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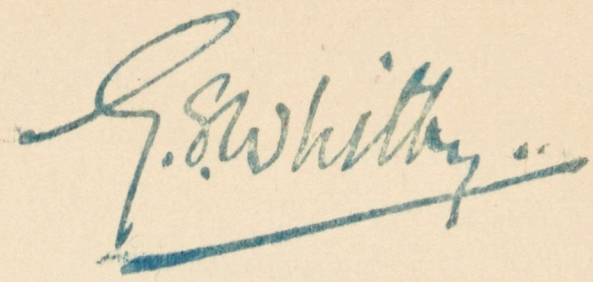
RESEARCH

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Dominion of Canada

NATIONAL RESEARCH COUNCIL

THE HONORARY ADVISORY COUNCIL FOR
SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT of the PRESIDENT

AND

FINANCIAL STATEMENT

1926-27

Ottawa
F. A. ACLAND
Printer to the King's Most Excellent Majesty
1928

OTTAWA, February 16, 1928.

The Hon. JAMES MALCOLM,
Chairman, Sub-Committee of the Privy Council on Scientific
and Industrial Research,
Ottawa, Ont.

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, 1927.

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.

57414—1½

THE SUB-COMMITTEE OF THE PRIVY COUNCIL ON SCIENTIFIC AND INDUSTRIAL RESEARCH, 1926-27

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Minister of the Interior and of Mines.
Minister of Agriculture.
Minister of Customs and Excise.
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NATIONAL RESEARCH COUNCIL

REPORT OF THE PRESIDENT, 1926-27

INTRODUCTION

The National Research Council has been at work for ten years. This being the case it seems fitting that stock should be taken of what has been accomplished in that time. Such a stock-taking should indicate how effectively the council has been operating and make it possible to plan future activities in the light of past experience.

The same period of years has been marked by an unprecedented growth of research activity throughout the world. In all the great industrial nations, the public generally as distinguished from the scientific few, have come to understand the significance of applied science in its bearing upon industrial development and world competition in industry. The result has been a great public demand for the intensification of scientific work. This is shown in the greatly increased appropriation for such work made in National Budgets, and the rapid growth of research laboratories under both government and private auspices.

In view of the above considerations this report departs from the procedure followed in previous years in that two new sections have been added. The first section reviews the history, organization and accomplishments of the council during the past decade and the second section reviews the present position of scientific and industrial research throughout the industrial nations of the world.

I. REVIEW OF THE ACTIVITIES OF THE NATIONAL RESEARCH COUNCIL DURING THE PAST DECADE

History

Under the stress of war the call went out throughout the British Empire for highly qualified research men and it was then discovered that there were more trained scientists in a few of the great German industries than could be found in the whole British Empire. However, if the British are slow to change and to adopt new ideas which disturb traditional procedure, it is equally true that once awakened to the necessity for action, Great Britain moves effectively and very surely.

The Committee of the Privy Council for Scientific and Industrial Research was created in Great Britain in 1915 to enlarge and organize the scientific resources of the country to meet the industrial situation which it was known would arise at the end of the war, thus making for the first time in the national history an organized attempt to equip scientific research in an adequate manner. It was clearly realized that such action was essential if the industrial fabric of the Empire were to be built up and maintained on a sound basis.

Under the Committee of the Privy Council the Government of Great Britain appointed an Advisory Council for Scientific and Industrial Research. Furthermore a dispatch was sent to each of the Dominions requesting them to establish similar organizations for the purpose of developing scientific and

industrial research within their own borders. In submitting this suggestion to the Dominions the hope was expressed that in due course an Empire research organization would evolve.

The Government of Canada, acting on this suggestion from the Government of Great Britain, established, late in 1916, the Honorary Advisory Council for Scientific and Industrial Research, now known under the short title—"National Research Council." This council, which consists of fifteen scientists and business men, all of whom serve on an honorary basis, has been charged among other things with the following duties:—

(1) To promote the utilization of the natural resources of Canada;
(2) 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;
(3) To undertake researches with the view of utilizing the waste products of said industries;
(4) To investigate and determine standards and methods of measurements, including length, volume, weight, mass, capacity, time, heat, light, electricity, magnetism and other forms of energy; and to determine physical constants and the fundamental properties of matter;
(5) To undertake researches the object of which is to improve conditions in agriculture;
(6) To have charge of the direction or supervision over researches which may be undertaken by or for single industrial firms or by such organizations or persons as may avail themselves of the facilities offered for this purpose.

One of the first activities of the council was to take, in 1917, a research inventory of Canada. This inventory disclosed two outstanding facts: first, that industrial research was at that time practically non-existent in Canada, and secondly, that the supply of research men, with such post-graduate training as to enable them to effectively undertake independent investigation, was entirely inadequate to permit of any general application of scientific research to Canadian industrial problems.

The next step was to consider what action should be taken to overcome this condition of affairs and to effectively carry out the duties which had been assigned to the council. After prolonged consideration and careful study of all phases of the question the council became convinced that it was quite impossible for it to fulfil its obligations to industry as set forth above, until it had been provided with reasonable laboratory facilities. The council consequently recommended to the federal Government that National Research Laboratories be established in Canada along the lines of those available to industry in the United States through the Bureau of Standards at Washington and the Mellon Institute of Industrial Research at Pittsburgh.

This recommendation was referred by the Government to a Special Committee of the House of Commons, which called witnesses both from Canada and abroad and studied the question during two sessions of Parliament. The final report of the committee unanimously and strongly endorsed the recommendations of the National Research Council and made definite recommendations as to the details of the action which it considered should be taken. However, owing to unexpected difficulties which have arisen, mainly related to the financial situation existing since the war, the federal Government has not yet found it possible to establish National Research Laboratories in Canada as recommended by the National Research Council and by the Special Committee of the House of Commons which investigated this question.

Pending the provision of such laboratory facilities as would make it possible to adequately assist Canadian industry, the National Research Council has been carrying on three specific major activities:—

1. The co-ordination of research work and the organization of co-operative investigations.
2. The post-graduate training of research workers.
3. The prosecution of research work through assisted research grants.

A description of the organization which has been established and the results which have been achieved during the past ten years under the three main activities set forth above will be given in each of the next two divisions of this section of the report.

Organization

1. Co-ordination and Co-operation

Consider first the organization which has been set up during the past ten years for co-ordinating research work and the activity of the council in establishing co-operative investigations on major Canadian problems. The procedure followed is simple but very effective. When a main problem arises the council calls a conference of all the leading persons in Canada who are working on that problem or who are particularly qualified to advise concerning it, by reason of their special training or experience. The first duty of such a conference is to thoroughly review the present state of knowledge, both in Canada and abroad, on the problem under consideration. When this has been done the conference is requested to draft a complete and specific research program on the problem under review, setting forth definitely the work which, in the opinion of the members of the conference, should be carried out in Canada.

At this stage the National Research Council usually appoints a carefully selected working committee, known as an associate committee on the subject under review. It is the first duty of such an associate committee to decide how and where the investigation of the problem listed in the research program which has been drafted, can be undertaken most effectively and economically. It is also the duty of the committee to direct all research work which may be carried on by the council on the recommendation of the committee. The National Research Council keeps in intimate contact with the activities of each associate committee through an arrangement whereby the president or some members of the council specially qualified serves as the chairman of each such committee. In this way the council utilizes to the fullest possible extent, all existing laboratory facilities and, what is of even greater importance, enlists the co-operation of the highly trained scientific man-power available throughout the Dominion for undertaking work on any important research problem.

The council has also organized another group of Associate Committees, one in each of the major departments of science. These committees serve in an advisory capacity in connection with the sciences which they represent and are available for consultation at any time in connection with important problems.

With the advice of twenty eminent chemists available when required in connection with chemical problems, with the advice of an equal number of outstanding Canadian physicists at the disposition of the council in connection with problems in physics and engineering and with the judgment of similar groups of experts available in various other departments of science, such as mining and metallurgy, biology, etc., it will be obvious that the council has available an extremely valuable consulting organization which enables it to render sound judgment on technical questions which come before it for decision.

Further indication of the extent and importance of the work carried on by the council through its associate committees will be found beginning at page 37 of this report.

The members of all Associate Committees serve in an honorary capacity. Furthermore, the National Research Council does not pay the whole operating cost of the co-operative investigations which it organizes under its associate committees, but by making comparatively small grants here and there to supplement the equipment or the junior staff of a laboratory, the council enables such laboratory to undertake work which it would otherwise find impossible. Each such laboratory invariably furnishes all of the ordinary equipment, much of the special equipment, and all of the direction and supervision of the investigation which it undertakes, entirely without cost to public funds. In other words, the National Research Council, in so far as this phase of its activities is concerned, simply provides oil for existing machinery.

It has been the constant endeavour of the National Research Council during the past ten years to co-ordinate all existing research work, in so far as this was possible, and to avoid in every way in connection with its activities all unnecessary overlapping and duplication of effort. The extent to which the council has sought the co-operation of existing laboratories and research workers and especially in the technical services of the federal Government is indicated in some slight measure by the section of the report beginning on page 29 describing in detail the many projects in connection with which the council has co-operated with various Government departments.

2. The Method of Training Research Workers

The second of the major activities of the council has been to make provision for the post-graduate training in science and research of the most promising graduates of Canadian universities, so as to build up in Canada a corps of research men thoroughly qualified to undertake independent investigation on Canadian problems. With this object in view a system of post-graduate scholarships was established just ten years ago.

Detailed information regarding the various classes of scholarships offered and regarding the regulations governing these awards will be found in this report in the section relating to the activities of the past year, beginning at page 28, but for convenient reference the following statement showing the number of Fellowships ($1,200), Studentships ($1,000), and Bursaries ($750) awarded each year since these awards were instituted and the expenditure incurred in connection therewith may be of interest and 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	7	17	23	40,082 75
1926–27	7	17	20	41,105 00
	54	120	152	

3. Assisted Researches Organization

The National Research Council has devoted the major part of its revenue during the past ten years to the granting of financial assistance to competent and highly trained investigators for the purpose of assisting them in carrying out researches on approved problems. These grants known as "Assisted Researches" are awarded under definite regulations, which provide among other things that no part of any grant may be used to remunerate a grantee for his services in directing the investigation for which the grant was awarded. A copy of the regulations governing these grants will be found in Appendix "D". Any qualified research man working in any Canadian laboratory may apply to the council for such an award. In this manner the laboratory facilities and the highly trained scientific man-power of university and other laboratories in Canada have been utilized to the fullest possible extent, within the limitations of the financial resources at the disposal of the council.

It will be obvious that investigations carried out largely in university laboratories, on a voluntary service basis, will tend rather to researches in pure science than toward applied science, or what is more popularly known as industrial research. There can be no question, however, but that there is great need for increased activity in Canada in the matter of industrial research. Significant indication of this need is furnished by a list of more than five hundred problems which await solution through scientific research, which has recently been compiled by the Associate Committee on Physics and Engineering Physics of the council.

During recent years there has been some difference of opinion and much discussion as to the extent to which it is feasible and expedient for university laboratories to engage in purely industrial research. Much has been said on both sides, but perhaps the most authoritative statement on this question has recently been uttered by one whose research experience and high position entitle him to be considered as the foremost scientist in the English-speaking world to-day, namely Sir Ernest Rutherford, Head of the Cavendish Laboratory at Cambridge University, England. Sir Ernest dealt with the question under consideration very clearly and very definitely in an address which he delivered recently in opening a new Physics Laboratory at the University of Bristol, when he said:—

*"Since the war there has been a notable increase in the number of scientific men who are engaged either in fundamental research or in applied research with special reference to industrial problems. The question thus naturally arises as to the nature of the research work which should be carried out in a laboratory like this. Should the spare time of its teachers and research students be devoted to investigations on the fundamental problems of physics, quite apart from any question of immediate practical bearing, or to researches of a character likely to be useful in industry? This is an important question, *but I should unhesitatingly say that our pure science laboratories should in the main be set aside for fundamental research.* Apart from the interest and importance of adding to our knowledge of the processes of nature, experience has shown that discoveries of the greatest significance to mankind, whether in the practical or intellectual sphere, are generally the outcome of fundamental research undertaken purely with the aim of adding to knowledge. Industrial research should be undertaken by manufacturers or the Government in special laboratories where research workers can come into close contact with manufacturing conditions. This does not exclude the desirability of occasionally conducting applied researches in university laboratories, especially where one or more of the staff may have a special knowledge of the problems involved. *In general, however, I should view as an unmitigated disaster the utilization of our university laboratories mainly for research bearing on industry."*

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* The italics are our own.

Achievements During Past Decade

1. Co-ordination and Co-operation

Consideration of the achievements of the National Research Council during the first ten years of its existence will show that at comparatively small cost to the public treasury an active and efficient research organization has been built up in Canada through which the investigation of any problem of national importance can be undertaken in an effective and businesslike manner, in so far as such work is possible on a voluntary service basis in existing laboratories.

At the present time the council has in active operation nineteen associate committees with a membership of 254 persons, who give freely of their time and experience in furthering the various projects undertaken. In view of the volume and importance of the work of these committees a complete section of this report, beginning at page 37, has been given to a detailed description of their activities. It is therefore unnecessary to here elaborate further on their work.

2. Post-graduate Research Scholarships

During the past decade the council has awarded 344 scholarships to 199 persons. These awards were held in sixteen departments of science at twelve Canadian universities. Each grantee worked under the direction of a member of the staff of the university where his award was held, who had agreed to co-operate in the careful supervision of the work of the grantee.

The main purpose of scholarships is to train men in research work, rather than to achieve valuable results as a consequence of the investigations carried out by grantees, but nevertheless some very valuable work has been carried out under these awards. The fact that 458 scientific papers, by persons holding National Research Council scholarships, have been accepted and published by prominent scientific journals in Great Britain, in the United States and in Canada will afford some indication of the calibre of the work carried on by scholarship grantees.

During the ten-year period 155 persons had completed their post-graduate training in science under these awards. The National Research Council has therefore increased to this extent the number of research workers available for service in Canadian industries and universities or in Government technical services.

It is of interest to note the present occupation of these grantees. Fifteen of them are continuing their post-graduate studies; fifty-two persons are engaged in the teaching profession, thirty-five of these having received appointment to the staffs of Canadian universities where the great majority of them will have an opportunity of securing further scientific training and of engaging in research work; twenty-six persons are employed in the industries and twenty-nine have accepted positions in the technical branches of the federal and provincial governments; seven grantees are employed in various capacities other than teaching, on the staffs of universities, sanatoria, etc. Of the 155 scholarship grantees, eight persons for various reasons are not at present actively engaged in research work, one grantee is deceased and seventeen have failed to furnish information regarding their present occupation.

It is especially gratifying to note that of the 155 grantees, 123 persons are in Canada actively engaged in scientific or associated work. There is still great need for an adequate appreciation of the value of trained research men in industrial development by those who are directing the industries of Canada. In this connection attention is directed to the section of this report beginning at page 19, which reviews present-day research activities in the important industrial nations of the world.

3. Results from Researches Assisted

During the past ten years the National Research Council has financially assisted in the prosecution of 120 researches, which were carried out in laboratories spread from Halifax to Vancouver.

These investigations may be conveniently classified by industries. Grouping them in this way reveals the fact that the council has served every important branch of industry in Canada, in addition to materially advancing the cause of pure science.

It is obviously impossible, in a brief summary, to make proper acknowledgment to every co-operating organization. It is equally obvious, however, that in most cases there has been such co-operation, since until very recently the council possessed no laboratories whatever of its own. Most of the researches have been carried out in the laboratories of Canadian universities, but acknowledgment is also due to many of the Dominion Government departments and certain industrial concerns. It is recognized that the greatest credit of all, however, belongs to those individuals whose fertile brains have conceived and carried through to a successful conclusion many researches undertaken.

Agriculture

Agriculture is the most important of Canadian industries. In this field the Dominion and provincial departments of agriculture and the agricultural colleges are doing excellent work, but the need for research is so great that the council has found ample scope for its efforts.

The first great problem attacked was that of grain rust, the average loss from which during the last ten years is estimated to be $25,000,000 annually in Canada alone. In a co-operative movement this research is being actively prosecuted along many lines—the destruction of common barberry and other hosts of the rust, the systematic crossing of varieties of wheat in an effort to secure one which will combine rust resistance with other necessary characteristics, the study of chemical factors conferring resistance, and methods of destroying the rust spores. The progress made to date justifies the hope that the problem will be satisfactorily solved.

Another agricultural research of great importance is on tuberculosis in cattle and poultry. Not only does this disease entail a monetary loss running into millions annually, but it is the direct cause of the death of many young children infected by the use of milk from tuberculous cows. In the prosecution of this research Canadian workers have the benefit of both American and European co-operation. The latest advances made at the Pasteur Institute, Paris, are being applied at several points in Canada, and the results so far obtained are decidedly encouraging. Reference to the work on human tuberculosis will be found on page 17 and details regarding all tuberculosis researches undertaken by the council will be found commencing at page 43 of this report.

In recent years the farmers of the West have suffered severe losses through unfavourable weather conditions, which resulted in damp wheat. Drying has been fairly general, but unfortunately much of the wheat has been damaged in the process, due largely to an imperfect understanding of the technique required. Drying methods are being studied and it now appears that the difficulties can be very readily solved, with a resultant annual saving of some millions of dollars.

The storage of apples in Nova Scotia warehouses is also being studied by a committee of the council. The results of the first season's work have been such as to indicate many possible improvements in the methods used, with very little additional expense. It is expected that the losses of fruit during storage will be much reduced as a result of this investigation.

Other important researches in agriculture of direct economic bearing are those of Dr. Sadler, on the relation of bacteria to the quality of butter; Dr. Newton, on the factors governing the milling and baking qualities of wheat; Drs. Clark and Davidson, on the growth of medicinal plants in British Columbia; Professor Strickland, on the destructive wireworms of Alberta; Professor Snell, on the quality of lime required by sour soils; Dr. Harrison, on the effect of soil acidity on the activity of the valuable nitrogen-fixing bacteria; Professor Du Porte, on the onion maggots in the Montreal district; and Mr. Fox, on a parasite of the destructive European corn-borer. There are numerous other agricultural researches under way, the practical value of which cannot yet be determined.

Forestry

Forestry is second only to agriculture in the value of its products, and although our forest resources are still large the drain upon them is very great. The council has from its inception recognized that reforestation is of national importance, and investigations of this problem have been carried out in both Ontario and New Brunswick. In the former province the work has now been given over entirely to the Dominion Forestry Branch, while in the latter investigation is being continued under a co-operative arrangement between the National Research Council, the federal Forest Service and the New Brunswick Forest Service. Various methods of reseeding cut-over and burnt-over areas are being tried, and extensive experiments have been carried out in scientific forestry.

Canada now leads the world in the production of pulpwood and newsprint. A very large amount of sulphite pulp is produced, but an even greater tonnage of wood products goes to waste in the " white water " of the sulphite mills. The utilization of these liquors for the manufacture of alcohol has been studied by Professor Krieble and others. Since the possible production of alcohol from this source is very great, a committee is considering the proper design of internal combustion engines using alcohol as a fuel. Work is also being done in the use of Canadian dolomite and magnesite in the preparation of bisulphite liquor for the pulp mills.

Mining

The third great primary industry of Canada is mining. The treatment of ores and the refining of metals are admirably suited to experimentation, and the National Research Council has been active in several lines of research.

One of the best known researches ever carried out in Canada is the study of ball milling made by Professor Haultain and associates. That investigation revealed for the first time what actually takes place inside a ball mill and the moving pictures which were taken with an ultra-speed camera have been internationally exhibited. Professor Haultain also did considerable work on crushing in jaw-breakers. As a result of these investigations two of the largest Canadian mining companies have given financial support to Professor Haultain for the continuation of his experiments.

The council's Sub-Committee on Iron Ores has carried out an elaborate series of experiments on the utilization of iron ore briquettes made of Canadian siderite ore. They established the fact that the methods used are close to a commercial success and under more favourable conditions there may result an important commercial development.

During the war Professor McLennan worked out methods for the recovery of helium from natural gas. A plant was installed at Calgary and only the close of the war prevented a large development of the process. Plans are now under way to continue this work on a co-operative basis with the natural gas at Inglewood, that gas being the richest in helium of any yet found in Canada.

An Associate Committee on Magnesite has been investigating the deposits of that mineral in the Grenville district of Quebec. The first objective was the working out of commercial methods for the separation of the magnesite from the impurities with which it is associated in these deposits. This has been successfully accomplished in the laboratory and a commercial application of the methods developed is under consideration. Other investigations under way involving the use of Canadian magnesite are the manufacture of refractory brick and of special refractories for open-hearth furnaces.

Professor Flynn has carried out a series of experiments on the oil shales of Nova Scotia. This work has attracted favourable attention not only in Canada but also in Great Britain and the United States. Dr. Porter has completed an investigation of rock-screening which throws considerable light upon the proper design of mechanically operated screens. Other researches related to mining and metallurgy include the reduction of iron ores by gases, by Dr. Stansfield; a method of smelting titaniferous iron ores, by Professor Cadenhead; a study of the clay deposits of the Lake Agassiz basin in Manitoba, by Dr. Wallace; the precipitation of iron and silica under natural conditions, by Professor Moore; and a new method of treating silver-lead-zinc ores, patented by Mr. Freeman. It is interesting to note that Mr. Freeman has made this work the basis of an entirely new theory of ore deposition, one which is now attracting considerable attention amongst geologists.

