence as a producer of oil. The wells drilled in the Turner Valley have proved that this district is of considerable importance, particularly for the production of light oils suitable for motor use. The Wainwright district has also developed into a commercial field. But, potentially of far more importance than either of these, the tar sands of Northern Alberta constitute a petroleum reserve of the first magnitude. Their utilization constitutes a yet unsolved problem, but if it can be placed upon a commercial basis it will be of enormous benefit, not only to Alberta but to Canada as a whole.

The present investigation is an attempt to learn the chemical nature of this bituminous deposit. If this can be satisfactorily worked out it will make possible an intelligent attack upon the large problem of oil recovery.

Two kinds of samples have been subjected to analysis,—those representing the weathered bituminous sand and those of fresh material not previously exposed.

A large quantity of the fresh tar sand was extracted with petroleum ether by percolation. This extraction took place much more easily than in the sample of exposed tar sand. The extract was more concentrated and also differed in other respects. There was also a very considerable portion of bitumen insoluble in petroleum ether. Sometimes this insoluble part separated out in the form of a stalactite adhering to the point of the percolator. Sometimes it separated in the receiver as a thick syrupy mass. Generally it did not separate at all, but could be obtained by evaporating most of the ether, dissolving the residue in carbon tetrachloride and diluting this with petroleum ether. The insoluble material was precipitated and could be filtered out. An attempt was made to filter the petroleum ether extract through fuller's earth to separate the resins, but this proved to be a hopeless task. Various solvents are now being used to separate this extract into fractions. At present the portion soluble in ethyl alcohol is being investigated in detail.

Apparently the fresh tar sand contains little if any volatile bituminous matter, nevertheless there is a decided change when exposed to the atmosphere. This may be simply due to the loss of water, but it is possible that changes in the bitumen also take place.

—(Investigation under the direction of Prof. A. Lehmann, University of Alberta.)

Nova Scotia Oil Shales

It has long been known that in the oil shales of the world there exist enormous resources of petroleum. In Scotland, where oil is high in price and labour is comparatively cheap, oil shale deposits have been worked at a fair profit since about 1850. In America, however, the supplies of crude petroleum have been so enormous, and labour has been so high, that the great deposits of oil shale are still practically untouched. The problem is to devise a method of oil extraction which will be so simple mechanically and so efficient chemically and thermally that it may be possible to produce oil from shale at a price which will enable it to meet the competition of oil from wells. No careful student of the subject can doubt that eventually shale will largely supplant crude petroleum as a source of heat, power and lubrication, but the transition will necessarily be gradual.

It is probable that the period of transition is now practically at hand, and it is consequently of the greatest importance that adequate preparations should be made to meet the new conditions. This is particularly true in regions like Eastern Canada, where no appreciable quantity of oil is recovered from wells, and important deposits of oil shale are known to exist.

The present investigation was undertaken to obtain information regarding the behaviour of Nova Scotia oil shales when subjected to distillation processes. All the work was on a laboratory scale, but the experiments were so varied as to include most of the conditions likely to be encountered in commercial operations. Detailed results are given in Report No. 18 of the National Research Council.

—(Investigation under the direction of Prof. A. E. Flynn, Nova Scotia Technical College.)

Properties of Secondary X-Radiations

The experimental work on this subject has led to a hypothesis about the scattering of X-radiation which is somewhat novel, but appears to account for the experimental facts. Since neither a wave theory nor a quantum theory

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by itself will explain all the phenomena associated with the scattering of X-rays, the following working hypothesis, which combines the two theories, has been adopted:—

(1) The average number of quanta scattered in a definite direction by an electron is a function of the wave-length, the angle of scattering, and possibly the position of the electron.

(2) The ratio of modified to unmodified quanta scattered on an average by an electron is a function of its position and the wave-length. This ratio will increase with the frequency of the primary radiation and the angle of scattering and will diminish as the energy of binding increases.

(3) Unmodified rays can interfere with one another.

(4) Modified rays cannot interfere.

To throw some light on this problem, experiments were carried out on the distribution of characteristic radiations for directions making small angles with the primary beam. As was expected, the distribution was found to be independent of the angle. This is a strong indication that there will be no interference in the case of modified radiation.

—*(Investigation under the direction of Prof. J. A. Gray, Queen's University.)*

The Culture of Fresh-Water Entomostraca

Canada's fishing industry is of very considerable importance. It forms a means of livelihood for some 70,000 people, and the annual value of its products is about $50,000,000. Methods of stocking lakes and rivers with fish have been fairly well worked out, but it is equally important to provide in these lakes and rivers sufficient food for the young fish. The present investigation is the beginning of an attack upon that problem.

Considerable attention has been devoted to the culture of a species of cladoceran (*Daphnia magna*), which has up to the present not been found in Canadian waters, and which because of its large size is especially interesting from an economic standpoint. It was at once found that this was a species eminently suitable for culture. Its characteristic habitat appears to be water in stagnant pools high in organic matter, and it is consequently much more resistant to the conditions incident upon stagnation than are the species previously experimented with. This fact, coupled with its large size, renders it a particularly valuable species for cultural operations, working towards a food supply for young freshwater fish.

Some idea of what can be done in the way of mass production of this species may be gained from the following: Eight specimens first obtained were placed in a battery jar and were supplied with palmella algae as a source of food. They thrived remarkably well, and as soon as the battery jar became crowded some of the animals were removed to other jars. At the end of three weeks there were ten jars containing approximately 6,000 daphnids.

The proper conditions of concentration were determined by allowing daphnids to multiply in jars until a maximum was passed. The history of these cultures was invariably the same. There was first a very rapid increase in numbers until the jars became crowded, when there followed a rapid diminution in the number of animals. This diminution could always be arrested if the water was changed, or if the over-crowding was relieved. If nothing was done the culture

practically died out. From a scientific standpoint it would be interesting to have some definite information as to the nature of those substances which, while in solution, appear to destroy the cultures when they reach a certain density. This density may be placed at about one animal for every 4 c.c. of water.

Experiments were performed in the culture of daphnids during the winter. They were fed on the usual food and were provided with rich leaf-mould in imitation of natural conditions. Some difficulty arose in connection with the water supply, as chlorinated tap water proved fatal. Lake water was available until cold weather came when melted snow was used, both of these proving to be perfectly satisfactory. These cultures differed from the previous cultures in two particulars. The first difference was that some of the crowded cultures produced about 90 per cent of males. The second was that in some of the cultures a bacterium developed and formed a thick coating over the surface, under which the daphnids died out rapidly.

Experiments to determine the most desirable acidity of the water indicated that the lower pH limit for this species is 5.4 and the upper limit is 9.5. These results are of interest economically because they show that this species is not suitable for stocking waters of bog lakes, which often have a pH lower than 5.

Possible variations in the number of entomostraca to be found under different conditions were discovered by a rough estimate of the number of *Simocephalus serrulatus* frequenting a small natural pool and a larger one artificially constructed nearby. The latter contained about 500 times as many individuals per cu. ft. This shows that favourable habitats for entomostraca can be artificially created.

—*(Investigation under the direction of Prof. A. Brooker Klugh, Queen's University.)*

The Biotic Effect of Light

The importance of the action of light upon both plants and animals is just beginning to be properly appreciated. Most of the conclusions so far arrived at are the result of empirical observation. Quantitative data are almost entirely absent. It is therefore important that methods should be developed for measuring not only the total amount of light, but also the amount of light of each wave-length.

Recent work in this investigation has consisted of the measurement of light penetration into the sea and into bodies of fresh water. This is of particular importance in studying the life conditions of aquatic organisms, and an instrument constructed for this purpose has been used with considerable satisfaction, but recently an improved model of duralumin has been completed. This metal is extremely light and strong, which makes it much more convenient to use, particularly when observations are taken from a small boat. Duralumin is sufficiently resistant to corrosion to be entirely satisfactory if washed well with fresh water after use in the sea.

The measurements in the sea carried out at St. Andrews, New Brunswick, were made to determine the amount of red, green and blue light at different depths in this coastal water. The approximate limits of the spectral regions in which the measurements were made are (1) red, wave-length 590 to the end of the visible spectrum, (2) green, wave-length 500 to 570, (3) blue, wave-length

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400 to 500. In each series of measurements the full value of daylight on a horizontal surface just above the water was taken as 100. The values obtained were as follows: —

Depth in Metres	Red	Green	Blue
	%	%	%
0·	100	100	100
0·5	52	85	75
1	40	78	55
2	24	52	34
3	14	35	18
4	5·5	22	11
5	3·5	16	7
10	—	2·5	—

The measurement of light penetration into Chamcook Lake was also carried out. The day was clear and the surface of the water was comparatively smooth. The values for the different depths were as follows:—

Dept in Metres	Per cent total light
0·5	70
1·0	58
3·0	42
5·0	30
10·0	10
15·0	Less than 4.

These figures are presented, not as absolutely precise values, but as approximations sufficient for use in considering the light relations of the plants and animals which live in the habitats in which these measurements have been made. The most important fact which has been established with respect to light penetration into the waters of the Bay of Fundy is that green penetrates to a greater depth than does blue light, this being a result different from that to be expected from a consideration of the data on light penetration into pure water, in which the coefficient of absorption is inversely proportional to the wave-length. The result found is nevertheless in agreement with data obtained recently by several investigators.

—(Investigation under the direction of Prof. A. Brooker Klugh, Queen's University.)

The Bacteriology of Certain Sea Fish

Fish is one of our most important foods. The flesh of fresh fish is sterile, and it is essential that it should be so handled as to reach the consumer in first-class condition. At present sufficient precautions are not always taken, with the result that in all large cities a considerable amount of fish is condemned. In the city of Montreal alone as much as 400,000 pounds of fish has been destroyed in one year.