Electrical Industry.

The recent large-scale hydro-electric developments in Canada are striking evidence of the importance of this industry. Two investigations on power losses in dielectrics have been carried out by Professors McLeod and Wendling, respectively. Professor Greig is studying the possibility of the commercial utilization of the winds of the prairies in the development of electric power and of its storage for use on individual farms. It has been established that ample power can readily be developed and a considerable application of the method may be expected if the cost is not too high.

Fisheries.

The products of the Canadian fishing industry are worth upwards of $50,000,000 annually. The need for research has been particularly great, since the industry is largely in the hands of small operators who cannot afford to establish laboratories or to finance investigations.

Dr. Harrison and associates have investigated several important problems with great success. The first of these was a study of the discolouration of canned lobster, a simple remedy for which was discovered with a resultant very large saving to the lobster fishermen. Large losses were formerly experienced in the codfish industry, due to a peculiar red discolouration caused by bacteria. Methods of entirely preventing this trouble were discovered. A third research was on the bacteriology of certain sea fish, the information secured pointing the way to greatly improved practice. Professor Klugh has studied the growth of food for fresh-water fish. The Associate Biological Committee has investigated the question of the artificial propagation of sturgeon and has had made accurate analyses of the principal brands of salt used in the curing of fish. Dr. Gross has reported on the putrefaction of eviscerated fish. Information secured in several of the above researches has been made available to the industry through the publication of technical reports.

In undertaking investigations in this field of science, the council has worked in close co-operation with the Biological Board of the Department of Marine and Fisheries and has thus avoided duplication of effort. The work of the council has been supplementary to that of the Biological Board of Canada.

Fur Production.

In spite of the rapid development of agriculture, forestry and mining, it is probable that certain areas in Canada will for a long time to come be of value chiefly as a source of furs. The recent growth of fur-bearing animals in captivity marks an important development in this industry. In this connection a committee of the council undertook an investigation of the influence of diet on the health and quality of fur of foxes in captivity. This work was highly successful and is now being continued on a permanent basis under the federal Department of Agriculture without further financial assistance from the council.

Manufacture.

Taking the manufacturing industries as a whole, much work of value to them is being carried out by the Canadian Engineering Standards Association, the Main Committee of which operates as an Associate Committee of the National Research Council. Standard specifications lead to great economies in manufacture and merchandizing, lower prices to the consumer and greater safety and satisfaction to the public.

Recent experiments by Professors Cameron, Morrison and Moffatt are revealing some startling facts regarding the effect of low temperatures on the resistance of metals to impact. The results are likely to have an important bearing on methods of manufacture of metals to be used at low temperatures, since it has been shown that proper heat treatment will greatly increase the impact resistance under sub-zero conditions.

Professor Parkin's work on the wind-channel testing of aeroplanes has given information of considerable importance in the design of air craft. Professor Gillespie has carried out a research on welding, Professor Davis on the extraction of benzene and toluene from coal gas, and Professor Davidson on the detarring of gas by electrical precipitation. Mr. Freeman has developed and patented a method for the manufacture of high-grade sodium sulphide. Dr. Keys is studying pressure variations in internal combustion engines, using new methods which promise greatly increased accuracy in results. Dr. Whitby has made an extensive study of the vulcanization of rubber, and his recommendations of additions to rubber mixtures are now being widely adopted in the industry.

Construction Industries

Owing to the severe climatic conditions prevailing in Canada, the problems of construction are of special importance. An Associate Committee on Heating and Insulation has undertaken a study of some of the fundamental problems involved and investigations are being carried on at three centres. Professor Arkley and Mr. Govan have investigated the fuel-saving possibilities of better methods of construction and heating.

Much damage has been done to concrete structures in many parts of the West by alkali waters. This problem is being very thoroughly investigated by Professors Mackenzie and Thorvaldson. The chief causes of deterioration have now been definitely established and the work is being aggressively pushed in the development of corrective measures. Dr. Shipley has completed a research on the corrosion of iron and steel in the soil; Professor Davidson has made a microscopic study of cement during the process of hardening, and Professor Gillespie has determined the causes of cracks in concrete protective coatings on iron and steel. The Associate Biological Committee has made a careful survey of the damage done to wood piling by marine borers. It has been ascertained that in Canada conditions are such that the number of borers is not likely to become sufficiently great to create a serious menace, but in warmer countries the annual damage runs into millions of dollars.

Service Industries

These industries have increased greatly in importance in recent years. Since the chief developments have taken place in comparatively new fields there has been more than the usual demand for research.

When radio was first introduced into Canada on a considerable scale much trouble was experienced with inductive interference. This was investigated by Mr. Merriman, working under Professor Rosebrugh, and means were developed for locating and correcting the trouble. This work has now been given over to the Radio Branch of the Department of Marine and Fisheries. Professor Vickers has investigated the elimination of magneto noises from aircraft receiving sets. Dr. L. V. King has developed radio fog signalling to the point where it is an important aid to the safety of ocean travel. Professor Shipley has worked out methods by which the generation of explosive gases in electric boilers may be entirely prevented.

Medical Researches

In connection with its co-operative investigation of tuberculosis in cattle and poultry the council is also giving the closest attention to the great problem of human tuberculosis. Groups at the Universities of McGill, Montreal, Queen's, Toronto, and Alberta, the federal Department of Agriculture, and the Queen Alexandra and Fort Qu'Appelle Sanatoria are working on different phases of the problem. While no single outstanding advance in tuberculosis research has been made anywhere for several years it is nevertheless a fact that real progress is being made in the control of this disease. Ample evidence of such progress is to be found in the greatly decreased death-rate. Tuberculosis has been very definitely removed from its previous unenviable position as the chief cause of death, and further progress in the same direction may be confidently anticipated.

Professor Collip has discovered that an extract of parathyroid glands can prevent or control parathyroid tetany in animals. An attempt is being made to secure equal control over the disease in humans. Drs. James, Laughton and Macallum have been successful in the separation and concentration of antipressor substances, a discovery which promises to be of great value in the treatment of high blood pressure. The Associate Committee on Food has worked on those mysterious but very important compounds called vitamines. Drs. McIntosh and Henderson are working on the preparation of radium emanation in concentrated form for therapeutic purposes. A published report by Mr. Hearle on the mosquitoes of the lower Fraser valley has attracted much attention amongst those who are engaged in the extermination of this carrier of disease.

Researches in Pure Science

Most of the investigations mentioned above and many others of a like character have been carried out with the definite object of solving industrial problems. Recognizing, however, that industry can advance no faster than the principles upon which it is based, the National Research Council has assisted many researches in pure science. It is not often easy to differentiate between researches in pure and those in applied science, since it is frequently found that the pure science of yesterday has an industrial application to-day.

For example, Dr. Boyle has been working on ultra-sonics, a highly scientific subject, yet the practical value of his work was discovered before the close of the war and the Admiralty became interested in its application in locating enemy submarines at a distance. The method is equally applicable to determining the proximity of icebergs, ships and rocks in foggy weather. It has recently found a practical use in measuring the depth of the ocean. So also with the extended researches of Prof. McLennan on the auroral spectrum. His

work has afforded a means of determining the nature of the upper atmosphere, which has so important an influence on radio broadcasting. Dr. Allen has carried out researches on the special senses, working along entirely original lines. The results are already finding application in interior lighting, and doubtless the information regarding other special senses will also be put to practical use. Dr. Whitby has made a scientific study of the constitution and deterioration of rubber. Every one of his discoveries is of great potential value to the rubber industry. So also Dr. Boswell is developing new methods for the chlorination of methane, and these may prove of commercial importance in view of the enormous wastage of natural gas now taking place in Alberta.

Of the large number of researches in many branches of pure science, it is impossible to select any list which can be definitely stated to represent the major discoveries in scientific knowledge. The following, however, are of more than ordinary interest:—

Research Director	*Subject of Research*
Dr. A. H. R. Buller	Fungi.
Dr. J. S. Foster	The Stark effect.
Drs. Johnson and Maass	Surface energy of solids.
Dr. A. B. Klugh	Effect of light on life processes.
Prof. J. F. Lewis	The resistance of plants to low temperatures.
Prof. J. C. McLennan	High-speed cathode rays.
Prof. J. C. McLennan	Researches in the field of low temperatures.
Dr. R. Newton	Winter hardiness in crop plants.
Prof. J. F. Roberts	The inheritance of sugar and starch in corn.
Prof. G. W. Scarth	The action of pure salts on the growth of vegetable cells.
Dr. A. N. Shaw	The vapour pressure of hygroscopic substances.

II. REVIEW OF THE RESEARCH ACTIVITIES OF THE LEADING INDUSTRIAL NATIONS

During the ten years which have elapsed since the National Research Council of Canada was founded great strides in industrial research have been taken by practically all of the leading industrial nations of the world. A brief survey of the present situation in a few of these countries will serve as illustrations.

Great Britain

In no country of the world has a more marked change of opinion taken place with regard to the value of research than in Great Britain. In 1913 the total amount granted directly by the British Government to science was only £4,000, apart, of course, from money spent on research in the army and navy. The change in attitude in Great Britain will be realized from a consideration of the following facts:—

1. The National Research Council, which was called into being in 1916 for the purpose of assisting in the solution of war problems and of giving direction to national energy for the development of post-war industry, has since been expanded into a separate government department of Scientific and Industrial Research.

2. In contrast with the £4,000 granted to science in 1913, last year £515,000 was spent under the direction of the council, and in addition a new scientific organization in the army and navy spent a similar amount.

3. Further, in addition to large current expenditures, a fund known as the £1,000,000 fund was established, upon which the Research Council was authorized to draw to assist associations of industry in the prosecution of research on their own particular problems on a basis of pound for pound.

4. In addition to large sums expended by British industries in establishing and maintaining private research laboratories, the British Government, through the Department of Scientific and Industrial Research, has been instrumental in the organization of twenty-five industrial research associations, each association being comprehensive of some particular group of industries having common problems. In the few years since the organization of these research associations a total sum of approximately $2,700,000 has been expended jointly by the British Government and the industries benefiting through membership in a research association. In addition to this sum $1,325,000 has been promised or paid to the Cotton Research Association by the Cotton Trade War Memorial Fund.

5. Investigations carried out by the British Electrical and Allied Industries Research Association, to mention only one of the twenty-five associations referred to in the preceding paragraph, are estimated in an official publication recently issued by the British Government to have an annual value to the supply industry of $5,500,000. A section of the official report describing this work concludes as follows: "It will be a matter of time for this annual saving of £1,100,000 to be fully realized, but it is estimated that at least one-third of the value has already accrued. The figures are large, but they are believed to be conservative."

6. In 1926 there were approximately 2,500 full-time and part-time research students working in the universities and technical schools of Great Britain.

7. In 1914 the government grant for higher education was £336,000; in 1925 it was £1,500,000, while the income of the universities from various sources had increased from £970,000 to £3,587,000. A very large proportion of this increase is being spent in the equipment and development of research schools.

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8. The National Physical Laboratories have been greatly developed and expanded.

9. A National Laboratory for Chemistry has been established.

The point of view of public authorities in Great Britain on the subject is indicated by the following statements, one made by the Prime Minister of Great Britain, the other made by the Earl of Balfour, President of the Privy Council:

Mr. Baldwin said in a recent address to the British Science Guild: "No one will assert that British industry can be saved by science alone, but it is none the less true that until scientific methods and scientific men can take their place in industry, and an equal place with the administrator and the financier, British trade will never be strong enough or resilient enough to meet the shocks that it is bound to meet as the years go by, or to meet the sudden and unexpected changes which will arise in international trade."

Lord Balfour said in a recent address in the House of Lords: "The amount of money spent on research is very large and there are people wholly ignorant of what science has done, is doing and can do, who are very much inclined to say that these are impracticable suggestions, the offspring of professors' brains, and that all that is required to maintain the industrial position of this country is to encourage the practical instincts of the ordinary Englishman, and to let him follow, like his forefathers, in the obvious path of plain, uninstructed progress. I not only disagree with that, but I believe that if that view got widely diffused among our people it would really mean the ruin of British industry. Nobody who has the smallest and most superficial acquaintance with the sort of things done in Germany, with the sort of things done in France and in America, with the number of scientific men who are brought in to help in the solution of these problems, can possibly entertain so absurd, as I think, a view of the needs of this country and of the proper way to meet those needs.

"I quite agree that when you are discussing this question with the Philistine he says: 'Well, show me the financial result of your scientific research.' It is quite easy to do it, but it takes a long time to do it, and some of the most important financial results cannot be simply and easily extracted from the facts. *They are part of the general development of the industry, and as such cannot be brought out by any simple actuarial analysis.** Nevertheless, I am perfectly certain that any industry in this country, which conceives that it can get on in competition with foreign factories, where there is not a single element in the problem in which we have an advantage over them—neither in the way of raw material, nor in the way of power, nor in the way of fuel nor skill, nor any superiority in any of the elements of successful industry—is greatly mistaken. We have, I hope, some superiority in the character of our people, if only they will use their capacity to the best of their abilities and in accordance with true and far-seeing wisdom. If they do not do that then I do not think that in the competition of nation with nation we have much hope of maintaining the ancient position of this country."

The results are already beginning to show themselves in the increased efficiency of many of the industries of Great Britain. For example, it is estimated that their fuel researches, on which £400,000 had been spent up to 1926, have brought about a national saving in gas production equivalent to £500,000 per year. In a recent government report it is estimated, on the basis of the figures produced by one of the great electrical industries, that research costing a very moderate amount of money has increased the value of the industrial plants engaged in that branch of industry, based on the increase in production, to the exent of £4,000,000. Many other industries have ben similarly assisted.

* The italics are ours.

Japan

Recently, while attending the Pan-Pacific Science Congress, the President of the National Research Council had an opportunity to make a study of the situation in Japan. As is well known, no nation in modern times has so rapidly risen from a position of comparative obscurity to be one of the productive industrial nations of the world. Due to causes which are well known, Japan has definitely set herself the task of re-organizing her industrial life on modern scientific lines. There is perhaps no other country where the same intensity of purpose on the part of educational institutions and government departments is being applied to ensure the industrial success of the nation.

In the first place, a complete system of vocational schools strategically placed in industrial centres of the country has been established for the purpose of preparing men for handling the machinery of industry. It will probably be ten years yet before the nation will receive the full benefit of the money being spent in this connection, but the Japanese are a people who take a long view.

In the second place, the six Imperial universities of Japan are supported by the state and are organized for both undergraduate and graduate work on thoroughly modern lines.

In addition, there are sixty-nine specific research institutions in the country working on the problems of industry and agriculture, of which forty-five are definitely under government auspices, being mainly centralized in the national capital. In the sixty-nine institutions which cover every phase of national industry, there are employed 1,102 experts, to whom are attached 2,214 scientific assistants, making a total of 3,316 specialists engaged in the solution of the technical problems of industry and agriculture. In the forty-five government and public institutions there are employed 681 expert research men with 1,674 assistants. In addition, every year 300 of the most brilliant graduates of the universities are selected and sent abroad at the expense of the government for foreign study, mainly to Germany, Great Britain, the United States and France, in order that the nation may be kept constantly in contact with the most recent advances in science and technology. The cost of all this to the country is very great, but they are convinced that it will ultimately be returned one hundred fold on national dividends. The travelling scholarships alone are costing the nation approximately $600,000 a year.

Without question, the industrial nations of the west will in the near future find the Japanese nation one of their strongest competitors in the markets of the world, while nations having a surplus of food products will find a ready market to enter, but on a strictly competitive basis.

Germany

The scientific pre-eminence of pre-war Germany is so well known as to not require comment. It is not so well known that since the war German scientists have intensified their scientific work in connection with industrial development. It was to this latter phase of German science that Lord Balfour referred in his address to the House of Lords above quoted. Two illustrations will suffice to indicate the present position in Germany.

Practically the whole of the work done in establishing the process of the hydrogenation of coal, producing directly oil and other products, has been done in Germany, and, further, both the scientific research and the practical method for the synthetic production of methyl alcohol have been done in that country. The perfection of these two processes may mean as much to Germany in the future as the development of the methods of nitrogen fixation and the synthesis of dyes have meant to the Germany of the past. Figures are not available as to the amount of money being spent in this kind of research to-day in Germany, but without question it runs into a very large sum.

United States

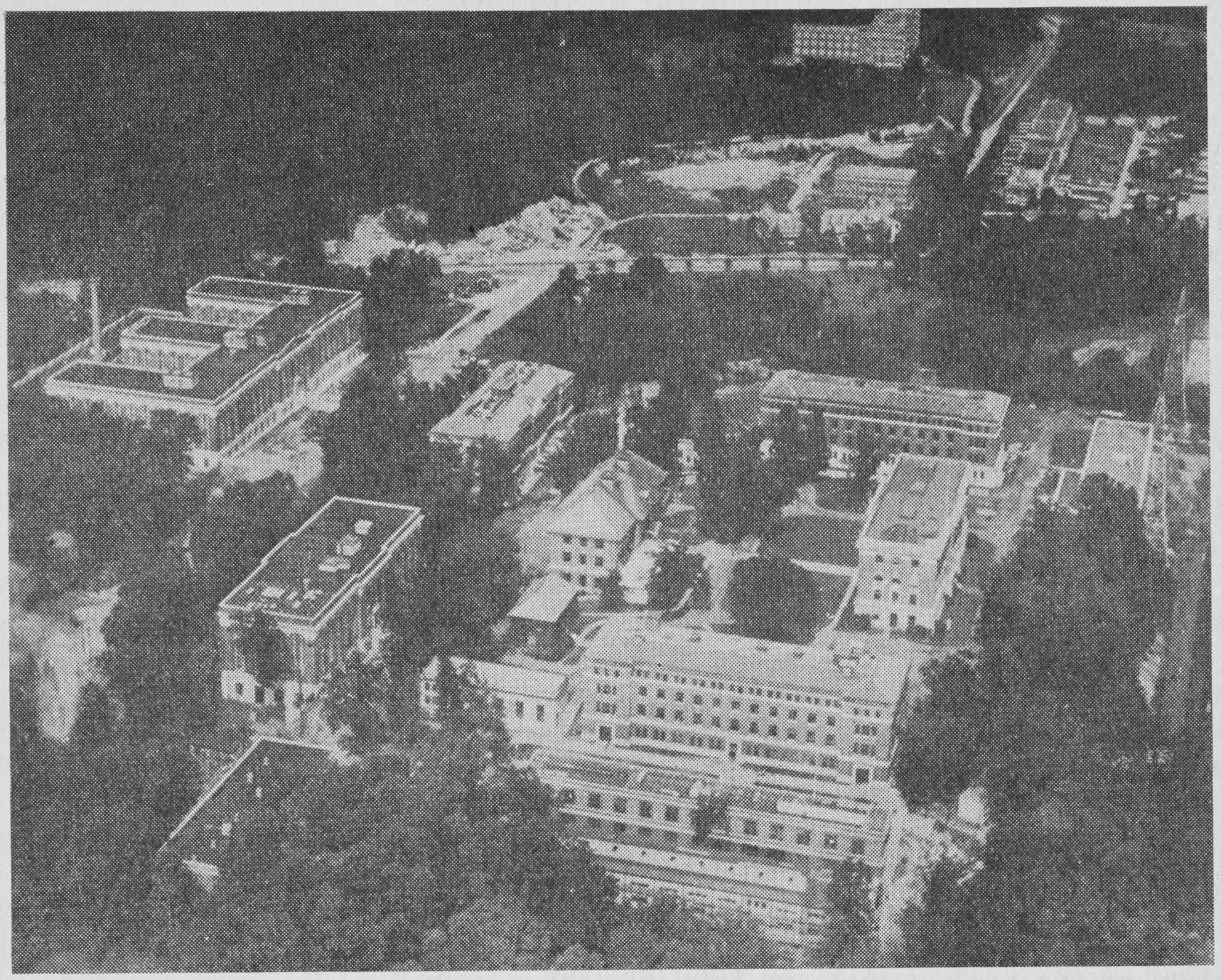
But to pass to the position of our nearest neighbour and greatest competitor, the United States of America. Here a very remarkable situation has developed. Next to Germany, probably no other nation has sensed so clearly the relation of their whole educational system to their industrial development. So much is this the case that it is doubtful whether the swing in that direction, unless checked, may not jeopardize the progress of pure science in the country. Look for one moment at the available agencies in that country, all of which have been brought into existence since the beginning of this century, and mainly since 1910. There are:—

1. The National Bureau of Standards.
2. The National Bureau of Mines, which is now associated with the Bureau of Standards.
3. The National Research Council, with an endowment of $5,000,000.
4. Highly organized graduate schools for research developed in all their leading universities, with 2,000 scholarships available to assist in the training of promising men.
5. Technical schools in most of their industrial centres for training in the mechanics of industry.
6. One thousand private research laboratories which have been established and are financed by individual industries in the United States, spending in individual cases as high as $10,000,000 a year. In these private laboratories there are constantly at work on American industrial problems 1,128 laboratory directors and nearly 11,000 research experts exclusive of more than 5,000 laboratory assistants.
7. The Mellon Institute, a great endowed institution, where private industries may carry out at their own expense investigations on their own problems.
8. Scientific foundations like the Rockefeller Foundation and the Carnegie Foundation. The Rockefeller Foundation alone is endowed to the amount of approximately $160,000,000, its purpose being the promotion largely of scientific medicine.
9. Agricultural faculties, organized in connection with all their great state universities and on a research basis.

Mr. Hoover, the present Secretary of Commerce, is responsible for the statement that there was spent in the United States last year approximately $200,000,000 on industrial research, when the work of all these organizations was taken into consideration, and in addition $10,000,000 in research in pure science. He was so impressed with the inadequacy of the latter amount for pure science that he put himself behind a movement to raise an endowment fund of $20,000,000 for the purpose of further promoting researches in pure science.

Generally speaking, the services of the Bureau of Standards and the Mellon Institute are rendered to the smaller industries of the country which have not attained a financial position which makes it possible to build laboratories for the purpose of conducting individual investigation. Both the Bureau of Standards and the Mellon Institute co-operate with industrial organizations for the purpose of promoting research in the specific industries represented by these organizations. There are to-day eighty advisory committees connected with various branches of industry co-operating with the Bureau of Standards, and about thirty such committees co-operating with the Mellon Institute.

In the year 1926 the Bureau of Standards conducted for the industry of the United States and for the departments of government approximately 180,000 tests of materials, involving over 600,000 exact scientific determinations, at



Research Laboratories of the Bureau of Standards, Washington, D.C.



Main Building of Mellon Institute of Industrial Research, Pittsburgh, Pa.

a cost of just over $2,000,000. In addition the industries of the country paid about $500,000 through industrial fellowships for the purpose of solving their own problems in the laboratories provided by the Bureau of Standards. In the same year the Mellon Institute through its system of industrial fellowships carried on sixty-seven industrial researches at a cost of approximately $600,000.

The question may well be asked what results have accrued to American industry as a result of the expenditure of all this money. Consider two or three illustrations.

The DuPont Powder Company affords an excellent illustration of the value of research to an individual business organization. A statement has been published of the commercial value of the work done in their laboratories, in which it is stated that they had spent $6,000,000 over a period of years in research and that their profit on the investment totalled $82,000,000.

A competent American authority has recently made the statement, which has been verified, that the present taxable value of property in the United States, based upon the discovery of electrical induction alone, reaches a total value of $20,000,000,000. Looking at this only from a taxing point of view and assuming that this property was taxed for federal, state, municipal and school purposes at only twenty mills on the dollar, it means a yield of $400,000,000 annually for the purpose of supporting the institutions of the country.

Mr. Hoover has recently made the statement, after a very careful study of the question, that the research and standardization work of the Bureau of Standards since its inception, resulting in the simplification and improvement of manufacturing processes and in the elimination of waste, is worth to the nation at the present moment $600,000,000 a year.

Another outstanding illustration is the development of the automobile industry.

It may be safely asserted that in the last thirty-five years there has been added to the national assets of the United States, through the application of science and research to industry, an amount not less than $50,000,000,000. If for the moment you consider this as taxed at a rate of twenty mills on the dollar for the purpose of maintaining the public services of the country, it gives you a collectible sum of $1,000,000,000, an amount which, I am sure is not overlooked by the tax-collecting authorities of the country. Such new revenue accounts to a very large measure for the ability to finance the more elaborate public services of to-day as compared with other days.

Paragraphs of equal significance could be written concerning what is going on in France, Belgium, and other European nations.

III. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL DURING THE YEAR 1926-27

Introduction

The Act of Parliament under which the National Research Council operates charges the council with the following specific duties in addition to the general responsibilities which have been assigned to it.

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 processess 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;

(viii) To 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.

(ix) To have charge of all matters affecting scientific and industrial research in Canada which may be assigned to it by the Committee of the Privy Council on Scientific and Industrial Research, and to advise the committee on questions of scientific and technological methods affecting the expansion of Canadian industries or the utilization of the natural resources of Canada.

It will be obvious that many of these duties cannot be undertaken without laboratory facilities and in the absence of such facilities the council during the year under review has concentrated its energies, speaking broadly, on three main activities:—

First, the development, co-ordination and prosecution of research work throughout Canada, especially through the organization of associate committees of the council. Each committee is thoroughly representative of all groups or institutions interested in the particular problem with which the committee has been charged, or in the case of committees of an advisory nature, representative of the science which the committee is intended to serve;

Second, the training of research workers through the awarding of post-graduate scholarships in science and research to outstanding university graduates;

Third, the investigation of special problems by granting financial assistance to qualified investigators working in established laboratories, thus utilizing the latent scientific man power and laboratory equipment available throughout Canada.

Organized Research

The policy adopted by the National Research Council of utilizing to the fullest possible extent the trained man power and the laboratory equipment existing in university, departmental and industrial laboratories both through its system of research grants and in connection with the activities of its associate committees has resulted not only in the stimulation of research work from coast to coast, but also in the building up in Canada, at comparatively small cost to public funds, of an effective and active research organization.

The council serves as the national co-ordinating agency through which all persons working on any problem of major importance may be brought into close contact, thus avoiding unnecessary duplication of effort and greatly enhancing the prospect of a successful solution of the problem in the shortest possible space of time and at minimum cost. Furthermore, by furnishing a piece of special equipment to a laboratory or by providing a research assistant to work under the supervision of some investigator eminently qualified to direct research work, but who is unable to undertake some desirable investigation because his laboratory lacks the special apparatus necessary for that particular research, or because he is too busy with other work to personally undertake additional activities, it is frequently possible for the council to enlist the co-operation of existing laboratories which would otherwise find it impossible to undertake the desired work.

At the close of the year 1926-27 there were organized under the National Research Council 19 associate committees which were in active operation. The membership of these committees was composed of 268 persons who without remuneration gave of their time and experience in furthering the work of the council.

In addition to the above, during the year under review, sixty-eight researches were in progress in laboratories spread from coast to coast, each investigation being supervised without remuneration by a highly trained research worker specially qualified to direct research on the particular problem entrusted to him. During the same period forty-four post-graduate research scholarships were also in active operation under the auspices of the council with the object of training outstanding university graduates in science and research, so as to build up in Canada a corps of men thoroughly qualified to undertake such work. Each scholarship was held under the personal supervision of some approved member of the staff of the university where the award was held, who co-operated with the council in the direction of the work of the grantee.

The total research organization actively at work under the auspices of the National Research Council during the year 1926-27 numbered 513, of whom 401 persons served without remuneration.

Obviously, co-operation and co-ordination must be the keynotes of an organization of this nature, and it is due to the persons who are directing this work and to the laboratories with which they are connected that attention should be very definitely drawn to the fact that the greater part, by far, of the cost of the research work carried out on a voluntary basis under the auspices of the council, is borne by the co-operating laboratories which furnish accommodation and all ordinary laboratory equipment required in connection with the work carried out, while all persons co-operating in the direction of research give their time and experience without cost to public funds.

It would be quite impossible for the council to pay for the service rendered and to provide the whole cost of the work carried out under its auspices, even if its financial resources were much larger than at present. A very real contribution is being made by these men and by the laboratories which they represent, in the development of scientific research in Canada.

Assisted Researches

Some indication of the results which have been accomplished by the National Research Council through its assisted researches program since the establishment of the council will be found in the first section of this report reviewing the activities of the council during the past ten years.

During the past year sixty-eight researches to which financial assistance has been granted were in progress in twenty-three departments of science. These investigations were carried out in the various departments of science at ten Canadian universities and in eleven Government or industrial laboratories.

It will be of interest to note the major departments of science in which these investigations were in progress. Twenty researches were carried out in departments of Physics, twelve investigations in the various departments of Chemistry, six in Botany, seven in Mining Engineering, four in Biochemistry, three in Biology, two researches each in the departments of Field Husbandry and Electrical Engineering, and one investigation was carried out in each of the following departments of science: Geology, Entomology, Bacteriology, Pathology, Plant Pathology, Animal Pathology, Plant Biochemistry, Plant Breeding, General Agriculture, Food Chemistry, Forestry, General Engineering, Engineering Standardization, Civil Engineering and Mechanical Engineering.

It will also be of interest to note the laboratories in which these investigations were carried out. They were as follows: the universities of British Columbia, Alberta, Saskatchewan, Manitoba, Toronto, Western Ontario, Queen's, McGill, Montreal, and Dalhousie. In addition to the above university laboratories, researches were also in progress at the Queen Alexandra Sanatorium, London, Ont.; the Fort Qu'Appelle Sanatorium, Fort San, Sask.; the Steel Company of Canada, Ltd., Hamilton, Ont.; the Atlantic Experimental Station for Fisheries, Halifax, N.S.; a co-operative investigation was carried out by the staffs of the Department of Lands and Mines of New Brunswick and the federal Forestry Service of the Department of the Interior; another co-operative investigation was carried out in the laboratories of the federal Department of Mines at Ottawa, and three co-operative investigations were in progress in various laboratories of the federal Department of Agriculture.

On consideration of the above facts it will be seen that *the research activities of the National Research Council were during the past year carried out in every province of the Dominion where facilities were available for work of this nature.* This is in accordance with the fixed policy of the council to utilize to the fullest possible extent all existing facilities both in trained man power and equipment, in order to stimulate and co-ordinate research work throughout Canada in so far as this may be possible with the facilities and financial resources which have been placed at the disposal of the council.

On consideration of the cost of this work, so far as public funds are concerned, interesting information will be found in the section of this report relating to finance and in Appendix "H" beginning on page . It will be sufficient to observe here that during the year under review approximately 49 per cent of the total expenditure of the council was devoted directly to the prosecution of research through this phase of its activities.

Attention should also be drawn to the fact that research grants are awarded by the council only under very definite regulations and after complete information has been furnished, on a form provided by the council, showing the qualifications and experience of the applicant for the particular investigation which he proposes, the scope of the proposed investigation and the details of his plans for carrying it out, also detailed information regarding the service on which the grant will be expended if awarded. Under the regulations *no part of any grant is used to remunerate the grantee for his services in directing the*

investigation. All apparatus and materials purchased from the grant remain the property of the council and are subject to recall at the discretion of the council. Reports on the progress of the investigation are required at regular intervals. A complete copy of the regulations which govern these grants will be found in Appendix "D" beginning on page 102 of this report.

It will therefore be apparent that this work is under such control as to make it possible to administer it in an effective and businesslike manner. It is, however, the constant endeavour of the council to avoid all unnecessary routine procedure and to administer all rules and regulations with the "saving grace of common sense", as is done in any well conducted business organization.

Training Research Workers

Three classes of post-graduate scholarships are awarded annually by the National Research Council, viz., 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 the above named 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. A copy of the regulations governing National Research Council scholarships and the submission of an application therefor will be found in Appendix "G" of this report.

The National Research 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. Detailed information on this point will be found in the section covering the past ten years' activities of the council, beginning on page 7 of this report. It will be sufficient to state here that these scholarships have proved of very great importance in the building up of research in Canada.

The main difficulty lies in the fact that there are so few scholarships available in Canada to promising university graduates, with the result that many of them complete their training in foreign countries under awards available there with the obvious result that their services are generally lost to Canada. It is of special interest and importance to note that although it is not feasible for the council to impose any restrictions as to the occupation or residence of a grantee subsequent to his holding an award, more than 80 per cent of the grantees have remained in Canada and are at work in our universities, technical government services, or our industries.

During the past year the council awarded seven Fellowships, seventeen Studentships and twenty Bursaries. Three times as many applications were received as there were awards available and while this ensures that the group of men who are granted awards were of the most desirable type and possessed very high qualifications, it also suggests that there is great need in Canada for additional post-graduate research scholarships.

The forty-four awards held during the year 1926-27 were won by graduates of eleven Canadian universities, as follows: University of British Columbia, 6; University of Alberta, 2; University of Saskatchewan, 6; University of Manitoba, 4; University of Toronto, 6; University of Western Ontario, 2; Queen's University, 2; McGill University, 9; University of Montreal, 2; University of Lennoxville, 1; Dalhousie, 4.

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 out by the students, will be found in Appendix "E" of this report, and in Appendix "F" will be found a complete list of the persons who held scholarships prior to the year under review and have completed their work under these awards.

Co-operation with Various Departments of the Federal Government

It has always been the policy of the National Research Council to co-operate in every possible way with the various departments of the federal Government and to avoid duplication of effort. The council is 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, co-operates with and assists the scientific divisions of the Government service in every possible way in furthering any research work which they are in a position to undertake.

The council has carefully avoided any inclination to unduly expand its activities. On the other hand there have been many instances in which it has co-operated with federal Government departments by organizing, and financing over a period of years, important investigations in which the departments were interested but unable to undertake. In each such case the work was carried out in co-operation with the department concerned.

In several cases after the work had been thoroughly organized and firmly established, the council has voluntarily withdrawn, leaving to the department concerned all the benefits of the work carried out by the council, as soon as the department felt that it was in a position to provide for and continue the work under its own auspices. In other words the council has used its financial resources and its facilities for the organization of research work, to assist various departments of the federal Government in getting work started which otherwise would not have been undertaken or would have been considerably delayed.

As an indication of the extent to which the National Research Council has co-operated in this manner with the various departments of the federal Government, the following specific examples may be mentioned:—

Department of Agriculture.

The council has been in constant touch 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. Five such investigations may be mentioned:

(*a*) An investigation on the nutritional problems of the fox breeding industry. This investigation was undertaken and carried on by the council in co-operation with the Department of Agriculture for several years but the entire results from this work, the trained staff and the laboratory equipment, were turned over to the department as soon as the latter was in a position to provide for and continue the work under its own auspices. This work is now being continued as a part of the permanent program of the Department of Agriculture.

(*b*) An investigation to determine the best methods for obtaining accurate results in testing varieties, strains and treatments of grains. When it was suggested that this investigation be undertaken, the council enlisted the co-operation of the federal Department of Agriculture and of the agricultural colleges connected with McGill University and the University of Alberta and arranged for simultaneous investigations to be carried out at various centres in Canada under the direction of senior officers of the Department of Agriculture and with financial assistance from the council.

(*c*) An investigation of the wheat rust problem. Under the auspices of the Associate Committee on Cereal Rust, the National Research Council, the federal Department of Agriculture and the Universities of Alberta, Saskatchewan and Manitoba have for several years been co-operating in a co-ordinated and concentrated attack on the problems of cereal rust. In connection with this work the Department of Agriculture has financed its own activities and the Council has assisted the work at the three universities, the work of all groups being thoroughly co-ordinated through the Associate Committee of the council.

(*d*) An investigation of the problems of tuberculosis, both human and bovine. In connection with this work the council has enlisted the co-operation of the federal Departments of Agriculture and Health in addition to seven outside groups which are also carrying out investigations under the Associate Committee appointed by the council to direct researches on the many problems of this disease. There is now no danger of any unnecessary duplication of effort in connection with such work in Canada.

(*e*) An investigation to determine ways and means of properly ventilating fruit storage warehouses. This investigation has been undertaken by the National Research Council in co-operation with the Department of Agriculture in the hope of improving the conditions under which apples are stored in warehouses in the Maritime Provinces.

Customs and Excise Department

The 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.

At the beginning of the year 1926-27, after consultation with the Chairman of the Associate Committee of Chemists of the Council, the department agreed to issue a specially denatured alcohol for use in the manufacture of nitrocellulose varnishes.

Department of Interior

(*a*) Shortly after it was established, the National 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 council. After the investigation had been in progress for four years, and when the work had been thoroughly established on a sound basis, the Forestry Branch was in a position to make the necessary financial provision to continue the investigation under its own auspices. The council therefore agreed to withdraw entirely from this work and it is now being carried on by the Forestry Branch of the Interior Department as part of its permanent research program.

(*b*) At the present time, in co-operation with the Dominion Forestry Branch and the Forest Service of the province of New Brunswick, the National Research Council is investigating the possibility of reseeding certain burned-over and cut-over areas in New Brunswick.

(*c*) The council has co-operated with the Surveys Laboratory of the Department of the Interior by loaning to that laboratory a considerable amount of technical equipment which has been secured by the council at a greatly reduced rate when the laboratories of the Imperial Munitions Board were disbanded, thus making it possible for the Surveys Laboratory to carry on work which they would otherwise have found it difficult to undertake.

(*d*) The council and department are also co-operating in connection with the work of the Associate Committee on the Heating and Insulation of Buildings and the Associate Committee on Magnesite.

Mines Department

The National Research Council has worked in close co-operation with the officials of the Department of Mines in connection with problems relating to the mining industry.

At the present time, in co-operation with the department, the council is carrying on an investigation of the technical problems in connection with the utilization of Canadian magnesite, of which large deposits occur near Granville, P.Q.

In connection with the work of the Associate Committee on Helium and the Associate Committee on the Heating and Insulation of Buildings, the council and the department have also worked in close co-operation.

Marine and Fisheries Department

(*a*) At the request of the department, the council carried out an investigation of the interference with radio broadcast reception.

(*b*) The National Research Council and the Department of Marine and Fisheries have also co-operated in connection with researches having for their object the improvement of equipment and conditions in navigation.

(*c*) The National 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 the 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.

The co-operation of the Biological Board of Canada was also enlisted in connection with a survey to determine the extent and prevalence along the Atlantic coast of Canada of a certain destructive species of pile borer which has caused enormous damage to wharves and piers along both the Atlantic and Pacific coasts of the United States.

National Defence Department

The National 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 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 department.

The activities of the Associate Committee on Helium, looking to a satisfactory method for the extraction of helium from natural gas found in Canada, have been carried on in close co-operation with a number of organizations concerned, including the Department of National Defence, the British Air Ministry, and the federal and Ontario Departments of Mines.

The council has also provided the Department of National Defence with funds to carry out an investigation on the use of ultra short waves in wireless direction finding apparatus.

Department of Trade and Commerce.

In co-operation with the Board of Grain Commissioners of the Department of Trade and Commerce, the National Research Council has organized a series of investigations on problems related to the grain industry, especially with reference to methods of drying grain and on the effect of commercial drying on the quality of grain.

The above examples will probably be sufficient to show conclusively that it has been both the policy of and the practice of the council to seek on all occasions the closest possible co-operation with the various government departments both with the object of assisting them in their work and of avoiding all unnecessary overlapping or duplication of effort in connection with any work undertaken by the council. It is, of course, not maintained that there is now perfect co-operation in connection with all the technical work carried out by the various departments of the federal Government. It may, however, be definitely asserted without the slightest fear of successful contradiction that the National Research Council has always done everything possible to insure that there was no unnecessary overlapping in connection with its activities and the work carried on by federal Government departments.

Wool Research

During the year under review a request was received from the Canadian Woollen and Knit Goods Manufacturers' Association that the National Research Council should undertake an investigation of the technical problems of the wool industry. This received the favourable consideration of the council and a member of the staff was instructed to make a brief survey of conditions in the industry, confer with representative manufacturers and report upon the steps which should be taken.

This preliminary study revealed the fact that any comprehensive investigation of the wool industry should include the problems of wool growing as well as those of wool manufacture. At present from fifteen to seventeen million pounds of raw wool are grown annually in Canada. Of this amount it is found necessary to export somewhat more than half, since the demand for Canadian wool in the home market is not large. At the same time Canadian manufacturers are importing the equivalent of about fifteen million pounds of raw wool annually, while the total consumption of the Canadian people, calculated to a basis of raw wool, is about seventy million pounds.

It was found that considerable work was being done by the Dominion and provincial Departments of Agriculture, this work being largely confined to a study of breeding methods and an effort to improve the grade of sheep grown in Canada. It appeared, however, that further work was required to co-ordinate these breeding methods, to determine the effect of feed and climate upon the quality of the wool produced, to ascertain in detail the defects of Canadian wool and to take such steps as might be found necessary to overcome them. In Canada mutton is a more important consideration of the sheep grower than is wool. At the same time it is believed that it may be possible to improve the quality of the wool without detriment to the mutton produced.

The wool manufacturing industry in general was found to be in a condition far from prosperous. This condition is no doubt due to economic as well as technical causes, but research is required to determine what advances can be made to improve technical methods. The practice of many of the mills is already fully equal to that in other textile manufacturing countries.

It was recommended that a conference should be called of representatives from every branch of the wool industry, including wool growers and manufacturers, in order that a comprehensive program of research might be drawn up after a full consideration of the whole subject. The council thereuuon authorized the president to proceed with the appointment of an Associate Committee on Wool to take charge of an investigation of the wool industry. As a preliminary step it was decided to obtain full information regarding the research on wool being carried out in other countries.

Information Service

Practically from the time of its establishment requests for information on a wide variety of topics have been received by the National Research Council. The permanent staff of the council has at all times been small, but on its many associate committees there are experts in nearly every branch of science and technology and through them it has been possible to satisfactorily answer a very large proportion of the inquiries. As the work of the council becomes better known, more and more inquiries are received, and the facilities for handling them are being increased in keeping with the demand. Assistance has thus been given in the improvement of old processes and the establishment of new ones, and information on recent researches has been supplied to investigators in many branches of science.

International Activities

The National Research Council of Canada serves as the Canadian link in a scheme for the co-ordination and development of scientific research throughout the Empire. This was one of the specific objects mentioned by the British Government when requesting the Governments of the various Dominions, in 1916, to undertake research work within their borders. At that time it was the expressed hope that in due course an Empire scheme for scientific and industrial research would evolve which would ultimately be of great assistance in maintaining the industrial position of the Empire.

In Great Britain the Advisory Council for Scientific and Industrial Research has developed into a Government Department of Scientific and Industrial Research, while national research organizations comparable to the National Research Council of Canada have been established in practically every unit of the Empire. The National Research Council of Canada keeps in close touch with the activities of all these organizations and particularly with the Department of Scientific and Industrial Research in Great Britain.