The spoilage of fish is chiefly due to the method of handling after catching. The principal source of bacteria is the slime on the outside of the fish. The bacterial content is greatly increased when, as on the smaller trawlers, fish are allowed to lie at ordinary temperatures for an hour or more after being caught, and are subsequently handled several times with pitchforks. Ordinarily the bacteria find ingress chiefly through the gills, but the pitchfork holes provide an easier path. When, however, fish are packed in ice as soon as caught, then dressed and frozen, they keep well for several months and have a low bacterial content. Halibut caught in the Pacific, frozen and shipped to Montreal, arrive in excellent condition. Mackerel keep fairly well when frozen but deteriorate rapidly after being thawed. Additional information has been obtained regarding haddock, salmon and certain other sea fish. The relation between the bacterial content and other evidences of decomposition has been found to vary widely with the different species. Sixty-eight different organisms in fish have been isolated and identified.

The results obtained in this investigation will be a useful guide to practical fishermen in pointing out the danger of improper handling, and in indicating those conditions which will guarantee the preservation and delivery of fish in first-class condition for the market. In addition there has been obtained much information of scientific value to all interested in the problems treated.

Full details of this investigation are being published in Report No. 19 of the National Research Council.

—(Investigation under the direction of Prof. F. C. Harrison, Macdonald College.)

The Surface Energy of Solids

The object of this research is to accurately determine the heat of sclution of coarsely crystalline sodium chloride in water, and also that of the very finely divided salt. From the difference in heat developed a calculation of the surface energy will be possible.

Early experiments indicated that the temperature differences which would have to be measured were exceedingly small, and the first problem became the development of a calorimeter sufficiently accurate to satisfy the exacting requirements. As a result of much experimental work and numerous mechanical changes a new type of calorimeter has been designed and built which, it is believed, will be sufficiently accurate to make possible at least an approximate determination of surface energy.

The present calorimeter is completely closed, having no openings for either stirrer or thermocouple. The stirrer is dispensed with by rotating the calorimeter, and the thermocouple is placed outside. Improvements were also made in many of the accessory parts of the apparatus, and preliminary experiments indicate that the apparatus is capable of giving results of a high degree of accuracy.

—(Investigation under the direction of Prof. F. M. G. Johnson, McGill University.)

Power Losses in Dielectrics

The study of dielectrics is becoming of greater and greater importance due to the present trend of electrical development. Low-loss condensers are required for radio and other circuits, better insulators are needed for high-voltage transmission, and efforts are being made to improve power factors of induction-motor loads by means of static condensers. Some work on dielectrics has already been done, but our knowledge is still all too limited.

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The present investigation is a continuation of research begun several years ago at Harvard University. In that work the equivalent series resistance of a condenser was determined by actual measurement on a special bridge designed for the purpose. The variation with frequency of the equivalent series resistance was determined by plotting the logarithm of resistance against the logarithm of frequency. Over the wide range of frequencies taken (500 to 1,000,000 cycles) the result is apparently a straight line. On the other hand, the power loss may be determined from the resistance, the capacity and the frequency. Again the curve takes the form of a straight line. But, since the capacity varies slightly with the frequency, these two results are not entirely consistent.

The present investigation was undertaken to determine which of these relations is the true one. It is hoped that a straight-line relation may be established for either the resistance or the power loss. When this is done a relation between the power loss and the change of capacity with frequency will be investigated, so that if the change in capacity of a condenser is measured its power loss and equivalent series resistance may be calculated. The change in capacity can be measured much more easily than the power loss.

This change in capacity and power loss is closely related to the residual charge current. It is hoped that an expression for this current may be obtained indirectly from the other measurements taken over a wide range of frequencies. It is also planned to build up condensers of different materials which might be suitable for the manufacture of commercial low-loss condensers.

For the purpose of this investigation a special bridge has recently been completed, suitable vacuum tubes have been secured and a new precision wave-meter has been purchased. With these it is hoped that the work will make rapid progress.

—(Investigation under the direction of Prof. H. J. MacLeod, University of Alberta.)

The Auroral Spectrum

In recent years the auroral spectrum has been made the subject of extensive research in an effort to determine the nature of the upper atmosphere, which plays so large a part in radio telephony and telegraphy. Canada and other northern countries are in a particularly favourable position in carrying out such studies, owing to the excellent displays of the aurora common to northern latitudes.

About two years ago Professor Vegard, of Norway, put forward the hypothesis that the bright green spectral line at 5577.35 A. had its origin in the luminescence of solid nitrogen suspended in a very fine state of division in the upper atmosphere. In this investigation proof has been obtained that this line is not due to nitrogen, but to oxygen at low pressure. This has been shown in several ways.

The auroral green line was first produced in the laboratory with a mixture of helium and oxygen, and its position was determined as exactly that found for the auroral line by Babcock. An effort was then made to secure this line from oxygen alone. This was finally done with pure oxygen in a tube about one metre long and three centimetres in diameter, the electrical discharge being passed with the gas at a pressure of two millimetres of mercury. The intensity of the line was found to increase with the strength of the exiciting electrical current up to a strength of 160 milliamperes.

Experiments were then carried out to determine the effect on the line of mixtures of other gases with oxygen. Neon and argon were both found to increase the intensity of the line even better than oxygen. Taking as unity the strength of the line for oxygen alone, its comparative strengths when mixed with the other gases are as follows: helium, 1.7; neon, 4.6; argon, 84.2.

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In studying the Zeeman effect with the line 5577.35 A. it was found that magnetic effects of moderate intensity resolved the line into a Zeeman triplet with normal separations of the components. It would appear that this spectral line originates in an electron transition between atomic levels for oxygen, according to one of two new singlet-triplet schemes recently put forward.

In this investigation an effort is being made to secure a series of photographs of the light of the night sky and of the auroral light as well. In addition, when weather conditions are favourable, the intensity of the luminosity of the night sky is being observed, in co-operation with others, in a scheme put forward by Lord Rayleigh. The light of the night sky is divided for this purpose into three spectral regions by means of colour filters. The middle region is that of the green auroral line, and the other two are regions in the red and blue, each excluding the green line. The light in each of these regions is found to vary considerably from time to time, but the full significance of these variations will not be known until comparisons can be made with the results obtained at other points on the earth's surface.

—(Investigation under the direction of Prof. J. C. McLennan, University of Toronto.)

Low Temperature Research

The Carnegie Corporation, the University of Toronto and the National Research Council have co-operated in providing cryogenic equipment for the physical laboratory at Toronto. Means have thus been provided for the liquefaction of air, hydrogen and helium, and for the study of the physical properties of substances at the low temperatures obtainable with these liquids, namely, —192° C., —252° C., and —272° C. During the past year the following investigations have been carried out:—

(1) *The Electrical Conductivity of Metals*

The electrical conductivity of thin films of various metals at low temperatures has been determined. It has been shown that the conductivity of these films follows the same laws as those for metallic wires. The importance of this result lies in the fact that it is impossible to draw into the form of wires many of the metals whose electrical conductivity requires investigation, while it is comparatively easy to obtain them in the form of films. The conductivities of indium, cadmium, beryllium, lead, sodium, potassium and various alloys were investigated at several low temperatures.

(2) *The Crystal Structure of Solidified Gases*

The gases studied were oxygen, nitrogen, pentane, hexane, haptane and octane. In each case diffraction X-ray patterns have been secured of the solidified gas, and progress is now being made in working out the crystal forms from the data obtained.

(3) *The Luminescence and Phosphorescence of Solid Nitrogen*

The phosphorescence of solid nitrogen has been very fully studied by the use of a Coolidge electron tube. The tube was provided with a window of thin nickel foil through which electrons were driven against solid nitrogen with the speed acquired in vacuo in an electric field of 125,000 volts. One single sharply defined narrow band was found at 5945 A. and eight well-defined bands in a wide region of luminosity between 5206 A. and 5240 A. Since no bands anything like these eight in wave length and appearance have ever been found in the auroral spectrum, this is a strong indication that no part of the auroral spectrum can have its origin in solid nitrogen. The temperatures in the upper atmosphere are therefore probably not low enough to solidify nitrogen. If that be the case the

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famous green line at 5577.35 A. cannot be due to solid nitrogen, as believed by Professor Vegard. This is supplementary to the evidence previously obtained that oxygen and not nitrogen was the cause of the auroral green line.

It has also been shown that solid nitrogen can exist in two forms, one of which becomes luminescent but not phosphorescent when irradiated with electrons, and the other of which phosphoresces strongly.

This research has an important bearing on wireless telegraphy and telephony, for in the spectrum of the aurora we have a means of investigating the constitution of the so-called Kennelly-Heaviside atmospheric layer, which plays so important a part in propagating ether waves over long distances on the earth's surface.

(4) *The Band Spectra of Hydrogen and Helium*

This investigation has been confined to hydrogen and helium, as these gases have the simplest molecular structures of any elements. The study of these band spectra furnishes information regarding the form and structure of the molecules which emit the radiations constituting the band spectra.

The band spectrum of helium in the visible region has been photographed with the discharge chamber at room temperature, at the temperature of liquid air and at the temperature of liquid hydrogen. The intensities of over 150 band components were measured at these three temperatures. In the case of hydrogen the band spectrum was studied at room temperature and at the temperature of liquid air, and the intensities of over 450 band components were investigated. These measurements are the most extensive that have yet been made on any band spectrum, and the results obtained have resulted in further progress in determining the characteristic features of the simpler forms of molecules.

(5) *Improvements in the Liquefaction of Helium and Hydrogen*

Further progress has been made in designing and constructing metallic thermos flasks. A special form has been developed which it is expected will enable one to entirely dispense with the use of glass flasks in liquefying helium. This should considerably lower the cost. Moreover, thermos flasks made of metal will be much more suitable for a variety of experiments than the present glass flasks, which are both costly and fragile.

—(Investigation under the direction of Prof. J. C. McLennan, University of Toronto.)

Vulcanization of Rubber

In recent years an enormous amount of research has been carried out in an effort to determine the exact composition of rubber and to devise truly scientific methods of treating it. The most important changes to be studied are those taking place during vulcanization, since this radically alters the physical properties of the rubber.

The procedure which has been adopted for experimental vulcanization in this investigation represents a very marked improvement over the customary methods. Ordinarily, prepared rubber mixtures are heated either by steam in an autoclave or between hollow platens heated internally by steam. In the present work samples have been placed in tight steel moulds and immersed in melted paraffin wax. The main advantages thus gained are (*a*) a better control of temperature, (*b*) a wider range of temperature, (*c*) the possibility of running at the same time samples with different periods of vulcanization. The Canadian Consolidated Rubber Company co-operated in the development of this apparatus.