Obviously the geographical location of any unit of the Empire determines to a considerable extent the particular problems which are most pressing. The problems of greatest importance in Canada are seldom urgent problems in Australia, South Africa or India, and, consequently it is essential that each Dominion should undertake the solution of its own research problems in an aggressive and businesslike way. Otherwise most of them are likely to remain unsolved.

Notwithstanding this fact 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 on especially in Great Britian, which is of very definite value to Canada. It is, therefore, the duty of the National Research Council of Canada to co-operate with the other research organizations of the Empire in the co-ordination and stimulation of research work.

The National Research Council of Canada is also affiliated with the International Research Council as is practically every important commercial country in the world. 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 scientists throughout the 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. At the close

of the year under review the council had 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.

The fees to the two latter unions have, during recent years, been maintained by the federal Department of the Interior which is most directly concerned with the work of these unions.

Through the International Research Council and its unions, the National Research Council of Canada is enabled to keep in touch with the development of scientific thought throughout the civilized world.

One of the functions of the National Research Council is to advise the federal Government on scientific questions and the council is frequently called upon by the Department of External Affairs to pass judgment on international questions of a scientific nature. During the year under review the council had under consideration a despatch from the Department of External Affairs requesting that the Government of Canada participate in a proposed International Chemical Conference to be held in Paris for the purpose of establishing an International Bureau of Chemistry at Paris.

On consideration of the information available on this question, the National Research Council of Canada unanimously recommended that the Government of Canada should not participate in the proposed conference as in the opinion of the council sufficient time had not been allowed to ensure that the objects of the conference would be achieved. Subsequently the council had under consideration a further communication from the Department of External Affairs advising that the proposed conference had been postponed and that a despatch had been received requesting that Canada be represented at the postponed meeting. Prolonged discussion ensued as a result of which it was the opinion of the council that if a practical method can be devised for international co-operation in chemical abstracting, this would be of very great benefit to all co-operating countries. The council was not convinced, however, that the proposed museum of chemical products would be of equal value. Nevertheless the council was of the opinion that if the leading nations were to be represented at the proposed conference, Canada should also be represented thereat, but on the understanding that the delegates were not to be committed in any way prior to the meeting to support the suggestion that the proposed Bureau should be established in Paris. The council was further of the opinion that the proposed conference should be of a preliminary nature only, and, that final action on this question should not be taken until negotiations have reached a stage which will ensure the success of any organization which may be established.

It was subsequently decided, when it was learned that the British Government did not intend to be represented at the conference, that it would not be necessary for a Canadian representative to attend.

During the year under review the council co-operated with the National Research Council of the United States in the compilation of "A Handbook of Scientific and Technical Societies and Institutions of the United States and Canada." The arrangement was that the National Research Council of Canada would compile a list of the scientific and technical societies and institutions of Canada giving in the case of each society or institution listed, the name and address of the chief executive officer, a synopsis of the history and objects of the organization and details regarding meetings, research funds, and publications.

The National Research Council of the United States agreed to compile the same information for that country and at its own expense to publish the joint reports in one volume and to provide the National Research Council of Canada with reprints of the Canadian section of the Handbook for special distribution in Canada.

The Canadian section of the Handbook contains information regarding seventy-four societies and institutions and is of considerable value especially for reference purposes.

During the course of the year under review the council was requested to take steps to announce in Canada to persons likely to be interested, the Fouler-ton Research Studentship offered by the Royal Society of London for research in medicine and also a research studentship by Emmanuel College, Cambridge, both of these scholarships being tenable in Great Britain.

The council was enabled to give the scholarships the desired publicity through the organization which it has established in connection with its own scholarships.

The council was also called upon during the year under review to pass judgment on the proposed reorganization of the Bermuda Biological Station for research. This project was endorsed, on the understanding that no financial assistance would be requested from the council unless in connection with definite applications to co-operate in the prosecution of specific researches, each of which could be considered on its individual merit.

The council also dealt with the question of Canadian co-operation in the publication of the International Tables of Constants and Numerical Data of Chemistry, Physics and Technology and with the question of Canadian repre-sentation at the Pan-Pacific Congress on Education and Rehabilitation held at Honolulu in April, 1927.

The council also received, during the year under review, a communication from the Imperial Institute, London, calling attention to the facilities now possessed by that institution and requesting the co-operation of the council, on consideration of which it was agreed that the council should co-operate with the Imperial Institute in every way possible and should utilize the facilities which it offers insofar as this may be feasible.

Another question of an international character dealt with by the council arose through a communication of the Association of Special Libraries and Information Bureau, London, requesting that the council become a member of that organization. Attention was called to the fact that this bureau did not propose to set up any central repository or information but rather to develop a channel through which any inquiring member would be put into direct touch with the appropriate source of information. The council decided on careful consideration of the matter to subscribe to membership in this organization.

The foregoing summary will offer some slight indication of the extent of and diversity of the questions of an international character which the National Research Council of Canada is called upon to deal with from year to year.

Meetings and Personnel

Four meetings of the National Research Council were held at Ottawa during the year under review.

In accordance with the requirements of the Research Council Act the term of office of five members of the council expired on April 1, 1926, viz., Sir George Garneau, Dr. J. H. Grisdale, Dr. A. B. Macallum, Mr. J. A. McClel-land, and Dr. R. F. Ruttan. On the recommendation of the council the five gentlemen named above were reappointed by His Excellency the Governor General in Council as members of the National Research Council for a further period of three years expiring on March 31, 1929.

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Finance

During the fiscal year 1926-27 the council received from all sources a total revenue of $163,332.37. Of this amount $150,000 was provided by the federal Government, $10,000 by the Sun Life Assurance Company of Canada as a special grant to assist in the co-operative researches on tuberculosis carried out by the council, and $3,332.37 was secured from miscellaneous sources, including refunds from research grants and scholarships.

The expenditures of the council during the past year totalled $163,326.06. Of this amount $41,105 was expended on post-graduate scholarships; $79,233.45 on research activities, including assisted research grants; $2,278.37 on the library of the council and in the publication of scientific papers; $2,651.70 in connection with conferences on research co-ordination and meetings of advisory committees; $8,690.11 in travelling expenses of members of the National Research Council and of its staff; $6,292.91 in the administration of the office of the council and of all its activities, including all committees associated with the council; and $23,074.52 was expended in the payment of the salaries of the staff of the council.

On consideration of the above figures, it will be obvious that during the year under review the council has continued to keep its administrative cost at the lowest figure which effective administration will permit and that the major part of the funds expended by the council have been devoted directly to the prosecution and co-ordination of research work and to the post-graduate training in research of the most promising graduates of our universities.

Publications of the National Research Council

In addition to its annual report the National Research Council issues two series of publications known as reports and bulletins. A report embodies the result of work actually carried out under the auspices of the council, while a bulletin may be a compilation of present knowledge on some subject of sufficient importance to justify the council in compiling and publishing a statement thereon. The reports issued by the council are mainly technical, but bulletins are usually prepared in non-technical language, which may be readily understood by persons without scientific training.

The great majority of the reports arising from researches carried out under the auspices of the National Research Council are published in approved technical journals by the persons who direct or actually carry out the work. However, the regulations governing the award of research grants reserve to the council the right to publish the report of any such investigation under its own auspices, if it so desires, and this right is exercised by the council in selected instances.

With reference to the distribution of the publications of the council, it will be obvious that there is a comparatively restricted field in which technical reports may be usefully distributed. It is also clear that the field will vary to a considerable extent according to the technical subject dealt with. Consequently, in the distribution of its publications the council sends out reports only to those organizations and institutions with which an exchange of publications has been arranged. All other persons on the list merely receive notification that a report on a certain subject has been issued and is available upon request. In addition, a special supplementary list of persons directly interested in the subject matter of each report is prepared when the report is issued and notification regarding the issue of the report is also sent to each person on that list. In this manner every effort is made to see that each publication is effectively distributed and also that distribution is restricted to useful channels. Up to the close of the year under review twenty reports and twelve bulletins have been published by the council. A complete list of the titles and authors of these publications will be found in Appendix "I" of this report.

IV. SUMMARY OF ACTIVITIES OF ASSOCIATE COMMITTEES

Foreword

The National Research Council has established two classes of Associate Committees, the main function of the first class being to advise the council on scientific questions and of the second, to direct research work on some major problem.

With the object of keeping the council closely in touch with important research problems requiring attention and with advances in science made from time to time, the council has established Associate Committees, one in each of the major departments of science. These committees provide the council with a source of reliable scientific advice in their respective fields. In some cases research work is carried on under the auspices of Advisory Committees, but research is not their main function.

The second group of Associate Committees has been appointed by the council for the specific purpose of undertaking the organization, co-ordination and prosecution of research work on some major problem or group of problems. This group of committees differs from the first group in that their main function is to undertake the direction of the research work specifically assigned to them, but they also serve in an advisory capacity in their own field.

At the close of the year under review nineteen such Associate Committees were in active operation under the auspices of the National Research Council. A complete list of these committees and of the personnel of each will be found in Appendix "K" of this report.

The Associate Committees of the council usually meet at least once a year at a time and place most convenient to the majority of the members concerned, to discuss that part of the work of the council with which they are concerned and to consider 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 synopsis of the activities carried on by Associate Committees of the council during the year 1926-27 follows. Perusal of this section will afford a general idea of the extent and importance of the work undertaken by these committees under the auspices of the council during the past year. It is obviously only through the unselfish co-operation of the members of committees and of other research workers who give freely of their time and experience without remuneration that the council is enabled to carry on such a volume of work with its limited appropriation.

Associate Committee on Cereal Rust

Co-operating Organizations:

Dominion Department of Agriculture.
University of Alberta.
University of Manitoba.
University of Saskatchewan.

Fortunately for the farmers of the Canadian West the season of 1926 was comparatively free from grain rust. West of Winnipeg the losses from this cause were small, though they were considerable in Eastern Canada. Even in the most favourable season, however, the damage is spread over such a large territory that the aggregate loss is one of considerable magnitude, demanding the utmost that scientific research can do to reduce it.

The facilities for carrying on the grain rust investigation during the year were considerably greater than at any previous time. Not only were researches in progress in all three of the universities of the Prairie Provinces but the splendidly equipped new Dominion Rust Laboratory with large greenhouses erected by the Dominion Department of Agriculture on the grounds of the Manitoba Agricultural College was available throughout the year, and greatly expedited the work.

As previously, the rust problem has been attacked from many angles, in order that no possibility even of a partial solution should be overlooked. One of the methods of plant disease control frequently used—exclusion of infection—could not be adopted in the present case. Owing to the fact that rust spores may travel hundreds of miles, wind-borne in the upper atmosphere from districts where rust is prevalent, it is obviously impossible to entirely prevent infection, and, once established, it spreads very rapidly.

It is possible, however, through the eradication of the winter hosts of rust spores, to reduce infection from local sources practically to the vanishing point. This has already been accomplished over the greater part of the Prairie Provinces by the almost complete destruction of the common barberry and buckthorn.

A very large part of the investigation to date has been concerned with the breeding of varieties of wheat and oats resistant to rust. This line of experimentation has proved of inestimable value in the production of Marquis wheat and other grains, and therefore amply justifies all the effort which is being made by this method to solve the rust problem. In this investigation the plan is to cross varieties possessing different desirable characteristics, such as rust resistance, productivity and high quality, in an attempt to produce hybrids which may combine these in one variety. Marquis, being the wheat most generally suited to conditions in the Canadian West, has been largely used in these crosses, as also have varieties of Indian Emmer, a grain very resistant to all forms of rust. Crossing is done on a very large scale, tens of thousands of hybrids being produced, and each of these must be criticaly examined by a competent investigator. Real progress is being made, but even with the best of success some years must elapse before the promising hybrids produced can be given a thorough trial.

Another method of attack is to work out means of destroying the rust spores before they can do serious damage, or of preventing them from getting a foothold. Obviously such a treatment, to be of commercial value, must be cheap and effective in operation, since the task of applying it to millions of acres of grain would be a very large one. For two seasons sulphur dusting has been tried on a small scale. In 1925 it proved very effective, but in 1926 the rust damage was too slight to show greatly improved yields in grain treated in this way.

Cereal Breeding at Saskatoon

This series of wheat-breeding experiments may be divided into five different projects, each with a specific object in view. Since Marquis is still unexcelled as a hard red spring wheat, it has been used in all of the crosses to date.

Project 1.—To produce a variety of wheat that shall possess the rust resistance of Marquillo (a cross between Marquis and Iumillo) and shall otherwise be equal to Marquis. Marquillo itself is unsatisfactory owing to the colour of its flour, but by back-crossing with Marquis it is hoped that the high baking quality of the latter may be retained. In 1926 some 20,000 plants of the second generation cross were produced. Most of these were discarded at once owing to rust susceptibility, but from the rest a large third generation was obtained. Of these 275 families have proved worthy of continued experimentation.

Project 2.—To produce a Marquis-Iumillo cross combining the best characteristics of both parents, but better if possible than Marquillo. Two hundred of the second generation of this cross were examined in detail and their characteristics have been recorded. Low fertility of the third generation prevented greenhouse rust tests, but the fourth generation will be tested in 1927.

Project 3.—To combine the desirable qualities of Marquis with the almost complete rust resistance of Khapli. Unfortunately these two varieties do not cross readily, but it seemed possible to first cross Khapli with Early Emmer and then cross the hybrid with Marquis. This cross was successfully produced, and the second generation appears to be more than usually resistant to rust.

Project 4.—To combine the resistance of Vernal with the quality of Marquis. These varieties cross readily, hence it seems a particularly desirable combination. The first hybrid generation will be grown in 1927.

Project 5.—To study the incidental problems, such as hybrid production by artificial light; the creation of a uniform rust epidemic in the field nursery; the variability of parental varieties for rust reaction in the greenhouse; the protection from loss of valuable hybrid material in the nursery; the correlation of rust results in the nursery with those in the greenhouse. Progress is being made on these and a number of other minor problems.

—(Investigation under the direction of Prof. J. B. Harrington, University of Saskatchewan.)

Cereal Breeding at Winnipeg

In the first two years of this investigation a large number of crosses of different varieties of wheat were made, one of the parents chosen being in most cases either Khapli or Iumillo, on account of the high resistance to rust of these two varieties.

In the spring of 1925 there occurred a very heavy late frost, which afforded an unusual opportunity of making observations on frost resistance. Some of the hybrids under experiment were untouched, while others were very badly damaged, so the record made of their behaviour on this occasion will be of considerable value if any of the varieties prove to possess combinations of desirable characteristics.

In order to determine the resistance to rust of each of the first and second generations of hybrids they were given a thorough spraying with rust spores in the field. The wheat plots were surrounded by muslin tents, the plants and ground were given a thorough wetting and this was followed by a very vigorous rust spraying. The tent was kept closed for three days after inoculation, and during this period the ground was constantly kept moist. Some of the hybrids displayed a marked resistance to rust, and these will all be grown separately during the following season, for a further test of rust resistance and other desirable characteristics.

There has now been worked out an additional plan of campaign to be followed during the next two seasons. Systematic crossing will be made of varieties noted for one or more valuable characters, in an effort to combine as many of these as possible. The groups to be crossed with each other are: .(1) Marquis and Mindum, high-yielding varieties; (2) Garnet, a new and remarkably early wheat; (3) Reward, possessing unusually stiff straw; and (4) Khapli, Iumillo, Pentad, Monad, Acme and Kota, all varieties resistant to rust.

—(Investigation under the direction of Prof. H. F. Roberts, University of Manitoba.)

In 1922 a series of experiments was undertaken on the crossing of certain common varieties of wheat. The crosses made were Kanred-Kota, Kanred-Ruby, Marquis-Kota, and Ruby-Kota, and these have now been obtained in the third and fourth hybrid generations.

Considering the first of these crosses, the object was to combine the resistance of Kanred to certain forms of rust with the resistance of Kota to other forms. Some further study of this cross is necessary, but it appears to be at least partially successful. Complete success would mean immunity to twenty-six out of the forty-one known varieties of rust, these including the common ones which are responsible for the chief damage. In the Kanred-Ruby cross the immunity of the former has been in part combined with the earliness of the latter. The quality of earliness is of special importance in relation to the rust problem because rust infection usually takes place near the close of the season, and early varieties may largely escape damage, even though susceptible to rust. The last two crosses mentioned are now being studied to determine their reaction to rust forms.

—(Investigation under the direction of Prof. W. T. G. Wiener, University of Manitoba.)

Cytology of Wheat Species and their Hybrids

Breeding for rust resistance usually involves crossing common bread wheats with other species. Very frequently such crosses fail to secure the desired combination of characteristics because the species differ in chromosome number. Common wheats have 21 chromosomes, those of the Emmer group, which show the chief resistance to rust, 14, and others only seven. In hybrids of these different species the chromosome numbers are usually the same as one or the other of the parents, and those which are intermediate frequently revert to one of the parental numbers in succeeding generations. In accordance with this fact, it is found that the character combinations in the hybrids are usually those of the parents. It has therefore been held by some that the characteristics of common wheat are carried in the extra seven chromosomes of that species, and that it is impossible to secure true combinations of characters of different species. This investigation is an attempt to clear up some of these obscure points.

A study was carried on to determine why the expected chromosome numbers fail to appear, and where the failure occurs. The method used was to back-cross hybrids with the parents and to determine chromosome conditions in the offspring. Since the parental number is known and the number in the offspring is determined, a simple calculation gives the numbers in the reproductive cell of the hybrid which functioned to produce the offspring. Many have been studied in this way, and it has been shown that the failure occurs in the reproductive cells, and not through the death of young offspring.

It has been observed that Black Persian wheat, which is known as a common or bread variety, has certain characteristics of the species with 14 chromosomes, including their crossing capabilities. Cytological studies showed that Black Persian itself has 14 chromosomes, though several of its outstanding characteristics are those of the 21-chromosome wheats. The combination supposed to be impossible therefore actually exists, and the extra chromosomes are not necessary to the "common" characteristics. It should follow that Black Persian will cross readily with Khapli, the most rust-resistant Emmer, which will not cross with bread wheats, and this is actually found to be the case. These crosses will be investigated.

By crossing wheats with 21 and 7 chromosomes, respectively—a cross which it is very difficult to make—there are obtained wheats with from 18 to 28

chromosomes. It is evident that the chromosomes of the two species have become so differentiated that it is impossible for them to go through the usual reproductive behaviour.

—(Investigation under the direction of Prof. W. P. Thompson, University of Saskatchewan.)

Nature of Resistance and Susceptibility to Stem Rust in Wheat

The enormous amount of detail work involved in breeding wheats resistant to rust has already been emphasized. A great difficulty is that there is no method of determining in advance the result of any particular cross, and each of the hybrids produced has to be studied individually. If the factors upon which resistance depends were definitely known it would be possible to proceed directly to secure the characteristics desired, instead of being restricted to the present empirical methods. The biochemical work of this investigation has up to the present been confined to three main studies: (1) the physiology of the host wheat plant; (2) the physical and chemical properties of the wheat-cell contents; (3) inhibiting or accessory substances. These three projects will be summarized in turn.

The physiology of the wheat plant probably has a direct bearing upon its resistance to rust, since there has been observed a close relation of the development of the rust fungus to the vigour of the host. This suggests that the parasite may be dependent for its nutrition upon certain intermediate products of the host's metabolism.

A comparative study has been made of the seasonal content of some substances related to physiological activity in eight varieties of wheat differing widely in susceptibility to rust. These substances include the enzymes catalase, diastase and oxidase, and the pigments chlorophyll and the carotinoids. The water content and per cent of substances extractable by acetone and ether were also determined. Tests were made at frequent intervals throughout the season.

There are many irregularities in the results obtained, but there is observed a well-marked general tendency, especially in the earlier stages of growth, for all of the foregoing substances to be most abundant in susceptible varieties, and less so in the resistant wheats. Intermediate varieties present a very complicated problem, being resistant to some rust forms and susceptible to others. As the season advances the differences between the varieties tend to disappear.

The cell contents appear to be the seat of the important reactions which determine the relation of the wheat plant and the invading rust parasite. With the object of discovering in the cell fluids properties which might be associated with rust resistance, a study was made of the hydrogen-ion concentration, osmotic pressure, electrical conductivity and colloidal properties of the press-juice of the same eight varieties of wheat.

Some of the foregoing properties were found in previous investigations to be related to frost and drought resistance. The present experiments have shown marked differences between varieties, but have not revealed any consistent relation to rust resistance. This work will be extended to cover chemical analysis of the cell contents of various substances which for any reason may be suspected to be concerned in rust reactions.

The action of inhibiting or accessory substances is being studied by the use of extracts from the leaves of varieties with opposite rust reactions, which may possibly contain such substances. For this purpose there have been used Khapli and Little Club, Vernal Emmer and Marquis, one of each of these pairs being resistant and the other susceptible to the rust form employed.

Three kinds of extracts of the leaves of these wheat varieties have been prepared, raw press-juice, filtered press-juice sterilized by boiling, and double-filtered sterile juice. These extracts have in turn been administered in three ways,—by adding them to water cultures of wheat seedlings, by adding them to sugar solutions in which leaves are supported and by direct injection into the leaves of growing plants. The results so far have been mostly negative, but some encouragement has been obtained to continue the experiments.

—(Investigations under the direction of Prof. R. Newton, University of Alberta.)

Crown Rust of Oats

This problem is closely related to that of wheat rust, and it is therefore advantageous to pursue the study of both at the same time. The plan followed in the investigations of the crown rust of oats has been to determine those factors that favour the spread and development of the disease, to test the resistance of oat varieties in the greenhouse and field, and to make a cytological study of uredospore infection.

The crown rust of oats, like the stem rust of wheat, has a number of hosts which play an important part in the spread of the disease. In the years 1922 and 1923 there was a very heavy infection, but in 1925 and 1926 it was comparatively light. Consequently the field studies of the past seasons have not yielded much new information. The cultivated buckthorn has been shown to be a very congenial host for crown rust of oats, and heavy infection of oats followed every inoculation with rust from this source. The infection from the native buckthorn is very slight, however, and after an extended study it has been concluded that while the two forms of rust found on these hosts are structurally similar they are physiologically distinct. Aecia on the wolf willow and the buffalo berry in Saskatchewan must be regarded as a species distinct from the crown rust of oats, although there was produced heavy infection of this type on certain grasses. The native grasses in Saskatchewan are not very susceptible to the crown rust of oats.

Of the large number of varieties of oats tested for susceptibility to crown rust a few have been found which are decidedly resistant. The most resistant of these came from Australia, and is known as Cowra 35. It will be of marked value in breeding. All the resistant varieties are being grown in Saskatchewan for further study and experiment.

A detailed cytological study has been made of uredospore infection in Cowra 35 and also in Banner, a valuable variety which is decidedly susceptible to rust. Generally speaking, infection follows a similar course to that observed in the stem rust of wheat. Entry takes place in the same way in both oat varieties. On Banner the host tissue gives evidence of being stimulated by the presence of the fungus. This is not true to the same extent on Cowra 35, on which there has been noted a marked variability in the reaction, even in different parts of the same plant. On the more resistant plants, attacked cells often collapse and die. Intracellular bodies occur, but they are fewer than on a susceptible host.

—(Investigation under the direction of Professor W. P. Fraser, University of Saskatchewan.)

Work of Dominion Rust Research Laboratory

In this laboratory a number of projects are under way. All the work is being financed entirely by the Dominion Department of Agriculture, and only a brief summary of their investigations will therefore be given here. Detailed results have however been made available to all those engaged in this co-operative research, in order that full advantage may be taken of all progress made. A more complete account of the work of this laboratory will be found in "Work of the Rust Research Laboratory and Nursery for 1926" and "Report of the Dominion Cerealist for the year 1926," both being publications of the Dominion Department of Agriculture.

Plant breeding for rust resistance forms a very important part of the work of this laboratory. A careful study is being made of the various forms of wheat stem rust, the existence of a large number of which has greatly complicated the whole problem. It is important to know, moreover, whether these forms of rust may be expected to increase in number, and attention is therefore being given to the possibility of the production of new forms by hybridizing, as well as to changes in the capability of the various forms for producing infection.

An annual survey is made of the extent of grain rust of different forms, and in this connection standard groups of varieties of both wheat and oats are maintained in many different parts of the country. An effort is made to determine the sources of infection in the various provinces, the manner of spread of the disease and the environmental factors which favour or retard its development. Detailed information is being secured regarding the susceptibility of all the commoner varieties of wheat and oats to the more important types of rust. Sulphur dusting experiments are also being carried out by the staff of this laboratory.

Associate Committee on Tuberculosis Research

Co-operating Organizations:—

Dominion Department of Agriculture.
Dominion Department of Health.
Fort Qu'Appelle Sanatorium.
Queen Alexandra Sanatorium.
Sun Life Assurance Company of Canada.
Queen's University.
University of Alberta.
University of Montreal.
University of Toronto.

Tuberculosis is one of the oldest diseases known to mankind. Hippocrates, who lived in the fifth century B.C., wrote that it was responsible for more deaths than any other disease. In spite of all the efforts which have been made to eradicate it, tuberculosis has until recently remained the most destructive of the diseases of civilized man. In the last twenty-five years, however, a marked improvement has taken place. Better sanitation, intensified research and education of the public have all been important factors in reducing the death rate from this cause. It has been estimated that in the United States alone the campaign against tuberculosis has been responsible for the saving of 100,000 lives annually, the present death rate being only half as high as twenty years ago.

Tuberculosis has also been the cause of an enormous economic loss through its prevalence amongst domestic animals. Cattle in particular are very susceptible to the disease, and thousands of animals suffering from it are slaughtered annually to prevent a further spread of the infection. Bovine tuberculosis, more-

over, has through contaminated milk infected a large number of children, the mortality amongst whom has thereby been greatly increased. The problems of human, bovine and avian tuberculosis are essentially alike, and any co-ordinated attack upon the disease must include a study of all types.

In Canada much valuable research on various phases of the tuberculosis problem has been under way for some years. The universities, federal and provincial departments of health, hospitals and sanatoria have been active in the study and treatment of human tuberculosis. The disease amongst domestic animals and poultry have been actively combated by the federal and provincial departments of agriculture and some other organizations. The Canadian Tuberculosis Association has done a valuable educational work and has been in close touch with the other organizations named. But not until the National Research Council in 1925 called a conference of all those in Canada actively engaged in tuberculosis research was any systematic organized effort made to place the campaign upon a national basis. The committee then formed, representative of all the co-operating organizations, formulated a definite comprehensive plan of research, and took steps to so allocate the work that no important phase of the problem would be neglected. This campaign is now under way, and progress is being made in all the principal researches.

The Sun Life Assurance Company of Canada, on being made acquainted with the research program of the Associate Committee on Tuberculosis Research, generously promised towards that work the sum of $10,000 annually for a period of from three to five years, depending upon the duration of the investigation. This contribution is an indication of the interest with which the progress of medical research work is being watched by the great life insurance companies. It will greatly assist in carrying out the program of tuberculosis research in Canada.

Much of the attention of the committee is being given to a vaccine not previously tried in Canada. It was developed at the Pasteur Institute in Paris by Professors Calmette and Guerin, from whom it derives its name, "Bacillus Calmette-Guerin", or "B.C.G.", as it is commonly called. This was produced only after thirteen years of research work and the trial of 230 cultures. B.C.G. consists of living bacilli, but they have been so attenuated that Calmette claims they have completely lost their virulence, while retaining their power to develop the resistance of the body to the disease. Calmette has worked with the greatest caution, first trying the vaccine on rabbits and guinea pigs, then on calves and apes, and finally extending its application to the new-born children of tuberculous parents, who, without its aid, would under normal conditions become infected with the disease in the first year of life, with a consequent very heavy mortality. While B.C.G. has not afforded complete protection against tuberculosis, even when used under Calmette's direct supervision, the results obtained are such as to justify the belief that this development marks an important forward step in tuberculosis research.

Tuberculosis Research among the Indians

It has long been known that Indians are far more susceptible to tuberculosis than are the white races of mankind. The reason for this is not definitely known, but it is supposed by many that the white man's contact with tuberculosis for many generations has been such as to develop in the race a resistance to the disease greater than that of the Indians. Great susceptibility to tuberculosis has been noted among many primitive tribes which have not for long been in contact with the white races.

The investigation at Fort Qu'Appelle has included a study of the history of the Indians of the prairie, in order to determine what changes have taken

place in their manner of living, and their past experience with regard to tuberculosis. From 1884 to 1894 it appears that nearly all the deaths amongst the Indians were due to tuberculosis, the death rate rising as high as 10 per cent in one year. Since that epidemic there has been a gradual decline in tuberculosis, but the rate still remains many times as high as that of the whites in the prairie provinces.

The tuberculin test was tried on a large number of children on admission to the Indian schools, at an average age of six years, and about 70 per cent proved to be sensitive to it, indicating the very large amount of infection which takes place in the homes in early childhood. By the age of eleven years about 92.5 per cent of the children are infected.

A test is now under way to determine the nature of the germ causing tuberculosis among the Indians, whether human or bovine, or both. Practical preventive measures are being undertaken and the advisability of instituting vaccination will also be considered.

—*(Investigation under the direction of Dr. R. G. Ferguson, Fort Qu'Appelle Sanatorium.)*

Tuberculosis Research at the Queen Alexandra Sanatorium, London, Ontario

In an investigation of tuberculosis immunity an effort has been made to determine the action of antibodies which form in the blood serum. It is believed by some authorities that these antibodies play an important part in the development of immunity to tuberculosis. The problem is a difficult one, since it involves careful fractionation of the blood serum, and no standard practice has yet been developed.

This work has been done on human and sheep blood serums which showed the presence of such antibodies. The serums were dried and extracted in selective solvents, using a reflux condenser. Each fraction was then studied to insure the absence of other chemical fractions and tested for antibodies. Many physical and chemical difficulties have been overcome, but the final decision as to the chemical location of the antibodies has not yet been made.

X-rays are being used to a very large extent in tuberculosis work, but unfortunately the technique of chest radiography has not yet been standardized. The products of different laboratories vary greatly in character, as do different films prepared in the same laboratory. This fact in turn greatly influences the presence and character of shadows and their interpretation. An effort has therefore been made to determine the physical character of those radiographs which most accurately reveal the condition of the lungs and other organs.

The method adopted in this investigation is to prepare a series of radiographs in which the various chemical and physical factors involved have been systematically altered. The films are then compared in special viewing apparatus to determine in which of them the object radiographed has been most accurately reproduced. From the results so far obtained it appears that no single type of film reproduces all types of structures equally well. An effort will be made to determine which type is best for any particular diagnostic type.

In the interpretation of radiographs it has been found that different observers will often give widely divergent opinions as to the significance of given shadows. A study is therefore being undertaken of the relation between shadow-producing tissues and the radiographs of same. An original technique has been developed. The method is to cut thin slices of autopsied lungs, which have been previously frozen to prevent deformation, followed by X-rays of the

sections, in order that the desired structures may be confined to the thickness of the slices.

Over 100 autopsied lungs have been so studied, with very striking results. The information obtained has partly corroborated common views, but some of it is decidedly new in character. It will be of substantial aid in the interpretation of chest radiographs.

There has also been started a series of tests on the blood serum of tuberculous and non-tuberculous individuals in order to determine the significance of certain reactions. It is proposed to correlate the results with clinical data.

—(Investigation under the direction of Dr. F. H. Pratten.)

The Relation of Iron to Tubercle Bacilli

Several tuberculosis research workers have in recent years observed that the growth and metabolism of tubercle bacilli were influenced by the presence of iron. An investigation of several phases of this problem has therefore been undertaken.

A study was made of the influence of acidity on the solubility of iron in a synthetic medium. A medium in which tubercle bacilli had been found to grow rapidly was prepared in several lots, which were adjusted in acidity by caustic soda and hydrochloric acid to give media varying in pH from 6.0 to 8.0, this being approximately the pH growth range of the bacilli. To each a definite quantity of a solution of ferric chloride was added, the precipitate which formed during twenty-four hours was filtered off and the clear solution was analyzed for iron. It was found that a slight but practically constant amount of iron always remained in solution.

It is well known that the salts of certain organic acids tend to prevent the precipitation of iron from solution. A definite quantity of sodium citrate was therefore added to each of a series of media similar to those already tested. It was found that in all cases much of the iron remained in solution, the quantity being greatest in the neutral solution, smaller in the alkaline medium and least in the most acid medium.

To test the rate of growth of bacilli in solutions such as these, cultures of a Koch strain of human tubercle bacilli were prepared, (1) to which no iron or citrate was added, (2) to which iron was added but no citrate, (3) containing both iron and citrate. A complete series was grown for five weeks, after which the growths were filtered off and weighed. A duplicate series was grown for eight weeks before being filtered. Growth was found in all tests to be more rapid when the iron was present. In the shorter tests the total amount of iron made no radical difference, but in the longer tests the difference was strikingly in favour of the solutions containing the largest quantity of iron. Apparently a small quantity of iron was sufficient for growth during five weeks, but not during the longer period. Other strains of tubercle bacilli showed less marked differences than these.

A series of experiments was carried out to determine the influence of iron on the colouring of tubercle and other bacilli. Acid-fast bacteria invariably showed markedly deeper colour in the media containing iron. Some of those in the iron-free solutions remained quite colourless throughout the whole period of test. The behaviour of the non-acid-fast bacteria was in sharp contrast to this. Yellow and brown pigments appeared in some of the cultures, but in no case did these bear any relation to the iron in solution.

The influence of the iron content of synthetic media on the production of tuberculin and other growth products is being investigated, but results are not yet available.

It has recently been shown elsewhere that acid-fast bacilli can by suitable dehydration be rendered non-acid fast. These observations have been confirmed, and a further study of the subject is being made. It seems unlikely, however, that such a change can take place in tuberculous tissue, in view of the necessity of a considerable degree of dehydration.

—(Investigation under the direction of Prof. G. B. Reed, Queen's University.)

Tests of B.C.G. Vaccine in Calves

The present method for the control of tuberculosis in cattle—based on the tuberculin reaction—is the only well-tried practical method available. This method, however, takes no account of racial or individual degree of resistance to the disease. In certain congested communities nearly all adults react to tuberculin, although less than 10 per cent of them eventually die of the disease. Many primitive peoples, on the other hand, do not react, but when infection takes place the course of the disease is usually a rapid one, proceeding to a fatal termination. Apparently, therefore, mild healed tuberculous lesions afford marked protection against the disease. It is on this principle that the value of B.C.G. vaccine as an immunizing agent is based.

The immunizing effect of healed lesions has been observed in cattle as well as in man. As early as 1900 cattle were vaccinated with human tubercle bacilli, which is of low virulence in cattle, and it was hoped that this might prove a solution of bovine tuberculosis. The resistance so produced was transient, however, and lesions of the udder in cows were sometimes responsible for the presence of virulent bacilli in the milk. The practice was therefore abandoned.

Since B.C.G. is claimed to immunize in a somewhat similar way—by producing slight lesions which are harmless and finally disappear—it is important that in the early stages of an investigation involving its use no attempt should be made to draw general conclusions. Certain observations may nevertheless be recorded regarding the experiments made to date in this investigation.

Up to the present 200 calves have been vaccinated with B.C.G., 50 of these a second time. No appreciable rise in temperature followed vaccination. The growth and development of all animals was apparently normal. No other lesions were produced than those at the site of the inoculation, and even these lesions gradually retrogressed and disappeared. From these lesions it has not been found possible to produce lesions in guinea pigs, which are very susceptible to tuberculosis. Some investigators have claimed that such lesions in guinea pigs can be produced.

In order to determine the degree of immunity conferred by B.C.G., groups of calves have been divided when a few days old into two sections. One section only has been immediately vaccinated, then both sections have been fed on milk containing active tubercle bacilli and have been allowed to mingle with animals suffering from tuberculosis. At the ends of periods varying from a few months to about a year these animals have been slaughtered and the carcasses examined. In other cases inoculation with tuberculosis bacilli was made. In one experiment the calves were not exposed to infection until two months after vaccination, in order that sufficient time might be allowed for the building up of resistance in the system, if this be necessary. These sections given parallel treatment contained from four to sixteen animals each, numbers too small to justify conclusions as to the value of the treatment, but it may be noted that in each experiment there was less evidence of tuberculosis among the vaccinated than among the unvaccinated animals. Only in the last experiment, in which sixteen vaccinated animals and seven controls were used, did none of the vaccinated animals show any evidence of tuberculosis.

It should be noted that the animals vaccinated with B.C.G. reacted when subsequently given the tuberculin test. These preliminary tests of B.C.G. have afforded ample encouragement for a continuation of the experiments on a larger scale.

—*(Investigation under the direction of Dr. A. C. Rankin, University of Alberta.)*

Tuberculosis Research at the University of Montreal

Vaccination with "B.C.G."

The committee was fortunate in being able to secure for a part of the year under review the services of Professor A. Pettit, who was previously associated with Prof. A. Calmette, in his work on tuberculosis at the Pasteur Institute, Paris. This was of special importance in view of the decision to try, for the first time in Canada, vaccination with B.C.G. Professor Pettit brought with him Professor Calmette's recommendations on the preparation and use of this vaccine, and these have been carefully followed throughout.

B.C.G. vaccine is administered as soon as possible after its preparation by feeding with milk, doses being given on each of the third, fifth and seventh days after birth. Up to date 176 babies have been so vaccinated. Of these, four are in contact with an active case of tuberculosis. No ill effect has been observed in any case. These children will be closely observed in order to determine the extent of the immunity conferred, if any, and its duration.

Reactions following Intrapleural Injections.

Several investigators have recorded their observations after injecting various chemicals into the pleurae of the lungs of animals. It has seemed worth while to extend this series of experiments to other chemicals, and to determine their effect upon the pulmonary structure.

The animals used in these experiments were guinea pigs. Injections of several coloured organic compounds were made, and after periods varying from twenty-four to seventy-two hours the animals were killed and detailed examinations made. It has been found possible to thus modify materially the pulmonary structure.

Chemical Researches

A number of hospital patients in the early stages of tuberculosis were subjected to examination. In all cases the basal matabolism was normal. This is in accordance with the findings of other investigators. Further observations will be made.

Acidity tests were made on cerebro-spinal fluids and on culture media from the bacteriological laboratory. Each pH determination was made by at least two experimenters, colorimetric methods being used. It was found that the normal pH of cerebro-spinal fluids is about 7.3, but that this figure increases rapidly within half an hour, requiring immediate determinations in order to secure correct results. Owing to this difficulty it has been decided to train a number of young doctors in the technique, in order that they may make tests whenever the opportunity arises. This will greatly increase the number of observations.

The sulphur content of the blood of thirty-one patients suffering from tuberculosis in an advanced stage has been determined. There was noted an increase in the sulphur content in 77 per cent of these cases. It does not appear possible, however, to determine the advance of the disease by means of the ratio of neutral to that of total sulphur.

Future Work

In addition to continuing the important investigations already begun, it is planned to carry out an epidemiological study in a given area by the application of health methods of known efficiency. An effort will be made to determine the methods of infection of humans with both human and bovine tuberculosis. Experiments will also be made to determine the ages at which infection occurs in humans.

—(Investigation under the direction of Dr. T. Parizeau.)

Tuberculosis Research at the University of Toronto

Through the co-operation of the Health of Animals Branch of the Dominion Department of Agriculture there have been obtained for investigation a number of tuberculin-positive cattle,—that is, those which had reacted previously to the test used by the Government in the accredited-herd plan. Five of these animals were slaughtered about four months after being received; the remainder are still under observation.

From ten to fourteen samples of milk, taken at varying intervals from each cow, were examined for acid-fast bacilli. These samples of milk were then centrifuged and guinea pigs were inoculated with a mixture of the cream layer and the sediment. Acid-fast bacilli were found in two or more samples of milk from each cow. By the inoculation of guinea pigs tuberculosis developed in only three instances.

Serological tests were made at six different intervals in order to determine what effect, if any, a general tuberculin reaction might have on the serological findings. It was found that the first triple test had rendered the animals refractory to tuberculin. On two occasions tuberculin was injected in amounts which it was thought would be sufficient to induce a systemic reaction, but both injections failed to do this.

The five animals were finally slaughtered and carefully examined for evidences of tuberculosis, both by members of the university staff and by the veterinarians appointed by the Dominion Government for that purpose. Three of the cows showed definite lesions either of the lymphatic system alone or in addition lesions of the viscera. One cow showed only a calcified gland and in the fifth no lesion could be detected. Emulsions made from the bronchial and mesenteric lymph nodes of the last two and injected into guinea pigs and rabbits gave negative results.

Human Tuberculosis

Through the Hospital for Sick Children in Toronto a study was made of the types of recovered strains of bacillus tuberculosis. The morphological, cultural and biological characteristics have been noted in each case, but rabbit virulence has been taken as the point of chief distinction between human and bovine tuberculosis.

Bovine strains were isolated in seven cases, all of which were in children under 14 years of age. These strains were isolated from various sources, including the lymph glands, mastoid process, knee-joints and sputum. Of these strains the lymph glands of the neck were the most common site of involvement. Up to the present no tuberculous lesions of bovine type have been found in adults. Human tubercle bacilli were isolated from thirty different cases, these also being under fourteen years of age.

—(Investigation under the direction of Dr. O. Klotz, Department of Pathology, and Dr. J. G. FitzGerald of the Connaught Laboratories.)

Tuberculosis Research of the Dominion Department of Agriculture

Details of this work will not be given here, since it was carried out by the Health of Animals Branch of the Department of Agriculture without financial assistance from the National Research Council. The results have, however, been made available to all those engaged in this co-operative research.

A study of the chemical nature and properties of tuberculin has been in progress for some years, and an attempt is being made to isolate its active principle. Considerable attention has also been given to the study of infection with the avian type of tuberculosis. Recently a series of experiments has been started to determine the effect of vaccination of calves with B.C.G.

Associate Committee on Storage of Fruit in Warehouses

Co-operating Organizations:

Federal Department of Agriculture.
Nova Scotia Department of Natural Resources.

During the year a request was received by the National Research Council from Hon. J. A. Walker, Minister of Natural Resources in the Province of Nova Scotia, asking for co-operation with a committee of his department in an investigation of fruit storage and dehydration in that province. As a result of this request there was appointed the Associate Committee on Fruit Storage, under the chairmanship of President A. S. Mackenzie of Dalhousie University, and with representation from the council and the Dominion Department of Agriculture. A grant was made to the committee by the council, and an investigation was immediately started, in order that a study might be made of operations during the whole fruit season.