For the first time pure rubber hydrocarbon (caoutchouc) has been prepared in quantity and a study of its behaviour during vulcanization has been com-

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menced. The results obtained indicate that the changes taking place in pure rubber closely parallel those of ordinary rubber, but the maximum tensile strength which can be developed is much lower. An effort will be made to determine whether this is due to the absence of protein.

The absence of natural rubber resin has been found to materially retard vulcanization, in the presence of certain catalysts, but the addition to the resin-free rubber of as little as 1.5 per cent of fatty acid raises the rate of vulcanization to a normal value. The influence of the individual constituents of the resin will be further investigated.

In this investigation there is being included a study of the technique of testing rubber for tensile strength. The work so far done shows clearly that in high-grade rubber mixtures ring-test pieces give different results from straight-test pieces. The work will be extended to include other grades of rubber. If possible improved testing methods will be developed.

—(Investigation under the direction of Dr. G. S. Whitby, McGill University.)

Biophysics

In previous reports of the work done under this investigation attention was called to the development of new methods for studying the senses of vision, touch and taste. This is a comparatively new and important field in biophysics, and the methods devised made possible for the first time the obtaining of quantitative information.

It became evident that weak and intense stimulation of the various senses produced opposite effects, and these have now been minutely studied. Many new facts of importance in the theory of sensory actions have been discovered. One in particular may be noted as being of considerable practical importance. It was found that when the intensity of illumination fell below a certain figure the eyes became depressed in sensitiveness and more easily fatigued. This produced a double disadvantage in using the eyes in poor illumination. First, the intensity of the light was low, thereby causing eye-strain, and second, the eyes themselves were weakened in their power to see. This indicates the necessity of avoiding shadows in artificial lighting of homes and industrial establishments. It explains also the development of eye troubles amongst miners, and at the same time indicates a partial remedy.

Recently the same methods of measuring sensory actions, previously applied to vision, touch and taste, have been extended to the senses of temperature and pain. These have been found to act in precisely the same manner as touch and to follow the same mathematical law.

It has also been found that there is a peculiar relation between the action of various muscles. Considering the contraction of muscles of the arms, it has been noted that the stimulation of one arm influences the other precisely the same as one eye exerts an influence on the other. The results show conclusively the similarity of all nervous actions of the body and hence make it possible to understand more clearly the operation of the entire nervous system.

It is to be expected that these discoveries will in due time be of service in the practice of medicine and there find a large field of usefulness.

—(Investigation under the direction of Prof. F. Allen, University of Manitoba.)

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FINANCIAL STATEMENT FOR THE FISCAL YEAR ENDING MARCH 31, 1926

RECEIPTS

Appropriation	$135,000 00	
Grant British Empire Exhibition Scholarship	1,191 25	
Refunds	1,342 49	
Sales	640 00	$138,573 74

EXPENDITURES

Grants in aid of Research		$ 61,931 65	
Fellowships	$ 5,100 00		
Studentships	16,554 00		
Bursaries	16,928 00		
British Empire Exhibition Scholarship	1,500 00	40,082 00	
Fees to International Research Council, its Scientific Unions, etc		23 75	
Library		1,539 84	
Printing		621 43	
Administrative expenses of Associate Committees		1,072 15	
General administration		4,488 21	
Travelling expenses of members of National Research Council and staff		6,463 50	
Travelling expenses of Associate Committees		3,104 46	
Salaries and honoraria		19,243 35	$138,570 34
Refund to Receiver General			3 40
			$138,573 74

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APPENDIX A

Grain Rust Research Program for Canada

Biochemical Studies

1. The fundamental nature of resistance to stem rust.

Plant Breeding

2 .The crossing of common wheats known to possess some resistance, with the hope of building up a hybrid in which several genetic factors, governing resistance to at least a majority of the biologic forms of rust, would be present.

3. The interspecific crosses between emer and durum varieties of adequate resistance and desirable common types.

4. Cytological investigations to determine the chromosome conditions in the hybrids resulting from various crosses with a view to determining the underlying causes of sterility and linkage.

Plant Pathology

5. Epidemiology studies involving investigation on
   - (*a*) Overwintering;
   - (*b*) Spread;
   - (*c*) Viability of various spore forms of Puccinia graminis;
   - (*d*) Conditions governing infection.

6. Epidemiology studies involving a study of the spore content of the air with particular reference to the origin and spread of black stem rust. This project also includes the accumulation of meteorological data and the correlation of this with rust development.

7. Biological Specialization. The culture and determination of biologic forms of P. Graminis tritici with particular relation to
   - (*a*) What forms are present in Western Canada.
   - (*b*) Their relative frequency.
   - (*c*) Their distribution.
   - (*d*) Seasonal variation in occurrence and distribution.

8. Biological Specialization. The origin and constancy of biologic forms. To determine if possible whether biologic forms of the stem rust organism arise by hybridization on the barberry and to investigate the stability of forms.

9. Stem Rust of Oats. To study further the nature and distribution of biologic forms of the oat rust organism, to make epidemiology studies and to determine varietal resistance in oats with a view to developing resistant varieties of oats.

10. Crown Rust of Oats. A parallel study with stem rust of oats with especial emphasis on the relation of the buckthorn to crown rust in Western Canada.

11. Barberry Eradication. An intensive survey of specially selected areas was proposed with a view of obtaining conclusive data on the probability of the barberry becoming established as a native shrub under western Canadian conditions. The desirability of eradicating whatever barberries still remain in Western Canada was emphasized.

12. Buckthorn Survey. Continuous with barberry eradication to locate buckthorn and get rid of it wherever possible.

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APPENDIX B

Regulations Covering the Award of Grants for Research

1. The recommending of the giving or refusing of grants by the National Research Council shall be in the hands of a committee of five members of the Council to be known as the Committee on Assisted Researches. This committee may utilize the advice and assistance of any persons inside or outside the Council who, in their judgment, may be of value in any application under consideration.

2. The applicant must give a brief statement of the proposed investigation, its scope, time required, results hoped for, total cost, grant asked, specific purpose to which grant applied for is to be put, evidence of ability to carry on the investigation, concise statement of adequacy of general equipment of laboratory where investigation is to be carried on. If the applicant has asked for or is receiving a grant from any other body, he must state this fact in his application.

3. Grants will, as a general rule, only be made to persons who are conducting investigations in established laboratories which possess the fundamental apparatus and facilities necessary for research of the nature proposed, and where the ordinary overhead charges are already provided for, and will not be made for the purchase of standard apparatus which a well-equipped laboratory should possess.

4. Grants made are to be for requirements for one year only, but further grants may be made annually.

5. Grants will be made only to persons who can show capacity for independent research, and who have a reputation for trustworthiness and responsibility.

6. Grants are to be made only for the actual expenses of investigation, but may be used in whole or in part for the payment of assistants, and are not intended to support the grantee while carrying out the investigation.

7. When a grant has been made for a specific purpose, it must be used for that purpose only. If the grantee desires to change in any manner the subject of his investigation he must make application to have the grant made available for the altered investigation.

8. All apparatus and materials purchased with grants are to be regarded as the property of the Council, and when the investigation is concluded are to be subject to the disposition of the Council.

9. The grantee shall submit annually, or whenever called upon, an itemized statement of all apparatus and material purchased during the preceding year with National Research Council funds. Such a statement, covering the entire investigation, shall also be submitted upon the completion or conclusion of the investigation, together with a report by the grantee on the condition of such apparatus and materials at the conclusion of the investigation.

10. A report of progress is to be made annually by the grantee, or whenever called for, and, in every case, on the completion or conclusion of the investigation.

11. The grantee shall render annually, or whenever called upon, an itemized account of his expenditure, with vouchers. Such account shall also be made on the completion or conclusion of the investigation, and the balance of the grant required shall be paid over to the National Research Council.

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12. The grantee shall present a complete copy of the results of his investigation, before its publication, to the National Research Council, who shall have the right of publishing it under their own auspices. When the grantee publishes his research, he shall make due acknowledgement of the assistance received from the Council.

13. The Council will give careful consideration to every application, but will not assign reasons for refusing to make grants applied for.

14. All apparatus used in researches subsidized by the National Research Council and purchased out of the Council grants shall, upon the conclusion of the research, be returned to the custody of the Council, unless otherwise provided for in specific cases by resolution of the Council.

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APPENDIX C

Regulations Governing Bursaries, Studentships and Fellowships

A. General Regulations

1. These bursaries, studentships and fellowships are intended, not to facilitate attendance on ordinary collegiate studies, but to enable students, who have passed through a university curriculum and have given distinct evidence of capacity for original research (or, in the case of bursaries, students who have at least won high distinction in scientific study during their undergraduate course), to continue the prosecution of science with the view to aiding its advance or its application to the industries of the country. Evidence of this capacity is strictly required, this being the main qualification. The most suitable evidence is the presentation of a research already performed.

2. They are open on equal terms to men and women, and are awarded to the applicants who are deemed best qualified by the evidence submitted.

3. An applicant for a bursary, a studentship or a fellowship must be a British subject resident in Canada.

4. An applicant, to be eligible for an award, must be not over thirty-two years of age.

5. A married person cannot hold a bursary, studentship or fellowship.

6. A candidate must (1) be a *bona fide* graduate of a university or college in which special attention is given to scientific study, or (2) have received an equivalent training in an institution possessing adequate facilities of a scientific character for providing such training.

7. The departments of science in which capacity for research will be accepted as qualifying for an award are: Biology (Economic), Chemistry, Engineering, Geology, Metallurgy, Mineralogy and Physics.

8. Application for a bursary, studentship or fellowship must be made by the candidate to the National Research Council. He shall, with his first application, submit a complete record of his academic career and recommendations from the heads of the scientific departments with which he was connected, and the professors or instructors under whom he studied, showing that in their estimation he promises to be worthy of training for scientific research. He shall state the institution at which he intends to study, and the general line of work to be followed. The application will be considered and decided upon by the National Research Council or by a special committee appointed by the same.