The first year's work has been of a preliminary character, the object being to ascertain under what conditions apples are being kept in the Annapolis and Cornwallis valleys. An attempt has been made to determine temperatures within and in the neighbourhood of typical warehouses; humidity inside and outside the warehouses; air circulation through the warehouses and the effect of storage under different conditions on the maturity of apples. The investigation has been carried out under the supervision of Mr. W. S. Blair, Superintendent of the Dominion Experiment Station, Kentville, N.S.

The practice in apple storage has been studied in two warehouses at Port Williams and two others at Berwick, N.S. The local fruit companies generously co-operated in the research and gave the committee an opportunity to study their conditions of storage.

Temperature records were obtained by maximum and minimum thermometer readings being taken inside each warehouse and also outdoors. Humidity determinations were taken with sling psychrometers and also with a recording psychrometer. An anemometer was used for determining the air velocity through ventilators. Wind velocity was obtained from the station at Wolfeville near Port Williams. Maturity tests were carried out with a Magness and Taylor pressure tester, a barrel of each of several varieties of apples being placed in different warehouses where pressure tests were made at intervals.

No artificial refrigeration was used in these warehouses and it was consequently the object to maintain the temperature as low as possible by means of ventilation. The temperatures inside the warehouses did not fluctuate over as wide a range as those outside, but the average temperature during the twenty-four hours was nevertheless slightly higher. It should be possible with adequate ventilation to maintain the temperature inside appreciably lower than that outside with a consistently low maximum daily temperature.

Air circulation is the chief means of temperature control in use. In addition to regulating the temperature it influences to a considerable extent the humidity and carbon dioxide content of the air. With natural circulation the velocity of the wind is an important factor. The circulation as recorded by the anemometer was considerably lower than that necessary to secure the best conditions.

Maturity tests did not show wide variations in the different storage rooms, since temperature conditions and humidities varied but slightly.

This study of present practice reveals the fact that considerable improvement is possible by modified methods. Warehouse construction should be changed by reducing the number of windows or eliminating them altogether and by providing ventilators of proper size and shape and ducts for the distribution of air through the storage rooms.

Temperature control has been maintained entirely by natural ventilation, but much better results could be secured with artificial ventilation. During the night, when the temperature outside falls rapidly, circulation should be increased. This is not always possible, however, with natural circulation, since at such times the wind normally falls somewhat and the circulation is thereby reduced. Fruit should not be admitted to the warehouse except when the temperature outside is approximately as low as that inside.

The Department of Natural Resources of the province of Nova Scotia is already planning to make use of the information obtained in this investigation to educate the fruit industry to better practice in apple storage.

It is hoped to continue the investigation for another season, when the observations of present practice will be continued and an effort will be made to effectively control conditions in one or more warehouses, without radical changes in construction, in order that the most favourable temperature and humidity possible may be obtained.

Associate Committee on Magnesite

Co-operating Organizations:

Dominion Department of Mines.
Dominion Forest Service, Department of the Interior.
North American Magnesite Company.
Scottish Canadian Magnesite Company.

Extensive deposits of magnesite, the native carbonate of magnesium, occur in the Grenville district of the Province of Quebec. Associated with the magnesite, however, are certain impurities which require partial elimination in order to satisfy the demands of the trade for magnesite to be used as a refractory material. In ordinary practice the impurities are reduced by cobbing and hand sorting in the pits and by repicking the rock after a preliminary crushing operation. Unfortunately some of the impurities closely resemble the magnesite in appearance, and much of the latter is discarded with the former, resulting in an increased cost of production per ton of good rock and an unnecessarily rapid depletion of the magnesite reserves.

When the co-operating magnesite companies approached the Dominion Government for assistance in the solution of their difficulties, the National Research Council was asked to undertake an investigation of the whole question. The Associate Committee on Magnesite was accordingly formed to study the various technical problems involved, and research was started, in close co-operation with the Dominion Department of Mines, in an effort to devise new methods of utilizing the Grenville magnesite. Several distinct lines of investigation have been followed.

The first problem undertaken was the separation of the magnesite from its associated impurities, the aim being to secure a good recovery of magnesite

and a satisfactory elimination of impurities by mechanical or chemical methods which would be cheap and efficient in commercial operation. The chief contaminating minerals are dolomite, a double carbonate of lime and magnesia, and serpentine, a hydrous magnesium silicate. Advantage was taken of the observed fact that magnesite is decomposed when heated to about 700 deg. C., forming a soft and friable magnesia, while at this temperature the dolomite and serpentine are not radically altered. The method devised consists in calcination of rock crushed to about half-inch size at approximately the temperature noted, followed by light selective crushing to break up the soft magnesia without unnecessarily reducing the size of the dolomite and serpentine constituents, and with subsequent screening to separate the coarse and fine material. Laboratory tests indicate that this method can be applied on a commercial scale at moderate cost, and with an average recovery of more than twice that previously obtained from a given tonnage mined. Patents have been applied for on the process as outlined. This work was begun in the laboratories of the Mines Branch by men employed by the committee, and was later carried on in the council's own laboratories.

Semi-commercial tests of the above method will shortly be tried in the full-sized kilns of the co-operating magnesite companies in order to determine the approximate cost of operation and the feasibility of using rotary kilns for low-temperature calcination of the magnesite rock. An effort will also be made to devise uses for the reject from the purification tests.

The use of Canadian magnesite in the manufacture of refractory brick has also been investigated. Such brick have in the past been made almost exclusively from Austrian magnesite, the methods of manufacture ordinarily used not having produced a satisfactory brick from the Canadian material. This has no doubt been due, in part at least, to the percentage of lime in the Canadian magnesite, but since lime is itself very refractory and also basic in character there seems to be no sufficient reason why such a material cannot be used.

The primary difficulty in the use of lime-bearing magnesia is caused by the fact that lime is fairly active chemically. It may of course be possible by a purification process to reduce the lime to a point where it will not be detrimental, but it will be commercially advantageous to include a reasonable amount of lime, and the chief effort has therefore been made to render the lime inactive. A ceramic engineer employed by the committee has been carrying on this work in the ceramic laboratories of the Department of Mines.

In making sample brick from the regular run of Canadian magnesite, trouble was encountered from cracking and from soft spots which crumbled readily to dust. The former trouble was probably due to a partial slaking of the lime in the magnesite, and the latter to the formation of di-calcium silicate. The former trouble may be overcome by a treatment which will render the lime inert, or by the use of a non-aqueous binder, the latter by regulating the composition of the magnesite and by very thorough mixing.

In ordinary practice the magnesite is converted into a clinker suitable for use as a refractory by mixing with a percentage of iron oxide and burning at a very high temperature. In experimental work the iron has been replaced wholly or in part by other stabilizing agents, and success has been attained in rendering the lime inert. It has also been found possible to accomplish a similar result by modifications in the regular method of burning the clinker, using iron oxide. No conclusion has yet been reached as to the best commercial method, but it is hoped by further experimental work, utilizing a variety of binders, to produce magnesite brick of satisfactory quality.

A considerable part of the magnesite sold is now used in open-hearth steel furnaces, where it is mixed with slag and sintered into a bottom of more or less permanent character. At intervals considerable patching is required, and some-

times a whole bottom has to be replaced. The troubles encountered are apparently due in great measure to the fact that the bottom is not a monolithic one, but consists of very refractory particles of magnesite cemented together with readily fusible slag. It has been thought possible to work out methods of manufacture of a refractory which would soften sufficiently at open-hearth furnace temperatures to form a monolithic lining without any admixture of slag. If this can be done it should be of very real service to the steel industry. An investigation with this object in view has been started, but is still in its initial stages.

Some magnesia is used in the pulp and paper industry in the production of a solution of magnesium bisulphite for the manufacture of sulphite pulp. Some investigators have claimed that marked advantages are obtained by the use of solutions of magnesium bisulphite in place of the corresponding calcium salt. The Forest Products Laboratories of the Dominion Government are investigating the advantages of the two compounds and have asked the committee to determine the best methods of preparing magnesium bisulphite liquors, and particularly whether these liquors can be satisfactorily produced in the towers now so commonly used in the industry. This problem is now being studied.

In connection with the magnesite investigation it has been found necessary to make careful observations of the operating practice of the co-operating companies. This study has enabled the research staff of the committee to make suggestions which have resulted in appreciable operating economies.

Extensive deposits of hydromagnesite have for some years been known to exist in British Columbia. Attempts have been made in the past to find commercial uses for this material, but so far without much success. Recently the National Research Council has been asked to study the problem and endeavour to work out methods for the utilization of hydromagnesite. This work has been assigned by the council to the committee and an investigation will shortly be started.

Associate Air Research Committee

Co-operating Organizations:

Royal Canadian Air Force, Department of National Defence.
University of Toronto.

Two meetings of this committee were held during the year under review. Reports of progress were received and plans were made for a further program of research.

The work on the Turnbull Variable Pitch Propellor has ben completed, the experimental propeller constructed by Messrs. Canadian Vickers having been tested in flight with satisfactory results. The design has proved mechanically sound and serviceable, and would appear to have distinct possibilities for commercial use.

Several important investigations have been completed by Prof. J. H. Parkin and his staff, and have been published by the University of Toronto as Bulletin No. 7 of the School of Engineering Research. These are:—

Aeronautical Research Paper No. 17—Research on Channel Wall Interference. This study deals with the effect of the walls of the wind channel on the measurements of angle of incidence, drag, etc., so that these can be applied to aircraft in an air-space infinitely extended in all directions.

Aeronautical Research Paper No. 18—Pressure Distribution over U.S.A. 27 Aerofoil with Square Wing Tips. The information in this paper is of value for aircraft designers using this excellent section, either in monoplanes or in biplanes.

Aeronautical Research Paper No. 18a—Pressure Distribution over Goettingen 387 Aerofoil with square wing tips. This investigation is similar to the above, and deals with another thick section having good aero-dynamic characteristics.

Aeronautical Research Paper No. 19—Biplane Investigation. This research was made to determine the influence of biplaning, stagger, and gap for the sections Airscrew 4, U.S.A. 27 and Goettingen 387 for use in the design of aircraft for Canadian service.

Another important investigation, that on rotary derivatives, the results of which are needed for the design of a new type of seaplane for the R.C.A.F., has unfortunately been delayed on account of the difficulty in sparing time from the teaching duties of the experimenting staff at Toronto. Efforts are being made to remedy this condition.

Dr. Eve, at McGill, has made an investigation regarding the position in the electro-chemical series of a number of alloys, including duralumin, the results of which have proved valuable in connection with the avoidance of corrosion in flying boat and seaplane construction. The experiments are being continued.

Work is being carried out by Dr. W. A. Keys, at McGill, on a piezo-electric method of determining pressure variations in the cylinders during the operation of internal combustion engines. This research has been directly assisted by the National Research Council and is reported under Assisted Researches.

The committee was further strengthened during the year by the addition of Major W. A. Steel, Dr. R. W. Boyle, and Mr. W. T. Reid.

Associate Committee on Engineering Standards

The Canadian Engineering Standards Association is now operating under the jurisdiction of the National Research Council, the Main Committee of the C.E.S.A. being known as the Associate Committee on Engineering Standards of the Council. Operations up to March 31, 1926, were carried on with an acting secretary, Prof. W. F. McKnight, but on April 19, 1926, Mr. B. Stuart McKenzie, M.E.I.C., was appointed full time secretary, his appointment being confirmed by the C.E.S.A. Executive on January 24, 1927. The work of the association received a very severe set-back on account of the uncertainty as to its future during 1925, and special efforts have therefore been made to revive interest in its affairs, especially among industrial interests. The return of Mr. H. H. Vaughan to the chairmanship of the Executive Committee has greatly stimulated the activities of the association.

Organization

The work of the association is carried on under the supervision of its Main Committee, which consists of forty-eight members representing industrial organizations, universities, various Government departments, technical associations, consulting engineers, etc. There are eight sectional committees, each covering one particular engineering field, and under these the detailed work is carried on by sixty-seven special committees and panels. The administration of the association is in the hands of an Executive Committee, consisting of the chairman, two vice-chairmen and an honorary secretary. All members of these various committees and panels give their services without remuneration of any kind. The secretary and staff at Ottawa are the only paid officers of the association.

Publications

During 1926 only one publication was issued, this being A19-1926, "Standard Classification of Items of Highway Expenditure", making nineteen publications issued since the incorporation of the association in 1919.

The first Year Book of the association was issued in January, 1927. This book gives the history of the association since its incorporation; details of its organization, a brief description of the projects on which it has been working, and a list of co-operating bodies who have appointed representatives on the various working committees. It has been widely distributed and very favourably received and commented on.

Work in Hand

Civil Engineering and Construction

Movable Bridges.—Draft of this specification is now in galley-proof, and will be submitted for the approval of Bridge Committees, Sectional Committee and Main Committee.

Concrete and Reinforced Concrete.—The majority of reports from the various panels have been received by the chairman and will be considered by the committee.

Reinforcing Materials for Concrete.—A recommended list of bars, giving a much simplified range of sizes and shapes, has been approved and added as a supplement to Standard Specification No. A9-1923.

Road Materials and Construction.—Final drafts of specifications for block pavement, concrete roads, broken stone roads and sand clay roads, have been prepared and drafts for other classes of roads, road structures and definitions of highway terms are being prepared.

Steel Railway and Highway Bridges.—Revisions to existing specifications are now being considered, these covering silicon steel, increased allowable unit stresses, highway loading, etc.

Steel Structures for Buildings.—Consideration is being given to proposed increase in allowable unit stresses.

Mechanical Engineering

Machine Screws.—A simplified list of screws has been prepared and when approved will be recommended to users, the object being to eliminate sizes subject to infrequent call, and thus relieve the manufacturers of the necessity of making and storing unnecessary sizes.

Sheet Metal Gauges.—An effort is being made to stabilize the gauge situation, especially as it concerns sheet metal, by obtaining official recognition of the gauge now predominant in the sheet metal trade. A memorial will be presented to the Dominion Government by the sheet metal interests.

Cast Iron Pipe.—Draft specification has been circulated for comment from the committee, and a meeting will be held shortly to consider same.

Electrical Engineering

Western Cedar Poles.—Draft specification is being held, awaiting report from committee of the American Engineering Standards Committee.

Rating and Testing of Electrical Machinery.—Reports from panels on large power rotating machinery and on transformers have been received and a report on rotating machinery under ordinary conditions is expected shortly.

Transformers.—Revisions to Standard Specification No. C2-1920, Distribution Type Transformers, have been considered, and a final draft has been

prepared and will be submitted for approval to the Sectional Committee and to the Main Committee for approval to publish. Data for specification on power transformers are being secured.

Control Cable and Colour Code.—First draft of specification has been prepared and will be discussed by the committee shortly.

Canadian Electrical Code.—Draft code has been prepared and was discussed in May last year and revisions approved. Further revisions in line with those in the National Code are now being made and preparations for a meeting in Winnipeg are under way with the object of approving at least a tentative code which can be published at once.

Automotive Work

Traffic Signals for Highways.—Final draft has been approved by the committee and submitted to the Sectional Committee. Certain revisions, however, have been suggested and further action has been deferred until these points have been settled.

Ferrous Metals

Heavy Steel Castings.—Draft specification has been prepared by a panel of the committee and will be submitted for comment shortly. This specification will cover clauses dealing with heat treatment and testing in more detail than usual.

Sampling for Check Analysis.—Draft specification has been prepared and will be submitted to the committee for comment.

Forging Quality of Bar and Billet Steel.—Draft specification has been prepared and will be sent to committee for comment.

New Work

Standardization of Brick Sizes.—At the Annual Convention of the Canadian National Clay Products Association, held in Toronto in February, 1927, the Secretary of the C.E.S.A. was asked to give a talk on industrial standardization. A resolution was passed at the convention recommending that Canada standardize on sizes now in use in the United States, and the C.E.S.A. was asked to take the matter up. A representative conference was held at Ottawa in March, 1927, at which the resolution made in Toronto was unanimously approved and a C.E.S.A. committe was nominated to prepare a specification to cover. Official approval of the resolution is now being obtained from the various bodies represented at the conference. It is expected that this movement will open the way to standardizing work on other forms of building material.

Coal Sampling and Analysis.—Suggestions have been made that a committee be appointed to look into these questions and discussions with representatives of the Fuel Testing Department of the Dominion Government and the National Research Council have been held. This matter is being actively discussed in the United States and the association has been asked to appoint representatives to act on American committees.

Finances

Funds have been supplied by grant from the National Research Council in accordance with arrangement made in 1925. A campaign for financial support from industry was inaugurated in February, 1927, in order to meet the conditions specified in the above arrangement. Results of the campaign have been

encouraging, the sum of $2,725 having been obtained at the end of March. The campaign is being actively pushed and it is hoped to attain the objective of $5,000.

Publicity

Co-operation on the part of the technical press and newspapers has been most encouraging and items covering meetings of committees, reviews of the Year Book and other matters have appeared frequently. Special articles have been written and published in "Industrial Canada", the official publication of the Canadian Manufacturers' Association, and in the Royal Bank Bulletin, the latter having been copied in several papers.

The chairman addressed a meeting of the convention of the Association of Canadian Building Industries in Ottawa in January and the secretary gave a talk to the Clay Products Association in Toronto in February.

General

The offices of the association were moved to the Bryson Building at the end of January, 1927, the National Research Council having moved to the same building at the end of 1926.

Associate Committee on Accurate Plot Work

Co-operating Organizations:

Dominion Department of Agriculture.
Macdonald College.
University of Alberta.

In testing different varieties of grain for yield the common practice has been to sow all at the same rate per acre irrespective of differences in size of kernel, per cent germination, or tendency to tiller. Since varieties differ considerably in the above characteristics the question has been raised as to whether or not the rate at which a given variety should be sown should take these variations into account. This question has been investigated previously in certain institutions, but it has been felt that the results were not generally applicable.

In order to obtain information which might lead to some definite conclusions it was decided to investigate the question at several widely separated institutions, tests running concurrently over a period of three years. The same seed were used and identical methods were followed in each case.

An invitation to participate in this investigation was issued to a number of experimental stations throughout Canada. This invitation was accepted by eight, of which the following four succeeded in carrying out the work in full detail for the three-year period; the University of Alberta, Edmonton; Experiment Station, Scott, Sask.; Macdonald College, Quebec; Experiment Station, Charlottetown, P.E.I.

The varieties of oats used in this experiment comprised the following:—

(1) Banner, characterized by medium-sized seed and medium tendency to tiller.
(2) Daubeney, characterized by small seed and relatively high tendency to tiller.
(3) Abundance, characterized by rather large seed and a low tendency to tiller.

All seed were supplied from the Central Experimental Farm, Ottawa, during each of the three years. The weight per 1,000 kernels and the per cent germination were determined in each case.

The field plan called for plots 18.5 feet in length and consisting of nine drills each. At harvest time one foot was removed from each end of all plots so that each plot as harvested was exactly one rod long. The drills were spaced seven inches apart, except at Macdonald, where they were spaced one link apart. At harvest time the outside row of each of the above plots was discarded. The central row was harvested separately. The per cent tillering and per cent stand for the plot were based on results actually obtained from this row. The remaining three rows on each side of the above central row were harvested as separate three-row plots.

Each of four different rates of seeding for each of the above three varieties occupied eight of the above nine-row plots, making sixteen three-row plots at time of harvest. Every second nine-row plot was sown at a constant rate per acre. By this arrangement each of the three-row plots adjoined a check plot of similar size, thus making possible a direct comparison between check and rate plots.

The most important observation recorded in this investigation is that the number of plants produced per acre, even from the same seed, may vary greatly from station to station and from season to season, quite independently of the per cent germination as determined by laboratory tests. This lack of a direct relation between the per cent germination and per cent stand of plants obviously minimizes the importance of taking the former into account when calculating the amount of seed to sow per acre in the case of different varieties being tested by yield. It follows also that differences in size of seed may also be disregarded to a considerable extent.

No other general conclusion has yet been reached from a statistical analysis of the mass of data resulting from these experiments. The study of the figures available will, however, be continued for some time in order that it may be possible to take full advantage of all the information which may thereby be obtained.

Associate Committee on the Heating and Insulation of Buildings

Co-operating Organizations:

Dominion Fuel Board.
Federal Department of Agriculture.
Federal Department of the Interior.
Queen's University.
University of Saskatchewan.
University of Toronto.

The subjects of heating and insulation are of particular importance in Canada, due to the cold climate and the nature of Canadian fuel problems. The Dominion Fuel Board has for some years been dealing with certain phases of these subjects in co-operation with the Natural Resources Intelligence Division of the Department of the Interior. The chief object of this work has been to consider the questions of heating and insulation from the economic point of view and to bring the information collected to the attention of contractors, builders and the general public.

There has been formed during the year under review an Associate Committee on the Heating and Insulation of Buildings, with representation of the organizations named and also of the Cold Storage Branch of the Dominion Department of Agriculture. To this committee has been assigned the task of co-ordinating the work which is under way and of extending it to a study of the research problems involved. Several of the laboratories of Canadian universities have for some years been engaged in research on insulation and the work of these laboratories is now being extended through the provision of special apparatus for the purpose of carrying out specific investigations.

A bibliography on insulation has been prepared by the staff of the National Research Council in co-operation with the staff of the Natural Resources Intelligence Division and the information thus obtained has been made available to members of the committee and to certain others who are specially interested in this subject.