9. Each applicant must arrange for his admission to some approved university, and submit with this application a statement from the professor under whom he intends to work in such university that such professor is willing to undertake the supervision of his work. Such supervisor will be expected to submit to the Council a confidential report on the grantee's work at the mid-year and on the conclusion of the award.

10. The date of the beginning of the tenure of an award shall coincide with the beginning of the academic session of the university at which the grantee is to carry on his work. In very exceptional circumstances, the National Research Council, upon a receipt of a formal application from the grantee, may permit a change of tenure to be made.

11. Successful candidates are required to devote themselves for a period of at least nine months of each year wholly to the objects of the award, and during that time are forbidden to hold any position of emolument or to engage in teaching.

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12. The holder of a bursary, studentship or fellowship shall furnish on or before February 1 a detailed mid-year report of his work up to that time; and also on completion of the tenure of his award, and not later than July 31, a complete and detailed report of the work carried on during the entire year.

13. Awards are payable as follows: Fifty per cent on October 1; forty per cent on February 1, or thereafter, on receipt of a satisfactory first half-yearly report; ten per cent after the expiration of the nine months' period of tenure and the submission to the National Research Council of a satisfactory report on the work of the holder for the whole period.

14. A person who holds a bursary is expected to qualify for and proceed to a studentship and as a general rule a bursary will not be renewed for a second year; but a person may be awarded a studentship a second time, or a fellowship a second time. In no circumstances, however, will the Council make more than three years' grants to any one person under any combination of bursaries, studentships and fellowships. However a Travelling Fellowship, similar to the Ramsay Memorial Fellowship, may be awarded to one who has already received three awards, if in the opinion of the National Research Council the applicant be of outstanding ability.

B. Special Regulations Governing Bursaries

15. A bursary is of the value of $750.

16. Application for a bursary must be made not later than March 15.

17. The principal work of the holder of a bursary must be a research in some branch of science, but he is expected to give considerable time to an advanced course of study.

18. A person who has held a bursary and who has, during his tenure of it, shown distinct evidence of capacity for original research is eligible to be a candidate for a studentship.

19. A bursary must be held at a Canadian university approved by the Council.

C. Special Regulations Governing Studentships

20. A studentship is of the value of $1,000.

21. Application for a studentship must be made not later than March 15.

22. The principal work of the holder of a studentship must be a research in some branch of science, the extension of which is important to the national industries; but he may give a reasonable amount of time to an advanced course of study.

23. A person who has held a studentship and whose work has been highly satisfactory to the Council is eligible to be a candidate for a second studentship, or even for a fellowship.

24. A first studentship must be held at a Canadian university approved by the Council; but a second studentship may, by special approval of the Council, be carried on in some Canadian scientific laboratory or works.

D. Special Regulations Governing Fellowships

25. A fellowship is of the value of $1,200.

26. Application for a fellowship must be made not later than March 15.

27. A fellowship will be awarded only to a candidate whose record shows that he possesses the capacity to conduct *independent* research.

28. The principal work of the holder of a fellowship must be a research in some branch of science, the extension of which is important to the national industries.

29. A person who has held a fellowship and whose work has been of great excellence is eligible to be a candidate for a second fellowship. In no circumstances will a third fellowship be awarded.

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APPENDIX D

Assisted Researches granted during 1925-26

Subject of Research	Grantee	Where carried on	Amount awarded
Reforestation experiments in cut-over and burnt-over lands of New Brunswick.	Associate Committee on New Brunswick Forest Problems.	Forestry Branch, Dept. of Interior, Ottawa and Lands and Mines, Fredericton, N.B.	$5,000 00
Deterioration of Concrete in Alkali Soils and Waters of Western Canada.	Committee of the Engineering Institute of Canada.	Departments of Chemistry and Engineering, University of Saskatchewan, Saskatoon, Sask.	$5,000 00
Engineering Standardization.....	Associate Committee on Engineering Standards	Ottawa.....	9,000 00
Grain Rust.....	Associate Committee on Cereal Grain Rust.	Various co-operating laboratories.....	10,000 00
Magnesite.....	Associate Committee on Magnesite.	Ottawa.....	10,000 00
Tuberculosis.....	Associate Committee on Tuberculosis Research	Various co-operating laboratories.....	10,000 00
Laws governing the screening of crushed ores.	Dr. J. B. Porter.....	Dept. of Mining Engineering, McGill University, Montreal, Que.	1,000 00
The nature of winter hardiness in crop plants.	Dr. R. Newton.....	Dept. of Field Husbandry, University of Alberta, Edmonton, Alta.	1,500 00
The inheritance of sugar and starch in corn.	Prof. H. F. Roberts.....	Dept. of Botany, University of Manitoba, Winnipeg, Man.	300 00
Fungi.....	Dr. A. H. R. Buller....	Dept. of Botany, University of Manitoba, Winnipeg, Man.	1,200 00
Investigation of the glucosides of plants-indigneous in Western Canada.	Prof. A. T. Cameron...	Dept. of Biochemistry, University of Manitoba, Winnipeg, Man.	300 00
Determining the elimination of magneto noises from aircraft receiving sets.	Prof. H. Vickers.....	Dept. of Electrical Engineering, University of British Columbia, Vancouver, B.C.	550 00
Effect of Violet Rays upon (1) laying hens (2) breeding hens, (3) eggs for incubation, (4) growing chicks.	F. C. Elford.....	Dominion Experimental Farm, Ottawa...	125 00
The Spectrum of the Aurora and the Light from the Sky, generally at night when the sun is down, before the moon is up in the cloudless sky.	Dr. J. C. McLennan.....	Department of Physics, University of Toronto, Toronto, Ont.	750 00
Colour Vision.....	Dr. Frank Allen.....	Department of Physics, University of Manitoba, Winnipeg, Man.	300 00
Further Studies on the Parathyroid Hormone and a Study of the Blood Chemistry in Animals with the Suprarenal Glands removed.	Dr. J. B. Collip.....	Dept. of Biochemistry, University of Alberta, Edmonton, Alta.	2,500 00
Chemical Separation: Identification and Possible Synthesis of Antipressor Substance from Hepatic Tissue.	Dr. A. A. James.....	Dept. of Biochemistry, University of Western Ontario, London, Ont.	1,000 00
Ultra-Violet Spectroscopy with Vacuum-grating Spectrograph.	Dr. R. J. Lang and Prof. Stanley Smith.	Dept. of Physics, University of Alberta, Edmonton, Alta.	1,200 00
The Effect of Temperature on the Strength of Castings.	Prof. R. W. Moffatt.....	Dept. of Civil Engineering, University of Manitoba, Winnipeg, Man.	1,000 00
Investigation of the Mechanical Properties of Metals at Low Temperatures.	Professors I. F. Morrison and A. E. Cameron.	Dept. of Mining, University of Alberta, Edmonton, Alta.	1,000 00
Studies of the Spermatozoa of Bulls and Studies of the Spermatozoa of Horses.	Prof. A. Savage.....	Dept. of Animal Pathology, University of Manitoba, Winnipeg, Man.	750 00
The Life History and Habits of the Tabanidae. (Horsefilies).	Prof. A. E. Cameron....	Dept. of Zoology, University of Saskatchewan, Saskatoon, Sask.	500 00
Investigation on the Vegetable Resources and the Flora of Eastern Canada.	Fr. Marie-Victorin.....	Dept. of Botany, University of Montreal, Montreal, Que.	1,200 00
The Effect of Radiant Energy upon Protoplasm.	Prof. A. H. Hutchinson.	Dept. of Botany, University of British Columbia, Vancouver, B.C.	1,500 00
The Chlorination of Methane.....	Prof. M. C. Boswell.....	Dept. of Organic Chemistry, University of Toronto, Ont.	1,500 00
Collecting, Identifying, Recording and Mounting the Marine Algae of the Canadian Atlantic Coast.	Prof. H. P. Bell.....	Dept. of Botany, Dalhousie University, Halifax, N.S.	800 00
The Effect of Light on Life Processes....	Prof. A. B. Klugh.....	Dept. of Biology, Queen's University, Kingston, Ont.	500 00

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APPENDIX E

Additional Researches in Progress during 1925-26 under grants previously awarded

Subject of Research	Grantee	Where carried on
The preparation (production) of metallic barium.	Prof. H. E. Bigelow.....	Department of Chemistry, Mount Allison University, Sackville, N.B.
The cultivation of medicinal plants in British Columbia.	Dr. R. H. Clark and Prof. J. Davidson.	Departments of Chemistry and Botany, University of British Columbia, Vancouver, B.C.
Grinding ore in ball mills and rock crushing in rolls.	Prof. H. E. T. Haultain.....	Department of Mining Engineering, University of Toronto, Toronto, Ont.
Separation of the bitumen of the Alberta tar sands into its chemical constituents.	Dr. A. Lehman.....	Department of Chemistry, University of Alberta, Edmonton, Alta.
The resistance of plants to low temperatures.	Prof. J. F. Lewis.....	Department of Botany, University of Alberta, Edmonton, Alta.
The chemistry of fish curing.....	Dr. A. B. Macallum.....	Department of Biochemistry, McGill University, Montreal, Que.
Researches in the field of low temperature..	Dr. J. C. McLennan.....	Department of Physics, University of Toronto, Toronto, Ont.
Ultra sonics (inaudible sound wave).....	Dr. R. W. Boyle.....	Department of Physics, University of Alberta, Edmonton, Alta.
Power loss in dielectrics.....	Dr. H. J. MacLeod.....	Department of Physical and Electrical Engineering, University of Alberta, Edmonton, Alta.
Crystallization of bicarbonate of soda.....	Prof. P. Riou.....	Department of Chemistry, University of Montreal, Montreal, Que.
Life history and damage caused by wireworms.	Prof. E. H. Strickland.....	Department of Entomology, University of Alberta, Edmonton, Alta.
The deterioration of rubber by oxidation and the nature of resin present in rubber.	Dr. G. S. Whitby.....	Department of Chemistry, McGill University, Montreal, Que.
Surface energy of solids.....	Prof. F. M. G. Johnson.....	Department of Chemistry, McGill University Montreal, Que.
Fog signalling.....	Dr. L. V. King.....	Department of Physics, McGill University, Montreal, Que.
The onion maggot.....	Dr. E. M. DuPorte.....	Department of Zoology, Macdonald College, Que.
The biological origin of false wild oats.....	Prof. J. R. Fryer.....	Department of Field Husbandry, University of Alberta, Edmonton, Alta.
Oil from shales.....	Prof. A. E. Flynn.....	Department of Mining Engineering, Nova Scotia Technical College, Halifax, N.S.
Bacteriology of certain sea fish.....	Dr. F. C. Harrison.....	Department of Bacteriology, Macdonald College, Que.
X-Rays.....	Dr. J. A. Gray.....	Department of Physics, McGill University, Montreal, Que.
The Lake Agassiz clay deposit.....	Prof. R. C. Wallace.....	Department of Geology, University of Manitoba, Winnipeg, Man.
Best methods for obtaining accurate results in testing varieties, strains and treatment of grain.	Associate Committee on Accurate Plot Work.	Dominion Experimental Farms.
Destruction of wood piling by marine boring animals.	Associate Biological Committee.	Atlantic Biological Station, St. Andrews, N.B.
Vitamines.....	Associate Food Research Committee.	Laboratory of Food Chemistry, University of Toronto, Toronto, Ont.
The recovery of helium from natural gas.....	Associate Committee on Helium.	Department of Physics, University of Toronto, Toronto, Ont.
Utilization of Canadian iron ores.....	Sub-Committee on Iron Ores of the Associate Committee on Mining and Metallurgy.	Hamilton, Ont.