Attention has also been given during the year to inquiries received regarding the value of insulating materials now on the market. An effort has been made to provide prospective builders with such information as would be required by them to properly insulate their houses. The possible saving by the adoption of these up-to-date methods is very great. It has been estimated that if all Canadian residences were insulated it would mean a saving of at least $30,000,000 annually in Canada alone.

Associate Committee on New Brunswick Forest Problems

Co-operating Organizations:
Federal Department of the Interior.
Provincial Forest Service, New Brunswick.

The work carried on by this committee is a co-operative investigation of methods of reforestation in New Brunswick, undertaken in conjunction with the Forestry Branch of the Dominion Department of the Interior and the Department of Lands and Mines of the province of New Brunswick. The year under review is the fourth in which methods of reforestation were investigated on cut-over and burnt-over areas of considerable extent.

This investigation, as far as establishing new areas was concerned, was completed during the 1925 season. Only work of checking was carried out during the season of 1926.

The findings of 1925 were sustained on this examination, that is, on older burns, already reproducing to intolerant hardwoods which could act as a nurse crop, or areas with a dense stand of dead trees which provide shade for the seedlings, the method was very successful.

Areas at Tabusintac, sown in 1923, under a dense stand of spruce, killed by the fire of that year, are very successful, showing a catch and survival of 75 per cent to 90 per cent of the spots sown.

At Weaver's Siding, where seed-spotting was done under an established small growth of intolerant hardwoods, the catch averaged about 80 per cent for spruce. The pine planted here, as on other areas, was a failure. This is due apparently to the larger seeds being picked up by the birds and rodents. Poisoning with red lead did not prevent the birds and rodents from picking up these seeds.

The areas planted at Betts Mill Stream and near Five Mile Bridge were similar to those at Weaver's Siding and show a very satisfactory catch.

On areas such as those at McGee's and Coulter's, that had been burned over several times and were devoid of hardwood reproduction that might act as a nurse crop, the results were not satisfactory. Here the percentage catch ran from 20 per cent to 60 per cent of the spots sown. In some cases the areas showed as high as 2,000 seedlings per acre, but these were not sufficiently distributed to give a final complete stand.

At Mavis Mills all skidding trails on an area of about 50 acres were seeded broadcast. The results here were highly satisfactory. It is an interesting fact that no coniferous reproduction has been established except where seed were sown.

So far, the results show that seed-spotting can be done successfully on areas where a nurse crop is established or where shade is supplied by standing dead trees or debris.

Associate Committee on Helium

Co-operating Organizations:

Federal Department of Mines.
Federal Department of National Defence.
Ontario Department of Mines.
British Air Ministry.
University of Toronto.

In the Annual Report of the National Research Council for the year ending March 31, 1926, a full account was given of the situation which led to the establishment in 1924 of an Associate Committee on Helium and the negotiations which had taken place prior to the beginning of the year under review with the object of setting up a helium extraction and gas research station near Inglewood, Ont., were fully outlined.

Early in the year under review the Council received through the Department of National Defence a communication from the British Air Ministry relating to the proposed transfer of the helium extraction plant which had been erected at Calgary under the direction of Prof. J. C. McLennan with funds supplied by the Air Ministry from Calgary to Toronto and advising that the Air Ministry are in agreement with the terms of the proposed transfer as suggested by the National Research Council, the plant to be vested in and operated by the University of Toronto and the extraction and other researches to be carried out with the advice and direction of the Associate Committee on Helium of the National Research Council. The Air Ministry, however, requested confirmation that the Air Ministry would be enabled to purchase helium so produced at cost price for any purpose they may deem necessary.

On consideration of this request, it was the consensus of opinion of the National Research Council that the British Air Ministry should be furnished upon request with a supply of helium commensurate with the amount of helium produced and the contribution made by the Air Ministry toward the operation and maintenance of the proposed helium extraction plant.

At the close of the year under review the chairman of the committee was able to report that one additional well had already been sunk in the Inglewood district and that another was under way, with the object of definitely determining the volume and extent of helium bearing gas in the Inglewood district, and that satisfactory progress was being made.

Associate Committee on Nitrogen Fixation

During the year under review there has been no meeting of the committee, but its work has been continued along the lines previously followed.

The chief activity of the committee has for some years been in connection with the compilation of information on nitrogen fixation and closely related subjects. This work has been carried out under the supervision of the chairman by Mr. A. S. L. Barnes, and has also received the consideration of the individual members of the committee. Report No. 11 has been issued during the year, and considerable material has been collected for a subsequent report.

These reports, as previously, comprise a general review of the progress made in nitrogen fixation in all the important countries of the world. The new and improved technical processes are outlined and new plants projected or constructed are described. Consideration is given to the use of nitrogen and nitrogenous products in the industries. Special attention has been paid to the nitrogenous fertilizers, since these absorb a very large proportion of the total nitrogen. Other fertilizers have been treated briefly in their relation to nitrogen.

The world production of nitrogen has for some years been increasing rapidly, with a marked decrease in price. From present activity in the con-

struction of new plants and the intense competition which has developed in the world's markets it may be anticipated that these trends will continue for some years, to the great advantage of the agricultural industry. As the prices of fertilizers decrease their use will play an ever-increasing part in the production of food-stuffs throughout the world.

Not many years ago the Chilean nitrate fields produced more than half of the world's nitrogen. To-day the situation is completely changed. Nitrogen fixation by artificial methods now accounts for nearly half of the total. Nitrogen from coal amounts to something more than a quarter and Chilean nitrate to a little less than a quarter of the world's production.

Amongst the various synthetic methods the ammonia process alone is making any rapid advance. New plants utilizing one of the three or four modifications of this process are under construction in most of the important European countries and the United States. Other synthetic processes are at a standstill or are on the decline.

In Canada no new developments have taken place. Aside from the one large plant which has been in operation for some years there is no nitrogen fixation here, but a number of large companies are known to be watching the situation closely. Unfortunately Canada is not a very large user of nitrogenous fertilizers, and no great plants could be operated without a further development of the export trade.

During the year the committee has published the bulletin "Nitrogen in Industry". This has been very favourably received, and a large part of the bulletin has been copied by one of the British chemical journals.

The information compiled by the committee has been made considerable use of by the council in answering inquiries regarding commercial fertilizers and methods of nitrogen fixation.

Associate Committee of Chemists

The ninth annual meeting of the committee was held in Montreal on June 4, 1926, with sixteen members of the committee in attendance. In addition to the members, Dr. A. G. Huntsman, Assistant Professor of Marine Biology at the University of Toronto and Director of the Atlantic Biological Station of the Biological Board of Canada, was present by invitation.

The chairman of the committee, Dr. R. F. Ruttan, the Dean of the Faculty of Graduate Studies at McGill University, occupied the chair and in his opening address he outlined fully to the committee the activities of the National Research Council during the past year and distributed certain lists and statements regarding that work which he considered to be of special interest to the committee. The chairman also reviewed the various accomplishments and problems which had been given special consideration by the Associate Committee of Chemists during the previous nine years.

Following the chairman's remarks, Dr. A. G. Huntsman addressed the committee on chemical problems of fish curing. Dr. Huntsman called attention to the fact that this is an extremely complex and extensive subject and outlined to the committee some of the investigations which have been started and the directions in which they point.

Following Dr. Huntsman, Mr. L. H. Cole, of the federal Department of Mines, addressed the committee on the Malagash salt deposit in Nova Scotia, which is used exclusively in the fishing industry. During the course of his remarks Mr. Cole called attention to the fact that the market for salt in Canada is steadily increasing. In 1925 there were 233,747 tons of salt produced and sold in Canada, while for the same year 193,632 tons were imported, principally for use in the fisheries. There is also an estimated consumption of 60,000 tons per

year in the fisheries of Newfoundland, while St. Pierre and Miquelon require 25,000 tons each year for the same purpose. It can thus be seen that while all this market is not available to the Malagash salt deposit, there is a market of sufficient size to warrant larger operations than are at present being carried on, provided the consumers can be educated to use the grades of material available.

The next question considered by the committee was the utilization of Nova Scotia coal. This question was presented by Dr. Douglas McIntosh, of the Department of Chemistry, Dalhousie University, Halifax, who reviewed the various types of fuel now in use and indicated the steps which are being taken looking toward a more economical use of coal. He also called attention to the necessity for research work on furnaces as well as on coal, in order that definite information as to the most efficient size of flues, grates, and methods of circulation of water may be obtained, so that equipment may be devised which will give greater efficiency than is secured from present furnaces. Considerable discussion ensued, especially with reference to the utilization of coke for domestic heating purposes.

The next question considered was the manufacture of potato starch in Canada. This subject was introduced by Dr. Ruttan, who pointed out that, although a considerable amount of potato starch is used in Canada, most of it is imported from Holland and Belgium and that all Canadian factories have gone out of business except two small factories manufacturing potato starch in Prince Edward Island. The explanation of this situation seemed to be that Canadian potato starch is not of sufficiently high quality to be used in the textile business and in confectionery. Another difficulty seemed to be that corn starch can be used as a substitute, thus eliminating the necessity for potato starch. According to information received from people interested the manufacture of potato starch in competition with corn starch is only profitable when potatoes can be purchased at a price not exceeding 15 cents per bushel, but when the price rises to 20 cents the process results in a loss to the manufacturer.

Dr. Hibbert, of the Department of Industrial and Cellulose Chemistry, McGill University, addressed the committee on present and future developments in cellulose chemistry and called attention to many problems in connection with cellulose awaiting solution through research.

Dr. G. S. Whitby, of the Department of Chemistry, McGill University, addressed the committee on the question of fats as a field for research and pointed out a number of research problems related to this question, after which he expressed the opinion that a more complete knowledge of the chemistry of the fats would be of value to many industries, such as the packing house industry, the paint industry, the soap industry, the fish products and other industries.

The question of the chlorination of methane was also considered and discussed by the committee.

The committee had under consideration the question of nominations to fill the vacancies arising through the retirement of certain members under the rotation schedule adopted by the committee, with the result that the following gentlemen recommended by the committee were subsequently appointed members of the committee by the National Research Council during the year under review: Dr. Harold Hibbert, Professor of Industrial and Cellulose Chemistry, McGill University, Montreal; Dr. F. W. Atack, Dye and Chemical Company, Kingston, Ont.; Dr. A. Bruce Macallum, Professor of Biochemistry, University of Western Ontario, London, Ont.; Dr. J. W. Shipley, Professor of Chemistry, University of Manitoba, Winnipeg, Man.

Associate Committee on Mining and Metallurgy

This committee usually meets immediately following the annual meeting of the Canadian Institute of Mining and Metallurgy. This year the Institute has decided to hold joint sessions with the Second Triennial Empire Mining and Metallurgical Congress, and the regular meeting of the committee has therefore also been postponed. The committee has nevertheless been engaged in certain activities throughout the year.

The Associate Committee on Physics and Engineering Physics has recently made a survey of research problems in Canada, and those problems which have a bearing on mining and metallurgy as well as physics have been considered by both committees.

Of these problems the study of the various methods used in geophysics for scientific prospecting appear to be of the greatest importance at the present time. A review of conditions in other countries shows that in Germany particularly research in geophysics has advanced very considerably. Courses in the subject are now given in a number of the large German universities and a geophysical institute is entirely devoted to it. There is in the German language a voluminous literature on geophysics. Two monthly bulletins are being issued regularly and books on the subject are being published. It therefore seemed to the committee that as a first step the information in the literature should be collected and made available to those in Canada interested in its application. A short bibliography has therefore been prepared and this has been distributed with other information in reply to many inquiries. Information is being obtained which may be incorporated in a bulletin on the subject, should this appear advisable.

A member of the staff of the National Research Council has made a brief study of the problems of the asbestos industry. His report is to the effect that the operating companies have at present no definite problems which could readily be subjected to laboratory investigation. Considerable information has been placed on file for future reference.

The Sub-committee on Iron Ore has throughout the year kept in close touch with developments in the iron and steel industry. Methods of beneficiation of iron ore have received particular attention, since this is a problem of vital importance to Canada. Recent advances made in the United States are now being applied on a commercial scale in Japan. Members of the Sub-committee have been in close touch with the originators of this method of beneficiation and will be kept informed of all progress made.

A number of problems submitted to the committee by the National Research Council have been studied and recommendations have been made. Advice has also been given on certain technical problems regarding which the industry desired special information.

There have been added to the committee during the year Dr. C. V. Corless, Prof. A. Mailhiot, Mr. R. H. Stewart, Mr. O. E. S. Whiteside and Dr. R. C. Wallace.

Associate Committee on Physics and Engineering Physics

The ninth annual meeting of the Associate Committee on Physics and Engineering Physics was held at Ottawa on May 21 and 22, 1926, under the chairmanship of Prof. J. C. McLennan, thirteen members of the committee being in attendance. Dr. A. S. Eve, Head of the Department of Physics at McGill University, was also present by invitation.

At the request of the committee, Dr. Tory outlined the policy followed by the National Research Council in the granting of scholarships and explained the

essential difference between scholarships and assisted research grants. Dr. Tory stressed the fact that scholarships are awarded for the training of men, while research grants are awarded with the main purpose of solving problems.

Dr. A. S. Eve was then asked by the chairman to present a report on recent progress in radio. Dr. Eve dealt with such phases of the question as broadcasting, the height of the Heaviside layer, and the requirements for small portable sets for use by explorers, survey parties and prospectors. He also gave an interesting account of the Radio Station at Rugby, England, and informed the committee that this station is able to signal all over the world, reaching the Antipodes at Sydney and overwhelming strong atmospheres, and he very briefly described the equipment used by this station.

A second paper on radio progress during 1925 prepared by Mr. J. H. Thompson of the Canadian Marconi Company, Montreal, was also presented. This paper very fully covers the progress made during the year under review on such questions as broadcast transmission and reception, vacuum tubes, transoceanic telephony and telegraphy, direction finding, ship radiotelegraph equipment, shore stations, transmission of photographs, radio beacons, short wave transmission and atmospherics.

The committee gave prolonged consideration to the various phases of the questions with the result that it was decided to recommend to the National Research Council that a sub-committee on radio should be appointed. On consideration of this recommendation the council in January, 1926, appointed a sub-committee on radio of the Associate Committee on Physics and Engineering Physics, as follows: Dr. A. S. Eve, Department of Physics, McGill University, Montreal, Chairman; Dr. J. C. McLennan, Department of Physics, University of Toronto (ex-officio); Dr. R. W. Boyle, Professor of Physics and Dean of the Faculty of Applied Science, University of Alberta, Edmonton; Commander C. P. Edwards, Director of Radio, Department of Marine and Fisheries, Ottawa; Dr. L. V. King, Department of Physics, McGill University, Montreal; Prof. T. R. Rosebrugh, Department of Electrical Engineering, University of Toronto, Toronto; Major W. A. Steel, Wireless Officer, Department of National Defence, Ottawa; and Mr. J. H. Thompson, Canadian Marconi Company, Montreal.

The council also requested that Dr. Eve, as Chairman of the Radio Sub-Committee, prepare with the assistance of his committee a complete report summarizing the present knowledge with respect to radio development, the said report to be presented at the next annual meeting of the Physics and Engineering Physics Committee in a form suitable for publication by the National Research Council. The council was later advised by Dr. Eve that he had consulted various members of the Sub-Committee on Radio of the Associate Committee on Physics and Engineering Physics and that he found it impossible to undertake the preparation of a report such as suggested.

The committee then proceeded to consider in detail the list of research problems in physics awaiting solution in Canada which had been collected by the committee during the previous year. In determining the urgency for action in connection with each problem the following classification was used:—

Class 1, problems of economic importance.
Class 2, problems of scientific interest and possible economic application.
Class 3, problems of purely scientific interest.
Class 4, problems regarding which it was recommended that no action be taken.

Each of the first three classes above are subdivided as follows:—
(*a*) Problems of special importance to Canada.
(*b*) Problems involving small special investigations worthy of the support of the council, and of a class in which application for assisted researches will be welcomed.

(*c*) General investigations, mostly of problems of a world-wide significance, and which are being or will probably be investigated in many countries and by many organizations. While recognizing in many cases the importance of these problems the committee did not feel that their investigation by the council is urgently required.

On consideration of each problem, in cases where it was felt that some existing institution or organization possessed facilities for undertaking the solution of that problem, it was referred to that authority in order that it might receive attention at the earliest possible moment.

The list of problems was subsequently submitted to the National Research Council for consideration and when they had all been carefully reviewed, the council gave prolonged consideration to the question of the most effective action which could be taken in connection therewith. It was noted that the council had already undertaken researches on a number of the problems recommended by the committee and that applications for grants to assist in researches on a number of additional problems were under consideration by the Assisted Researches Committee. It was also noted that the National Research Council was indirectly assisting very materially in the solution of such problems through the scholarships which it awards annually for the training of research workers in Canada. When the question had been thoroughly discussed the council agreed,—

1. That a small committee should be appointed by the Associate Committee on Physics and Engineering Physics to select from the list of problems certain outstanding researches in physics and engineering physics which it is prepared to recommend to the National Research Council for intensive study.

2. That the council should collect all available literature in connection with the six problems specifically recommended by the Associate Committee on Physics and Engineering Physics.

3. That certain special problems which it appears could best be handled by other organizations such as the Dominion Fuel Board, the Geological Survey, the Connaught Laboratories, etc., be referred to these organizations for such action as they may find possible and advisable.

On the recommendation of the committee the following gentlemen were apointed members of the Associate Committee on Physics and Engineering Physics by the National Research Council for a period of three years, in order to fill the vacancies created in the membership of the committee through the retirement of certain members in accordance with the rotation schedule of the committee: Mr. W. P. Dobson, Hydro-Electric Research Laboratories, 8 Strachan Ave., Toronto; Mr. J. L. Clarke, Transmission Engineer, Bell Telephone Company of Canada, Montreal; Commander C. P. Edwards, Director of Radio, Department of Marine and Fisheries, Ottawa; Major W. A. Steel, Wireless Officer, Department of National Defence, Ottawa; Prof. R. C. Dearle, Department of Physics, University of Western Ontario, London.

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V. ANALYSIS OF REPORTS ON ASSISTED RESEARCHES

Many detailed reports have been received during the year of researches carried out 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 A, B and C.

The Nature of Winter Hardiness in Crop Plants

Co-operating Organization:

University of Alberta.

The development of hardy varieties of plants is of particular importance in northern countries like Canada. Ordinarily some years of exposure to winter conditions are required to enable plant breeders to determine which of newly developed varieties are hardy, and the progress of breeding researches is thereby greatly delayed. If, however, the fundamental nature of winter hardiness can be definitely determined, it may become possible by chemical analysis or other rapid method to differentiate, without actual trial, between those varieties which may be hardy and those which are not. The present investigation has been undertaken in the hope of discovering and turning to practical use nature's methods of conferring resistance to low temperatures.

Existing theories hold that the ability of hardy wheat plants to withstand freezing is due to adaptations which prevent the precipitation of the cell proteins. It was demonstrated in the early stages of this investigation that the most important single factor conferring frost resistance is the concentration of the natural sugars, and that salting-out and acidity both play a part in the precipitation of the proteins.

In general, hardy varieties of wheat contain the greatest amounts of sugar during the winter months. In November the sugar concentration reaches a maximum and thereafter falls off gradually. In an attempt to explain the disappearance of the sugars an investigation has been started of the rates of respiration of winter wheats at low temperatures. Owing to the weather conditions encountered and the technical difficulties involved it has not yet been possible to complete enough experiments to justify the drawing of definite conclusions. The indications, however, are that hardy wheat varieties respire at a slightly greater rate than the tender varieties. This is in line with the observed fact that a correlation exists between the greater reduction in sugar content and the higher catalase activity of hardy varieties. The method of test has now been thoroughly standardized and conclusive evidence may be looked for as a result of the next season's work.

It is thought that the ability of the cell contents to retain water against the crystallizing force of ice in the intercellular spaces is of considerable importance in frost resistance. Since this power is in all probability due to the quantity and quality of the cell colloids a further study has been made of the colloidal properties of the cell fluids of hardy and tender varieties of wheat. An attempt has also been made to compare the combined osmotic and inhibition pressures

of the cell fluids of hardy and non-hardy varieties by measuring the speed of hydration of hulled barley soaked in them. These results are inconclusive, but serve to point out the complicated nature of winter hardiness and the futility of expecting any single factor to show a constant relation to this property.

The opinion has been widely held that the splitting of proteins to simpler and less easily precipitated forms is an adaptation against frost injury. Some of the results obtained in this investigation, on the other hand, suggested that the splitting of the proteins might be merely a frost effect. To clear up this point a further study has been made of the effect of freezing on the proteins of the cell fluids of unhardened wheat plants. The results have shown a measureable splitting of the proteins during freezing, thus favouring the hypothesis that protein splitting is a result of frost rather than an adaptation against it.

As a result of the investigation to date it is believed that enough light has been thrown upon the fundamental nature of hardiness to make possible certain tests of practical value to the plant breeder in his task of selecting hardy varieties. The lack of constancy in physiological properties makes it inadvisable to rely on any one biochemical test and indicates that a number of points will have to be investigated in deciding the relative hardiness of new varieties of plants. The best method of arriving quickly at a reliable estimate of frost resistance is probably to harden artificially under controlled conditions the plants to be compared, and then test them by exposure to definite degrees of frost in refrigerating chambers.

—*(Investigation under the direction of Prof. R. Newton, University of Alberta).*

The Inheritance of Sugar and Starch in Corn

Co-operating Organizations:

University of Manitoba.
United States Department of Agriculture.