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APPENDIX F

Assisted Researches Completed prior to 1925-26

Subject of Research	Grantee
The Use of Canadian Oils in Ore Concentration	Dr. J. B. Porter.
The Extraction of Benzine and Toluene (Valuable Liquids) from Coal Gas.	Dr. H. S. Davis.
Nicotine from Tobacco Waste	Arthur D. Hone.
De-Tarring of Gas by Electrical Precipitation	Dr. J. G. Davidson.
Canadian Waste Sulphite Liquor as a Source of Alcohol	Dr. V. K. Krieble.
The Inheritance of Earliness and Lateness in Wheat	Dr. W. P. Thompson.
Reduction of Iron Ores by Gases	Dr. A. Stansfield.
The Action of Ultra-Violet Rays	Prof. L. Bourgoin.
Water Requirements of Crops in Western Soils	E. S. Hopkins.
The Relation of Bacteria to the Quality of Graded Butter	Prof. W. Sadler.
The Properties and Liquefaction of Helium	Dr. J. C. McLennan.
A Method of Smelting Titaniferous Iron Ores	Dr. C. W. Drury and A. F. G. Cadenhead.
The Microscopic Examination of Cement during Hardening	F. M. Dawson.
Surface Tension in Liquids and Emulsions	Dr. J. C. McLennan.
Utilization of Milk Weed	Dr. A. C. Neish.
The Testing of Oil Shales in the Field	Louis Simpson.
Fungi	Dr. A. H. R. Buller.
Constitution of Rubber	Dr. G. S. Whitby.
The Discolouration of Cured Codfish	Dr. F. C. Harrison.
The Discolouration of Canned Lobster	Dr. F. C. Harrison.
The Treatment of Silver-Lead-Zinc Ores	H. Freeman.
Problems of Industrial Fatigue	Associate Committee on Industrial Fatigue.
The Utilization of Peat	Department of Mines.
Causation of Cracks in Concrete Protective Coating on Iron and Steel Structures.	Prof. Peter Gillespie.
Intensity Measurements in Spectra	Prof. J. K. Robertson.
The Bridging of the Gap in the Ether Waves between those Produced by the Ultra-Violet Light and the So-called X-Rays.	Prof. A. Ll. Hughes.
Artificial Propagation of the Sturgeon	Associate Biological Committee.
Acidity and Lime Requirements of Soils in Quebec and New Brunswick.	Dr. J. F. Snell.
The Influence of Acid in the Soil on Useful (Nitrogen Fixing) Bacteria.	Dr. F. C. Harrison.
Insulin-Like Substances in Plants	Dr. J. B. Collip.
The Spectrum of Infra-Red Rays	Dr. J. C. McLennan.
Chemical Reactions at High Pressures	Dr. J. C. McLennan.
The Spectrum of Tin	Prof. J. K. Robertson.
Conductivity and Vapour Pressure of Salt Solutions	Dr. A. N. Shaw.
The Food Relations of Certain Minute Organism (Entomostraca) in the cultivation of Fresh Water Fishes.	Prof. A. B. Klugh.
Channel Interference in Wind Channel Testing	Prof. J. H. Parkin.
The Corrosion of Iron and Steel in the Soil	Dr. J. W. Shipley.
Action of Pure Salts on the Structure and Growth of Vegetable Cells.	Prof. G. W. Scarth.
The Influence of Diet on the Fur and Health of Captive Foxes.	Associate Committee on Nutritional Problems of the Fox Industry.
Interference in Radio Broadcast Reception	Prof. T. R. Rosebrugh.

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APPENDIX G

List of Scholarships Awarded, 1925-26

FELLOWSHIPS

Grantee	Graduated	Where held	Subject of Research work.
D. M. Morrison, Ramsay Memorial Fellowship.	B.Sc., University of B. C., M.Sc., Ph.D., McGill University.	Dept. of Physical Chemistry, Cavendish Laboratories, Cambridge University, Cambridge, England.	Experiments on the Chemical Activity of Helium.
R. S. Jane, British Empire Exhibition Scholarship.	B.A.Sc., University of B.C., M.Sc., Ph.D., McGill, University.	Department of Colloidal Chemistry, The Sir John Cass Technical Institute, University of London, London, England.	Die Vickositat von ammoniumoleot-Losungen.
Miss H. D. Chataway..	B.A., B.Sc., M.Sc., Manitoba Ph. D., McGill University.	Department of Chemistry McGill University, Montreal, Que.	The Action of Sulphur, Sulphur Halides and other Re-agents on Some Unsaturated Compounds.
A. B. McLay.....	B.A., McMaster, M.A., University of Toronto.	Department of Physics, University of Toronto, Toronto, Ont.	Investigation of the Infra-red Spectrum of Gold and various other Elements in order of their Importance in Relation to Series Spectra.
John Russell.....	B.A., University of British Columbia, M.Sc., McGill University.	Department of Chemistry, McGill University, Montreal, Que.	Vapour Densities of Binary Mixtures.
L. L. Bolton.....	B.A., M.A., University of British Columbia.	Department of Biology, University of Toronto, Toronto, Ont.	The Histological Structure of the Digestive Tracts of some Pacific Coast Fishes.
P. A. Berard.....	B.A., Joliette Seminary.....	Department of Chemistry, University of Montreal, Montreal, Que.	The Rapidity of Absorption of the Gas SO_2 in Alkali Solutions.
P. Cartier.....	B.Sc., Ste. Hyacinthe Seminary.	Department of Chemistry, University of Montreal, Montreal, Que.	The Effect of Viscosity on the Rapidity of Absorption of Gases.
N. D. Clare.....	B.Sc., M.Sc., University of Manitoba.	Department of Chemistry, University of Toronto, Toronto, Ont.	The Supersaturation of Oxygen in Water.
G. W. Holden.....	B.A., Bishop's College, M.Sc., McGill University.	Department of Chemistry, McGill University, Montreal, Que.	Hydrogen Peroxide as an Oxidizing Agent in Acid Solution.
E. J. King.....	B.A., M.A., McMaster University, Ph.D., McGill University.	Department of Chemistry, University of Toronto, Toronto, Ont.	Reactions of Lactones with Aromatic Hydrocarbons in the presence of Aluminium Chloride, with special reference to Furfuran Derivatives–Cumuritic Acid and Pyromucic Acid made from the Oxidation of Furfural.
W. M. Martin.....	B.S.A., University of Alberta.	Department of Plant Bio-chemistry, University of Alberta, Edmonton, Alta.	The Nature of Winter Hardiness in Crop Plants.
M. J. Mulligan.....	B.A., M.A., University of Toronto.	Department of Chemistry, University of Toronto, Toronto, Ont.	The Electrolysis of Glass.
Miss I. J. Patton.....	B.A., M.Sc., McGill University	Department of Physics, McGill University, Montreal, Que.	The Correlation of Electrolytic Conductivity and Aqueous Vapour Tension of Hygrometrical Measurements and also an Inquiry into Cause of Formation of Ground Ice and Anchor Ice.
Miss C. E. Robertson..	B.Sc., M.Sc., McGill University.	Department of Chemistry, McGill University, Montreal, Que.	The Properties of Sulphur Dio xide.
B. Shaffer.....	B.A., M.A.Sc., University of Toronto.	Department of Chemistry, University of Toronto, Toronto, Ont.	Investigation on the Chemistry of Rubber.
C. Sivertz.....	B.A.Sc., University of British Columbia, M.Sc., McGill University.	Department of Chemistry, McGill University, Montreal, Que.	Reaction Velocity with Special Attention to the Influence of Pressure in the Gaseous Phase and Concentration in the Liquid Phase.
E. W. R. Steacie.....	B.Sc., M.Sc., McGill University.	Department of Chemistry, McGill University, Montreal, Que.	The Solubility of Gases in Metals (principally oxygen, hydrogen, and nitrogen in silver).
C. W. Sweitzer.....	B.A., M.A., University of Toronto.	Department of Chemistry, University of Toronto, Toronto, Ont.	Light Scattering in Salt Solutions.
K. Thomson.....	B.A., M.A., University of Western Ontario.	Department of Physics, University of Toronto, Toronto, Ont.	Spectrum of Solid Nitrogen Phosphorescing at the Temperature of Liquid Hydrogen.
J. O. Wilhelm.....	B.Sc., University of Saskatchewan, M.A., University of Toronto.	Department of Physics, University of Toronto, Toronto, Ont.	The Crystal Structure of Solidified Gases.
F. H. Yorston.....	B.Sc., M.Sc., McGill University.	Department of Chemistry, McGill University, Montreal, Que.	A Study of the Constituents of Hevea (rubber) Resin, and Serum.

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BURSARIES

Grantee	Graduated	Where held	Subject of Research Work
N. J. Atkinson	B.Sc., University of Saskatchewan.	Department of Biology, University of Saskatchewan, Saskatoon, Sask.	A Study of Certain Phases of the Life History of the Red-backed Cut-worm.
C. H. Bayley	B.A.Sc., M.A.Sc., Toronto University.	Department of Chemistry, University of Toronto, Toronto, Ont.	The Relation of the Colloidal State to Catalytic Activity.
R. W. Beattie	B.Sc., M.Sc., Queen's University.	Department of Chemistry, Queen's University, Kingston, Ont.	A Further Examination of the Reactions of Cyclohexylidene-cyano-aceticester and other alkylidene cyanoaceticesters.
K. H. Butler	B.A., Dalhousie University.	Department of Chemistry, Dalhousie University, Halifax, N.S.	A Problem Dealing with Liquified Chlorine.
H. M. Cave	B.A., Queen's University	Department of Physics, Queen's University, Kingston, Ont.	I. The Scattering and Absorption of the Rays of Radium. II. The Properties of Scattered and Characteristic X-radiattions including Distribution, Intensity and Wavelength.
Miss M. L. Chalk	B.A., M.Sc., McGill University.	Department of Physics, McGill University, Montreal, Que.	Potential Distribution in the Crooke's Dark Space in Tubes of Different Shapes by Means of the Stark Effect.
R. N. Crozier	B.A., M.A., University of British Columbia.	Department of Chemistry, McGill University, Montreal, Que.	A contribution to the Question of the Constitution of Caoutchouc.
J. H. Fox	B.A., Univeristy of Western Ontario.	Department of Biology, University of Western Ontario, London, Ont.	A Problem in the Field of Economic Zoology—The Life History of Exeristes Roborator, a Parasite of the European Corn Borer (Pyrausta nubilalis Hubn).
W. E .Graham	B.A.Sc., University of British Columbia.	Department of Chemistry, University of Toronto, Toronto, Ont.	The Effect of Changes of Currents on the Voltage of Carbon Arcs.
C. Y. Hopkins	B.A., M.A., Queen's University.	Department of Chemistry, Queen's University, Kingston, Ont.	The Action of Hypochlorous acid on Arylidene Cyanoacetic Acids.
C. M. Jephcott	B.A., M.A., University of Toronto.	Department of Chemistry, University of Toronto, Toronto, Ont.	Friedel & Craft's Reaction on Quinolinic Anhydride.
I. W. Jones	B.A., B.S.c., University of Alberta.	Department of Geology, University of Toronto, Toronto, Ont.	The Microscopy of Coal with Special Reference to the Correlation of Coal Seams by Microscopic Examination.
P. A. Macdonald	B.Sc., University of Manitoba	Department of Physics, University of Manitoba, Winnipeg, Man.	Research on the Temperature Sense, the Method Employed being the critical Frequency of Flicker.
J. H. McLeod	B.Sc., University of Saskatchewan, M.A., Toronto.	Department of Physics, University of Toronto, Toronto, Ont.	Spectroscopic Investigation of Oxygen and Helium.
C. D. Niven	M.A., B.Sc., Aberdeen	Department of Physics, University of Toronto, Toronto, Ont.	Electrical Conductivity.
Miss L. E. Paynter	B.Sc., M.Sc., University of Saskatchewan.	Department of Chemistry, University of Saskatchewan, Saskatoon, Sask.	Guanidene and Methane Derivatives Including their Preparation and Physiological Properties.
W. Rowles	B.Sc., University of Saskatchewan.	Department of Physics, McGill University, Montreal, Que.	The Stark Effect for Silver in the Visible and the Ultra-Violet Regions.
W. W. Simpson	B.A., University of British Columbia.	Department of Physiology, University of Toronto, Toronto, Ont.	The Mechanism by which Insulin causes the Sugar of the Blood to become reduced in amount and the Behaviour of the Blood Sugar in Fishes.
H. DesB. Sims	B.A., University of Toronto.	Department of Chemistry, University of Toronto, Toronto, Ont.	The Purification of Bios I from from Tea Dust.
V. Sivertz	B.Sc., Washington, M.Sc., W. Virginia, Ph.D., McGill.	Department of Chemistry, McGill University, Montreal, Que.	The Effect of Molecular Attraction on the Total Pressure of Gas Mixtures.
F. R. Terroux	B.A., Laval, B.Sc., McGill	Department of Physics, McGill University, Montreal, Que.	The Striated Discharge in Pure and Mixed Gases at Low Pressures.
E. E. Watson	B.Sc., McGill University	Department of Physics, McGill University, Montreal, Que.	The Development of an Improved Type of Cathode Ray Oscillograph.

APPENDIX H

Scholarship Graduates

Grantee	University where undergraduate training received	Present occupation
F. B. Adamstone, B.A., M.A., Ph.D.	Toronto	Instructor in Zoology, University of Illinois, Urbana, Ill.
D. S. Ainslie, B.A., M.A.	Toronto	Instructor in Physics, University of Western Ontario, London, Ont.
Miss M. Anderson, B.A., M.Sc.	New Brunswick	No information.
F. M. Archibald, B.Sc.	Acadia	Chemist, Imperial Oil Refineries, Ltd., Sarnia, Ontario.
W. F. Baker, B.A., B.Sc., M.Sc.	Manitoba	Student Assistant on Geological Survey under Dr. P. S. Warren.
H. C. Bates, B.A., M.A.	Toronto	Demonstrator and Research Assistant in Physics, University of Toronto, Toronto, Ont.
A. H. Bell, B.A., Ph.D.	Toronto	Geologist with Illinois State Geological Survey, Urbana, Ill.
H. P. Bell, B.Sc., M.Sc., M.A., Ph.D.	Dalhousie	Associate Professor of Biology, Dalhousie University, Halifax, N.S.
G. H. Berkley, B.A., M.A., Ph.D.	Queen's	Senior Plant Pathologist, Field Laboratory of Plant Pathology, St. Catharines, Ont.
E. G. Bishop, B.Sc., M.Sc.	McGill	Post-graduate student, Department of Geology, Schermerhorn Hall, Columbia University, New York, N.Y.
Miss E. L. Bishop, B.A., M.A.	Toronto	Teacher of Mathematics, Collegiate Institute, Picton, Ont.
E. H. Boomer, B.Sc., M.Sc., Ph.D.	McGill	Professor of Chemistry, University of Alberta, Edmonton, Alta.
H. A. Braendle, B.A., M.A.	Toronto	Consulting Microscopist, 316 Park Street, Kitchener, Ont.
O. C. Bridgeman, B.A., M.A.	Saskatchewan	No information.
B. S. W. Buffam, B.Sc., M.Sc.	McGill	Assistant in Geology, Princeton University, Princeton, N.J.
J. W. Burns, B.Sc., M.Sc., F.C.I.C.	New Brunswick	Instructor in Chemistry, University of Western Ontario, London, Ont.
Miss F. M. Cale, B.A., M.A.	Toronto	Married (Mrs. W. C. McQuarrie).
G. C. Chamberlain, B.S.A.	Ontario Agricultural College.	Assistant, Plant Pathologist, Dominion Laboratory of Plant Pathology, St. Catharines, Ont.
E. Chauret, I.Ch., L. es Sc.	Montreal	Chemical Engineer in the Laboratory for Testing Materials, Montreal, Que.
H. R. Chipman, B.A., M.A., Ph.D.	Dalhousie	Teaching Fellow in Chemistry, Dalhousie University, Halifax, N.S.
Miss M. L. Clark, B.A., M.A.	Toronto	Teacher of Mathematics, Collegiate Institute, Sarnia, Ont.
R. J. Clark, B.A.	McGill	Demonstrator, Department of Physics, McGill University, Montreal, Que.
Miss L. Corbett, B.A., M.A.	Queen's	Married (Mrs. H. Rowley).
R. G. Corneil, B.Sc., A.C.I.C.	Queen's	Insurance Agent, 23 Adelaide Street, N., Lindsay, Ontario.
Miss A. E. Dempsey, B.A., M.A.	McMaster	Assistant Chemist, Maple Leaf Milling Company, Port Colborne, Ont.
A. D. dePassille, B.Sc.A., I.C.	Montreal	Professor of Chemistry, Ecole Polytechnique, University of Montreal, Montreal, Que.
E, P. Dolan, B.Sc., M.A., M.Sc.	St. Francis Xavier	Deceased.
V. H. Emory, B.A.Sc.	Toronto	Research, Abitibi Power & Paper Co., Iroquois Falls, Ont.
T. S. C. Fawcett, B.A.Sc., M.A.Sc.	Toronto	No information.
R. E. Foerster, B.A., M.A., Ph.D.	British Columbia	Research, Dominion Government Hatcheries at Cultus Lake, Vedder River Crossing P.O., B.C.
J. C. Forbes, B.A., M.A., Ph.D.	Saskatchewan	Assistant Director, Atlantic Experimental Station for Fisheries, Biological Board of Canada, Halifax, N.S.
H. R. Foreman, B.A., M.A.	Toronto	President and Manager, H..R. Foreman and Co., Ltd., Oil Heating and Mechanical Refrigeration Engineers, 75 King St., W., Toronto, Ont.
Miss C. W. Fritz, B.A., M.Sc., Ph.D.	McGill	Timber Pathologist, Forest Products Laboratories, Montreal, Que.
Miss M. A. Fritz, B.A., M.A., Ph.D.	McGill	Geological Survey, Department of Mines, Ottawa, Ontario.
W. A. Gale, B.A.Sc., M.Sc.	British Columbia	American Trona Corporation, Trona, Cal.
J. L. F. Germain, B.A., A.R.C.Sc.	Montreal	Director, Quebec Testing Laboratories, Rouyn, Que.
B. E. Gilbert, B.A., M.A., Ph.D.	McMaster	Head, Chemical Department of Rhode Island Agricultutal Experimental Station, Kingston, R.I.
Miss K. F. Godwin, B.A., M.Sc.	McGill	Married (Mrs. J. W. Pinhey), Holding Philip Carpenter Fellowship in Zoology, McGill University, Montreal, Que.
W. L. Gordon, B.S.A., M.Sc., A.A.A.S., C.S.T.A.	McGill	Assistant Plant Pathologist, Department of Agriculture, Winnipeg, Man.
C. Greaves, B.Sc., M.Sc., Ph.D.	McGill	Junior Chemist in Division of Wood Preservation, Forest Products Laboratories, Montreal, Que.

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Grantee	University where undergraduate training received	Present occupation
H. B. Hachey, B.Sc., M.Sc.	St. Francis Xavier	Demonstrator, Department of Physics, McGill University, Montreal, Que.
R. Hamer, B.A., M.A., Ph.D.	Saskatchewan	Assistant Professor of Physics, University of Pittsburgh, Pittsburgh, Pa.
R. H. Harris, B.A., M.A.	Saskatchewan	Chemist, Quaker Oats Company, Saskatoon, Sask.
W. H. Hatcher, B.A., M.Sc., Ph.D.	McGill	Associate Professor of Chemistry, McGill University, Montreal, Que.
E. Hearle, B.S.A., M.Sc.	Toronto	Assistant Entomologist in Charge of Insects Affecting Man and Animal, Entomological Laboratory, Department of Agriculture, Indian Head, Sask.
G. H. Henderson, B.A., B.Sc., M.A., Ph.D.	Dalhousie	Professor of Mathematical Physics, King's College, Dalhousie University, Halifax, N.S.
P. G. Hiebert, B.A., M.A., M.Sc., Ph.D.	Manitoba	Lecturer in Chemistry, University of Manitoba, Winnipeg, Man.
Miss E. M. Hill, B.A., M.Sc.	McGill	No. information.
W. V. Howard, B.A., M.Sc., Ph.D.	McGill	Instructor in Geology and Mineralogy, University of Illinois, Urbana, Ill.
H. J. C. Ireton, B.A., M.A.	Toronto	Demonstrator and Research Assistant, Department of Physics, University of Toronto, Toronto, Ont.
A. B. Jackson, B.S.A.	Toronto	Plant Pathologist, Dominion Laboratory of Plant Pathology, St. Catharines, Ont.
W. F. James, B.A., M.Sc., Ph.D.	St. Francis Xavier	Associate Geologist, Geological Survey, Department of Mines, Ottawa, Ont.
Miss M. B. Kearney, B.A., M.A.	Toronto	Instructor in Mathematics and Physics, Converse College, Spartanburg, S.C.
K. H. Kingdon, B.A., M.A., Ph.D.	McMaster	Physicist, Research Laboratory, General Electric Company, Schenectady, N.Y.
A. L. Kuehner, B.A., M.A.	Queen's	Lecturer in Science, Bishop's University, Lennoxville, Que.
P. Larose, B.Sc., M.Sc., Ph.D.	McGill	Professor of Physics and Physical Chemistry, Laval University, Quebec, Que.
W. A. Lawrance, B.A., M.A., Ph.D.	McMaster	Stanley Professor of Chemistry, Bates College, Lewiston, Me.
J. F. Lehmann, B.Sc., M.Sc.	Alberta	Holding 1851 Exhibition Scholarship at Cambridge, England.
S. Lehrman, B.A., M.A.	Toronto	No information.
A. H. Leim, B.A., Ph.D.	Toronto	Ichthyologist to Biological Board of Canada, Biological Station, St. Andrews, N.B.
Miss M. Levi, B.A., M.A.	Toronto	Married (Mrs. M. Rotenberg).
F. R. Lorriman, B.A., M.A., Ph.D.	Toronto	Research Chemist, Dye-Stuffs Department, Jackson Laboratory, E.I. du Pont de Nemours and Co , Inc., Wilmington, Del.
G. H. W. Lucas, B.A., M.A., Ph.D.	Toronto	Biochemist, Department of Pharmacology, University of Toronto, Toronto, Ont.
A. D. Macallum, B.A., M.Sc., Ph.D.	Toronto	Acting Professor of Chemistry, Manitoba Agricultural College, Winnipeg, Man.
Miss A. P. Macdougall, B.A., M.A.	British Columbia	Married (Mrs. P. G. Paterson).
D. G. MacGregor, B.A.	Dalhousie	Professor of Physics, Mount Allison University, Sackville, N.B.
J. E. Machacek, B.S.A., M.S.A.	Saskatchewan	Department of Biology, Macdonald College, Que.
C. A. Mackay, B.A., M.A., Ph.D.	Dalhousie	Professor of Physics, University of Saskatchewan, Saskatoon, Sask.
D. J. MacLeod, B.A., M.A.	Queen's	Pathologist-in-Charge, Field Laboratory of Plant Pathology, Fredericton, N.B.
R. H. F. Manske, B.Sc., M.Sc., Ph.D.	Queen's	Department of Chemistry, Queen's University, Kingston, Ont.
J. E. Maynard, B.A., B.Sc., M.Sc.	Manitoba	Department of Geology, University of Toronto, Toronto, Ont.
A. W. McCallum, B.Sc.F., M.A.	Toronto	Forest Pathologist, Division of Botany, Dept. of Agriculture, Ottawa, Ont.
W. H. McCurdy, B.A., M.A., Ph.D.	Dalhousie	Fellow in Physics, Johns Hopkins University, Baltimore, Md.
J. L. McDonald, B.A.	St. Francis Xavier	Harvard Medical School, Cambridge, Mass.
S. R. McDougall, B.Sc., M.Sc.	British Columbia	Chemical Engineer, Northern Electric Company, Montreal, Que.
J. W. McKinney, B.Sc., M.Sc., Ph.D.	Alberta	Chemist, Department of Health, Ottawa, Ont.
C. G. McLachlan, B.Sc., M.Sc., Ph.D.	British Columbia	Metallurgist, the Moctezuma Copper Co., (Phelps Dodge Corporation) Nacozari, Sonora, Mexico.
H. R. McLarty, B.A., M.A.	McMaster	Pathologist-in-Charge, Dominion Laboratory of Plant Pathology, Summerland, B.C.
Stuart McLean, B.A., M.A.	McMaster	Experimental Engineer, Laboratory of National Lamp Works, General Electric Co., Nela Park, Cleveland, Ohio.
T. C. McMullen, B.A., M.A., Ph.D.	Toronto	Dean, Alberta College, Belleville, Ont.
Miss A. I. McPherson, B.A., M.Sc.	McGill	No information.
W. C. McQuarrie, B.A., M.A.	Toronto	Instructor in Physics, Lafayette College, Easton, Pa
J. A. McRae, M.A., Ph.D., F.I.C.	Queen's	Professor of Chemistry, Queen's University, Kingston, Ont.
John Melville, B.A.Sc., M.A.Sc.	British Columbia	Water Works Department of City of Vancouver, B.C.
J. H. Mennie, B.A., M.A., B.Sc., Ph.D.	British Columbia	No information.
G. Moller, I.C.	Montreal	The Commission of Streams (Running Water) of Quebec, Lac Tremblant, Que.
D. D. Mossman, B.Sc., M.A.	McGill	No information.
Miss B. K. E. Mossop, B.A., M.A., A.A.A.S.	Toronto	Assistant Pathologist, QueenAlexandra Sanatorium, London, Ont.
Miss Irene Mounce, B.A., M.A., M.Sc.	British Columbia	Assistant Plant Pathologist, Experimental Farm, Ottawa, Ont.

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Grantee	University where undergraduate training received	Present occupation
L. A. Munro, B.A., M.A.	Dalhousie	Department of Chemistry, Manitoba Agricultural College, Winnipeg, Man.
Miss D. E. Newton, B.S.A., M.Sc	McGill	No information.
Miss M. Newton, B.S.A., M.Sc., Ph.D	McGill	Plant Pathologist, Dominion Dept. of Agriculture, Winnipeg, Man.
Miss M. K. O'Brien, B.A., M.A.	Toronto	No information.
H. G. Oddy, B.A., M.A., Ph.D	McMaster	Assistant Prof. of Chemistry, University of Florida, Gainsville, Fla.
H. B. O'Heir, B.A., B.Sc., M.Sc	McGill	Geologist, J. Mackintosh Bell, Keeley Mines, 92 Wellington Street, S., Hamilton, Ont.
Miss M. Olding, B.A.	McGill	Married) Mrs. W. R. McClelland).
A. L. Patterson, B.Sc., M.Sc	McGill	Holding C. E. Moyse Travelling Fellowship of McGill University in London, England.
R. A. Pelletier, B.Sc., M.Sc	McGill	Department of Geology, McGill University, Montreal, Que.
J. F. Phillips, B.A.Sc., M.A.	Toronto	Teacher, Malvern Collegiate, Toronto, Ont.
R. A. Prosser, B.Sc., M.A.	Acadia	Prevented from doing scientific work at present by illness.
H. R. Racicot, B.A.	McMaster	Pathologist-in-Charge, Dominion Laboratory of Plant Pathology, Ste. Anne de la Pocatière, Que.
C. D. Reid, B.Sc., M.Sc	Alberta	Assistant, Department of Physics, Harvard University, Cambridge, Mass.
H. L. Robson, B.Sc., A.C.I.C	Saskatchewan	Teaching Fellow, University of California, Berkeley, Cal.
D. C. Rose, B.Sc., M.Sc	Queen's	Holding 1851 Exhibition Scholarship, Cambridge, Eng.
P. V. Rosewarne, B.A., M.A	McMaster	Chemist-in-Charge, Oil Laboratory Fuel Testing Station, Department of Mines, Ottawa, Ont.
W. W. E. Ross, B.A.	Toronto	Assistant Magnetician, Meteorological Service, Toronto, Ont.
J. E. Saunders, B.Sc., M.Sc	McGill	Thompson Cadillac Mines, Limited, Amos, Que.
J. O. G. Sanderson, B.Sc., M.Sc	Alberta	Assistant Geologist, Yale University, New Haven, Conn.
D. A. Scott, B.A., M.A	Toronto	Associate Director, Insulin Division, Connaught Laboratory, University of Toronto, Toronto, Ont.
W. F. Seyer, B.A., M.Sc., Ph.D	Alberta	Associate Professor of Physical Chemistry, University of British Columbia, Vancouver, B.C.
Miss E. Shanly, B.A., M.Sc	McGill	Research in Department of Pathology, McGill University, Montreal, Que.
W. W. Shaver, B.A., M.A., Ph.D	Toronto	No information.
G. M. Shrum, B.A., M.A., Ph.D	Toronto	Senior Research Fellow, Department of Physics, University of Toronto, Toronto, Ont.
C. W. Small, B.Sc., M.A	Acadia	Moreton's Harbour, N.D. Bay, Nfld.
H. G. Smith, B.A., M.A	Toronto	No information.
Miss J. D. Spier, B.A., M.Sc	McGill	No information.
H. D. Squires, B.A., M.Sc	New Brunswick	No information.
H. N. Stephens, B.A., M.A., Ph.D	McMaster	Instructor in General Inorganic Chemistry, University of Minnesota, Minneapolis, Minn.
Miss E. M. Taylor, B.A., M.A., Ph.D	Toronto	Research, Connaught Laboratory, University of Toronto, Toronto, Ont.
W. W. Thompson, B.Sc., M.Sc	McGill	No information.
A. S. Townshend, B.Sc., M.Sc	Queen's	No information.
Wm. Ure, B.A.Sc., M.A.Sc	British Columbia	Teaching fellow in Chemistry, California Institute of Technology, Pasadena, Calf.
W. H. Vining, B.Sc., M.Sc	Queen's	No information.
O. J. Walker, B.A., M.A., Ph.D	Saskatchewan	Associate Professor of Chemistry, University of Alberta, Edmonton, Alta.
Miss M. Weinberg, B.A., M.A., M.Sc	Manitoba	Research Assistant Department, of Physics, University of Manitoba, Winnipeg, Man.
E. F. Whyte, B.A., M.A., Ph.D	Dalhousie	Assistant Chemist, Department of Health, Halifax, N.S.
D. Wolochow, B.A., M.A., B.Sc	Saskatchewan	Research, Dept. of Chemistry, University of Saskkatchewan, Saskatoon, Sask.
C. A. H. Wright, B.Sc., M.Sc., Ph.D	British Columbia	Consolidated Mining and Smelting Company of Canada, Trail, B.C.
K. S. Wyatt, B.A., B.Sc	Mount Allison	Prevented from doing scientific work, at present at Kentville sanatorium.
W. S. Yarwood, B.Sc., M.Sc	Manitoba	Research Assistant, Department of Geology, University of Minnesota, Minneapolis, Minn.
E. G. Young, B.A., M.Sc., Ph.D	McGill	Professor of Biochemistry, Dalhousie University, Halifax, N.S.
J. F. T. Young, B.A., M.A., Ph.D	Toronto	Associate Professor of Physics, University of Manitoba, Winnipeg, Man.

APPENDIX I

Expenditure

Year	Grants in aid of Research	Scholarships	Library and publication	Administration of Council and Committees	Travelling expenses		Salaries	Total
					Research Council and Staff	Associate Committees		
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
1916–17	163 00	.....	.....	4,104 67	2,630 60	.....	3,256 98	10,155 25
1917–18	8,344 79	5,550 00	1,316 64	7,714 30	6,877 06	698 60	19,610 35	50,111 74
1918–19	19,519 96	7,150 00	1,737 95	4,087 12	3,628 46	2,507 25	22,520 88	61,151 62
1919–20	38,815 24	20,850 00	2,421 87	4,703 44	4,672 33	2,500 99	25,908 55	99,872 42
1920–21	61,731 24	17,700 00	1,874 62	3,117 71	5,297 48	4,627 57	21,057 39	115,506 01
1921–22	24 795 46	38,575 00	3,067 13	9,170 56	4,317 39	3,301 88	19,125 77	102,353 19
1922–23	39,472 79	35,725 00	2,794 47	5,249 91	2,857 78	3,190 94	16,703 76	105,994 65
1923–24	60,854 04	37,830 00	1,642 89	2,853 97	4,281 90	2,762 89	15,091 37	125,317 06
1924–25	50,972 25	40,101 66	1,634 40	3,239 30	4,864 39	2,209 59	17,989 17	121,010 76
1925–26	61,931 65	40,082 00	2,161 27	5,584 11	6,463 50	3,104 46	19,243 35	138,570 34
Total	366,600 42	243,563 66	18,651 24	49,825 09	45,890 89	24,904 17	180,507 57	929,943 04
Average shown in percentage	39·4%	26·2%	2·0%	5·4%	4·9%	2·7%	19·4%	100%

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APPENDIX J

Publications of The National Research Council

ANNUAL REPORTS

Annual Reports covering the years 1917–18 to date.

GENERAL REPORTS

Report number	Title	Author
1	The Briquetting of Lignites	R. A. Ross, E.E., D.Sc.
2	The Recovery of Vapours from Gases	Harold S. Davis, M.A., Ph.D., and Mary Davidson Davis, B.A.
3	The De-tarring of Gas by Electrical Precipitation	J. G. Davidson, Ph. D.
4	Nicotine and Tobacco Waste	A. D. Hone, M.A.
5	Canadian Waste Sulphite Liquor as a Source of Alcohol	V. K. Krieble.
6	An Investigation into the Question of Early Putrefaction of Eviscerated Fish in which the Gills have been left	L. Gross, M.D.
7	Survey of General Conditions of Industrial Hygiene in Toronto	The Associate Committee on Industrial Fatigue of the National Research Council.
8	A Method of Smelting Titaniferous Iron Ore	W. M. Goodwin.
9	Food Requirements of the Ranch Fox	G. E. Smith, B.A.Sc.
10	Fuel Saving Possibilities in House Heating	L. M. Arkley and James Govan.
11	The Red Discolouration of Cured Cod Fish	F. C. Harrison, D.Sc., F.R.S.C., and Miss M. E. Kennedy, B.A., M.Sc.
12	The Discolouration, Smut or Blackening of Canned Lobster	F. C. Harrison, D.Sc., F.R.S.C., and E. G. Hood, Ph.D.
13	Cultural Criteria for the Distinction of Wood-destroying Fungi	Miss Clara W. Fritz, B.A., M.Sc.
14	On the Utilization of the Low Grade Iron Ores of Canada	Sub-Committee on Iron Ores, J. G. Morrow, Chairman.
15	Marine Borers on the Atlantic Coast of Canada	R. H. M'Gonigle, B.A.
16	The Relation of Bacteria to the Quality of Graded Butter	Wilfrid Saddler, N.D.D., B.S.A., M.Sc., and R. L. Vollum, M.A.
17	The Mosquitoes of the Lower Fraser Valley, British Columbia, and Their Control	Eric Hearle, M.Sc.
18	Investigation on the Treatment of Nova Scotia Oil Shales	A. E. Flynn, A.R.S.M.

BULLETINS

1	The Need for Industrial Research in Canada	Frank D. Adams, Sc. D., LL.D., F.R.S.
2	Researches on Sound Measurement with reference to the testing of Fog Signal Machinery	Louis V. King, M.A., D.Sc., F.R.S.C.
3	How to Handle Frozen Fish	E. E. Prince, D.Sc., LL.D.
4	Hints on Frozen Fish	E. E. Prince, D.Sc., LL.D.
5	Science and Industry	Prof. J. C. Fields, Ph. D., F.R.S.
6	Heating of Houses, Coal and Electricity Compared. (Out of print)	A. S. L. Barnes.
7	The Manufacture of Ethyl-Alcohol from Wood Waste	G. H. Tomlinson, B.A.
8	Some Problems of the Fox-Raising Industry (Out of print)	Andrew Hunter, M.A., M.B., Ch.B. Edin.
9	The Honorary Advisory Council for Scientific and Industrial Research and its Work. A Brief Résumé of the Activities of the Council up to 1921	Frank D. Adams, Sc.D., LL.D., F.R.S.
10	A Plan for the Development of Industrial Research in Canada	R. F. Ruttan, B.A., M.D., F.R.S.C.
11	Nitrogen Fixation	Nitrogen Fixation Committee, Prof. J. C. McLennan, Chairman.

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APPENDIX K

Publications of the Canadian Engineering Standards Association, now the National Research Council's Associate Committee on Engineering Standards

No.

A1 —1922—Standard Specification for Steel Railway Bridges.

A1a—1922—Material Specifications, Steel Railway Bridges (Reprint).

C2 —1920—Standard Requirements for Distribution Type Transformers.

C3 —1924—Standard Specification for Galvanized Telegraph and Telephone Wire.

B4 —1921—Standard Specification for Wire Rope for Mining, Dredging and Steam-Shovel Purposes.

A5 —1922—Standard Specification for Portland Cement.

A6 —1922—Standard Specification for Steel Highway Bridges.

D7 —1922—Standard Specification for Flexible Steel Wire Rope and Strand for Aircraft Purposes.

G8 —1923—Standard General Specification for Commercial Bar Steels.

A9 —1923—Standard Specifications for Reinforcing Materials for Concrete.

C10 —1923—Standard Specification for Tungsten Incandescent Lamps.

D11 —1924—Interim Report on the Manufacture, Testing and Use of Gasoline.

B12 —1924—Standard General Specification for Galvanized Steel Wire Strand

E13 —1924—Standard Specification for Railway Wire-Fencing and Gate.

C14 —1924—Standard Specification for Reinforced Concrete Poles.

C15 —1924—Standard Specification for Eastern Cedar Poles.

A16 —1924—Standard Specification for Steel Structures for Buildings

C17 —1925—Standard Requirements for A.C. Watthour Meters.

B18 —1925—Standard Specification for Stove Bolts.

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APPENDIX L

Associate Committee on Cereal Grain Rust

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