Year by year Canada's profitable agricultural territory is being extended farther and farther to the north. One of the most important factors in this movement is the development of early varieties of grain, which will ripen in the northern part of the country before damage by early frosts. Great success has been achieved in the breeding of early wheats, such as Garnet, which will add thousands of square miles to the area where wheat can be grown, but it has up to the present not been profitable to grow corn on the Canadian prairie. Such dent varieties as have been grown have reverted rapidly to the flint form, and have therefore lost much of their value.

This investigation was undertaken in the hope of producing, by systematic crossing, early varieties of corn which would not so revert. In order to determine the progress being made in such breeding the hybrids have been carefully analyzed for sugar and starch. In breeding, starch is a dominant and sugar a recessive factor, so the ratio of these two constituents immediately reveals the success of the crosses.

Much of the actual crossing has been done at the Iowa Experiment Station of the United States Department of Agriculture, in order to avoid the danger of the loss of an entire crop through early frosts. Two generations of many different crosses have been produced. Several selections have been made from crosses of the dent corn type which give promise of being of economic value. Some of these are of particular interest from the point of view of earliness.

—*(Investigation under the direction of Prof. H. F. Roberts, University of Manitoba).*

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The Wireworms of the Canadian Prairie

Co-operating Organization:
University of Alberta.

Wireworms are responsible for damage in every grain field in Alberta. In many fields which have been carefully examined it is believed that they have destroyed from one-quarter to one-half of the entire stand of grain. Their depredations are frequently such that farmers are obliged to reseed portions of their fields. Until about ten years ago these losses were not of a serious nature, but in the last few years the damage done by them has greatly increased. In fact, a fairly close relation has been observed between the length of time which fields have been under cultivation and the depredations of the wireworms. This serious condition may therefore be expected to become more aggravated with the passage of time, unless successful remedial measures are developed and adopted.

Pests resembling the prairie wireworms have been known in other countries for many years, and various methods have been developed to cope with them. Some of these methods have been tried in the Canadian West, but with very poor success. A study of the question has shown that this is due largely to the fact that the varieties of wireworms responsible for the chief damage in Canada are a different variety and have different habits from those commonly known in other countries.

While many varieties of true and false wireworms are found on the Canadian prairie it has been learned that the chief damage in nearly every district has been due to *Ludius aeripennis*. The life history of this wireworm has therefore been carefully studied, both in the field and in the laboratory. Since, however, this species requires several years for the completion of its life cycle it has obviously been impossible to obtain full information in the two seasons during which this investigation has been in progress.

The eggs of *Ludius aeripennis* are laid in loose moist soil during May and June, the adult females usually burrowing to a depth of five or six inches for this purpose, if conditions permit. The eggs usually hatch within a month, the time varying with the conditions. The young wireworms grow very little during the remainder of the summer, and by the following spring are still too small to do much damage. In the next two or three years, however, they may cause very severe losses to newly seeded grain, spring being the time when most feeding is done. In July they pupate near the surface of the soil, and are then in a helpless condition in which they can be readily destroyed by cultivation. Mature beetles do not emerge from their pupal cells till the following spring.

Wireworms are remarkably free from mortality due to destruction by other insects. They rarely if ever suffer from a shortage of food. Poisoned food is almost entirely ineffective in destroying them. Crop rotation, as practised elsewhere in the control of similar insects, is neither practicable nor effective. It appears that the only hope of satisfactorily checking them lies in the adoption of modified methods of cultivation.

Adult beetles of *Ludius aeripennis* cannot burrow into hard soils to lay their eggs. This fact alone is sufficient to account for the small numbers of these insects found on sod. If therefore summer-fallowing be practised to a depth of only about two inches the eggs will be deposited near the surface. These have very thin shells, and in air-dried soil collapse within a few hours. Eggs deposited in shallow soil are therefore almost certain to be destroyed in the warm dry weather frequently prevailing on the Canadian prairie. If, however, cultivation be deep, conditions are favourable for development.

The corrective measures recommended are therefore summer-fallowing of heavily infested fields, with very shallow cultivation in May and June to force the beetles to deposit their eggs near the surface, and, in late July and August, further cultivation to destroy the fragile pupae. These recommendations are, however, subject to modification, since it has not yet been possible to definitely determine what degree of soil firmness constitutes an impenetrable barrier to the adult beetle, what length of time is necessary to give the necessary degree of firmness, whether mechanical packing of the soil can be used to advantage, what combination of minimum soil moisture and maximum soil temperature the eggs can withstand, and to what depth from the surface these fatal conditions penetrate in a normal season.

Only when these facts have been determined can it be definitely stated that the cause of the increasing severity of wireworm damage has been discovered and that its reduction can be brought about by cultural methods. On account of the slow development of this insect final proof cannot be secured in a short time. The recommendations made are being followed by many farmers, however, and the results which they obtain will indicate whether the tentative conclusions already drawn are sound.

This investigation is being continued on *Ludius aeripennis* and is being extended to other similar insects, including both true and false wireworms. While these are individually of less importance they are responsible in the aggregate for a great amount of damage.

—*(Investigation under the direction of Prof. E. H Strickland, University of Alberta).*

The Generation of Electricity by Windmills

Co-operating Organization:

University of Saskatchewan.

Windmills have long been used on a small scale for the pumping of water and certain other farm purposes. In the last few years they have also been tried as a source of electricity, particularly in Denmark, Sweden and Germany. The great advantage of the development of electricity over the direct utilization of the power obtained is that the power can be stored for use throughout the twenty-four hours as either power or light. The amount of wind on the Canadian prairie is such that it seems a particularly favourable location for the extensive use of windmills for the generation of electricity, provided that the cost is not prohibitive. This investigation was therefore started to determine what power is thus available and the approximate cost at which it can be developed.

A windmill with a 10-foot propeller geared to a one-k.w. direct-current generator producing current at 120 volts has been installed, and a record is being kept of the total amount of power generated. During the five winter months during which it has been under test the monthly generation of power has varied from 80 to 200 kilo-watts, an amount ample for all light and a reasonable amount of power on an ordinary farm.

The chief cost of an electric plant of this type for farm use lies not in the original price of the windmill but in the purchase and replacement of suitable storage batteries. These have a life of not more than five years, and renewals are from 80 to 90 per cent of the first cost. A number of types of storage batteries will be tried out, in order that it may be determined which is most suitable for this particular purpose.

The investigation will be continued for some time under present conditions before attempting any new design. The advantages and disadvantages of the

present installation will be carefully studied, and particularly the relation of the battery problem to this type of service. Wind conditions must be observed over a long period, and methods of governing during particularly high winds must be developed. It is hoped that in time it may be possible to design a plant which will give satisfactory service with a minimum of depreciation.

—(Investigation under the direction of Prof. A. R. Greig, University of Saskatchewan.)

Glucosides of Plants Native to Western Canada

Co-operating Organization:

University of Manitoba.

In this investigation a systematic attempt is being made to study those plants of Western Canada which contain glucosides. Such glucosides may or may not prove to be of economic value, but this can be determined only by their isolation and detailed study. Should any prove to be of therapeutic value the cultivation of the plants containing them may be of importance.

The Bourquelot biochemical method is being used throughout in the detection of glucosides. By its use it has been shown that a number of plants in Western Canada contain glucosides, and several of these appear to be new.

During the past season a large amount of material was collected from ten different varieties of plants—the bush honey-suckle, downy lady's slipper, prairie crocus, poison ivy, snowberry, wolfberry, cranberry, small round-leafed orchis, tiger lily, and marsh marigold. Sufficient extracts of all these have been obtained for initial study, while in most cases the material available is sufficient to permit a detailed study, with a possibility of the isolation and purification of the glucoside present.

The first extract chosen for detailed study was that from the wolfberry, an extract distinctly fluorescent. Several other fluorescent glucosides are known; all belong to the coumarin class, and most of them appear to have been readily isolated and purified. The isolation of the wolfberry glucoside proved to be a most difficult task, and it has not yet been obtained in a perfectly pure condition. It is distinctly a new glucoside, a monomethoxy or monoethoxy derivative of coumarin. It appears to be pharmacologically inactive, but its coumarin derivative has yet to be studied pharmacologically.

—(Investigation under the direction of Prof. A. T. Cameron, University of Manitoba.)

The Breeding Efficiency of Animal Sires

Co-operating Organization:

University of Manitoba.

It has long been recognized by practical breeders of cattle and horses that not all sires are equally effective in begetting healthy offspring. Some animals are nearly perfect in this respect. Others leave a considerable proportion of weak and sickly offspring. A few are completely sterile. Obviously, therefore, it is of importance to breeders to secure some means, other than experience, of determining in advance the effectiveness of sires. No reliable method has heretofore existed.

In a preliminary investigation there was observed some relation between the genital effectiveness of bulls and the head length variations of spermatozoa. It was therefore decided to carry out a systematic series of tests to definitely determine the relation between these factors in a large number of bulls. The results were so encouraging that the tests were extended to include horses, but up to the present this part of the investigation has not proceeded far enough to permit of more than tentative conclusions.

Bulls

There were available for this study more than fifty perfectly sound bulls of good breeding record, twenty-one fairly good animals and twenty-four definitely poor ones. In each case the sperm head length variation was determined, and comparisons were made with the normal limits. As a result it may be stated that whenever an abnormally high coefficient of variation is shown the animal in question is an undesirable sire. This appears to be the case whether any other fault can be found with him or not. The converse is not wholly true.

Horses

The method followed in this part of the investigation is the same as that noted above. All the horses tested were race horses. They represented a wide variety of reputations both as sires and as runners. In a general way the results obtained for bulls were found to apply to horses also. The main point of difference was that there was great difficulty in separating the distinctly good horses from those which were only fair.

—(Investigation under the direction of Prof. A. Savage, University of Manitoba.)

Bacillary White Diarrhœa in Poultry

Co-operating Organization:
University of British Columbia.

Bacillary white diarrhoea is a contagious disease of an acute or chronic type. It is apparently prevalent in all parts of the country and is said to be responsible for more losses than all other poultry diseases combined. Amongst chicks it is usually acute, and results in very high mortality. Adult birds suffer from the disease in chronic form and occasionally succumb to an acute attack. In mature pullets and hens the disease is localized in the ovaries, causing many of the developing ova to become abnormal and undergo degeneration. In this way it causes heavy losses due to low productivity of eggs, and to low fertility and low hatchability of infected eggs.

There has been in use for some years a macroscopic agglutination test for bacillary white diarrhoea, and much work has been devoted to the simplification and perfection of the test, so that it can be used accurately and efficiently in the diagnosis of the disease in adult fowls. While the method is undoubtedly of value the technique employed varies widely, and markedly different results are obtained by testing blood sera in different laboratories. There is consequently great need for further research work in the standardization of the test. The present investigation was therefore undertaken to make a restudy of the whole problem and, in particular, to subject present methods and technique of the agglutination test to a critical examination.

A survey was first made to determine the prevalence of the disease in British Columbia. Out of forty-three flocks submitted for examination fifteen flocks were found with indications of bacillary white diarrhœa. In some of these flocks the losses were very heavy, and many complaints were received from purchasers of day-old chicks. The distribution of young chicks from these flocks is a matter of considerable consequence, since each flock serves as a nucleus from which infected flocks are bound to develop in different parts of the country. In one flock the infection was 85 per cent.

Hatching experiments were carried out under various conditions on eggs from reacting hens. In general, fertility was fairly satisfactory but a large number of chicks died in the shell, reducing the percentage hatched to a low

figure. A considerable number of the young chicks also died. No general conclusions can be drawn until further experiments have been completed.

Many experiments have been made in an effort to determine what should be considered the standard technique for the agglutination test. Methods used in many other places have been given a trial, and the accuracy of the results obtained has been carefully checked. Some measure of success in standardization has been attained, but much more work is required, in continued co-operation with investigators elsewhere, before the optimum conditions for making the test can be definitely stated. It is important that such standards should be secured, since the only method of control available at the present time is the testing of all breeding stock and the elimination of reactors.

Experiments are also under way to determine the relation of chilling, overheating, overfeeding and unfavourable brooding conditions to the livability of chicks from infected and from non-infected birds.

—(Investigation under the direction of Professors H. W. Hill and E. A. Lloyd, University of British Columbia.)

The Use of Ultra-Violet Light in the Poultry Industry

Co-operating Organization:

Poultry Division, Dominion Department of Agriculture.

Ultra-violet light has not yet been used extensively in the poultry industry, but some individual investigators have claimed to secure remarkable results, particularly in the treatment of young chicks. It has been definitely shown that ultra-violet light assists in bone formation, and it is thus an efficient means of preventing and treating rickets. Whether it is of sufficient importance to merit wide use in the industry has not yet been definitely demonstrated.

In this investigation the action of ultra-violet light is being tried in a rather wide field. It embraces not only its effect on young chicks but also its influence upon the metabolism of the laying hen, as shown by egg production, egg fertility and egg hatchability, as well as upon egg embryos during the process of incubation.

In a series of experiments on young chickens parallel tests were run on pens receiving direct sunlight, sunlight through ordinary window glass which removes the ultra-violet rays, sunlight through a special glass which is said to allow ultra-violet light to pass, electric light only, and sunlight through window glass supplemented by exposure for a short time each day to ultra-violet light from a quartz mercury vapour lamp. In each case a parallel test was run upon a pen in which the chickens received cod-liver oil daily, this furnishing a source of vitamines. The basal ration fed to all pens consisted of a mixed dry mash containing wheat, corn and oat meal, beef and bone meal and salt; a commercial chick scratch mixture; grit; green feed; charcoal; and milk and water to drink.

The results of this test were inconclusive. The pens under treatment by ultra-violet light showed rather high mortality and only a moderate gain in weight. Cod-liver oil produced little if any beneficial result. It is worth noting, however, that in no case was there any sign of leg weakness. This is an indication that the quantity of vitamines in the basal ration was sufficient, in which case no great improvement with either ultra-violet light or cod-liver oil could reasonably be expected. The experiments will, however, be continued over a period of years.

In the experiments tried on laying hens the pen exposed to ultra-violet light showed slightly greater productivity than the control pen. The eggs produced also showed increased fertility and hatchability. On the other hand, the mor-

tality was rather high. No conclusions will be justified without extensive tests over a period of years.

The eggs treated with ultra-violet light during incubation showed a very high evaporation of water. This resulted in many of the chickens dying in the shell. The number hatched was nevertheless higher than that in the control test. If ultra-violet light is to be used regularly on eggs provision will probably have to be made for additional humidification.

—(Investigation under the direction of F. C. Elford, Dominion Poultry Husbandman).

The Measurement of Light for Ecological Purposes

Co-operating Organizations:

Queen's University.
Biological Board of Canada.

Light is a factor of supreme importance to both plant and animal life. Its measurement, however, involves numerous difficulties, because, unlike temperature, humidity and certain other factors, it varies not only in quantity but also in quality. For example, the light from a clear blue sky at noon and that from the setting sun may be equal in total intensity, but they are radically different in character, the former predominating in blue rays and the latter in red. These different rays produce quite different effects on living organisms, and the measurement of the quality of light is therefore essential to a careful study of its biotic effects.

The measurement of light intensity in the laboratory and in the field are quite different problems. In the former the most exact apparatus may be used, and it can be adjusted with the utmost care. In field work, however, portability is a first essential, and wide ranges of measurement and quickness of reading are also of importance. To meet these requirements a radically different design of instrument is needed.

During the period under review a large number of instruments have been tested. These have been calibrated either against the pyrheliometer, an instrument which gives the absolute value of light intensity, or against the ecophotometer, a precision instrument which has been developed in this investigation particularly to study the light conditions surrounding various forms of life.

The land model of the ecophotometer has been used in the measurement of light, not only in various habitats, but also under different conditions. These light conditions comprised a range from full sunlight through faint sunlight and moonlight to starlight. In each case the curve for the quantity of light of different wave lengths was found to take the form of a straight line, but the slope of the lines varied greatly, showing the different qualities of light produced under the variety of conditions included in the tests.

From work done in previous years it appeared that the neutral wedge presented decided possibilities for the measurement of light in ecological habitats. One chosen for a series of tests consisted of a wedge-shaped strip of gelatine, stained with a neutral dye, placed between two strips of optical glass, and having a gradient of 1 to 0.01. This was mounted in a duralumin case which permitted exposures of thirty seconds or more to be made with ease and certainty. The light passing through the wedge was made to fall on special photographic paper, sensitive to light of all wave lenghts in the visible spectrum. The intensity was measured by comparison with a standard tint duplicated in mineral colours. This apparatus is remarkably simple, and the results so far obtained with it have been highly satisfactory.

—(Investigation under the direction of Prof. A. B Klugh,. Queen's University).

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The Effect of Monochromatic Light on Protoplasm

Co-operating Organization:
University of British Columbia.

The effect of light on protoplasm is shown by sunburn and snow blindness in animals and photosynthesis in plants. These effects are produced by the light waves found in the sun's rays, most of which lie in the visible spectrum. Outside the visible spectrum, however, there are known rays extending over a very wide range. At one end are the infra-red rays, at the other end ultra-violet and X-rays. It has long been known that certain kinds of light kill bacteria, and may be used for the sterilization of water and milk. X-rays, ultra-violet light and infra-red rays have been used in therapeutics with varying degrees of success. In recent years it has been shown that animals may be protected against the development of rickets by exposure to ultra-violet light, while a still later discovery is that the exposure of certain kinds of food to ultra-violet light has an effect sufficient to protect against rickets the animals consuming it.

As yet, however, very little is known of the reasons for these observed facts. It has not been explained satisfactorily why certain light is beneficial to some kinds of life, fatal to others and possibly neutral to a third class, nor why certain wave-lenghts of light may be generally beneficial while others are neutral or harmful. This investigation has therefore been undertaken to determine the specific effect of various forms of light, as far as that may be possible.

A monochromatic illuminator has been used in order to confine each experiment to light of a definite wave length. Moreover, since the total amount of light of any one kind proceeding from a mercury vapour lamp may not be sufficient to affect large bodies it has been decided to confine the first study to microscopic organisms.

Using these methods it has been shown that the growth of yeast cultures is adversely affected, though not markedly so, by ultra-violet light. The small green plant Nitella is not adversely affected, however. It is concluded that the green colouring matter of the plant protects it from the ultra-violet light, and perhaps even utilizes the light energy which would otherwise be harmful. The plant is in this respect more highly developed than the animal.

It is proposed to continue the study of the specific effects of light of definite wave-lengths in the hope that a knowledge of its action may help to place its utilization on a sound basis.

—(Investigation under the direction of Prof. A H. Hutchinson, University of British Columbia).

Survey of Flora in Eastern Canada

Co-operating Organization:
University of Montreal.

Before a country can utilize its natural resources it is necessary to know what they are. Since flora are amongst the important natural resources a complete survey of these is a necessary preliminary to their utilization. The task is one of great magnitude and requires many years, but the results obtained from such surveys are of both economic and scientific interest.

More than twenty years ago the staff of the Department of Botany of the University of Montreal began such a survey of the flora of Eastern Canada and it has been continued to date on such a scale as was possible with the staff, time and funds available. The present investigation is an extension to new areas of the work already done and a more intensive study of the flora on areas

previously surveyed. During the year under review the territory covered comprises part of the archipelago of Mingan, the south coast of the island of Anticosti, the land along the mouth of the St. Lawrence river and a part of the eastern counties.

In the survey already carried out there have been collected over five hundred species of grasses and some two hundred specimens of material mounted for histological study. There have been discovered certain species of plants previously unknown to science. It has been learned that there exists around the Gulf of St. Lawrence a non-glaciated territory in which there still persist numerous examples of the tertiary flora. In the region extending from Quebec to l'Islet there have been found many varieties of flora which exist nowhere else. The eastern counties have furnished a number of interesting plants and much information has been obtained regarding the distribution of various species.

When the laboratory studies on the material so far collected have been completed it is planned to publish all the information obtained, in order that the details of the new discoveries may be made generally available.

—*(Investigation under the direction of Professor Fr. Marie-Victorin, University of Montreal).*

Reflex Action of the Muscles

Co-operating Organization:

University of Manitoba.

The studies on the various senses of vision, hearing, touch, taste, temperature and pain, which have been made in this investigation, have indicated a perfect uniformity of nervous actions not previously discovered. Without exception the sensation has always been found exactly proportional to the logarithm of the intensity of the stimulus. New types of nervous actions have also been discovered which are fundamentally concerned with the normal operation of the senses. There seems good ground for believing, therefore, that the same law will be found to govern the muscles in their action. This last problem has now been studied by new methods.

Taking advantage of a phenomenon used by children for amusement a completely successful method of measuring reflex muscular action has been developed. If the back of the fingers is pressed firmly against a wall for ten seconds and the arm then left free it will rise without effort, giving a sense of being without weight. This method was made quantitative by pressing the fingers against a stirrup attached to definite weights for a period of ten seconds, thus giving rise to certain measurable intensities of stimulation. The rise of the arm after the release of the hand was also measured. The results obtained with different persons, with the same person for different times of stimulation, and under conditions of inhibition and augmentation, exactly paralleled the same phenomena found in all the various senses previously tested.

It now appears completely proved that a very large portion of the nervous system concerned with the special senses operates in one uniform manner. There can be little doubt that some of the various pathological conditions of the nervous systems which are so obscure in their origin, especially in the senses, are due to disturbances in the efferent nerves. If therefore these are more carefully studied it may be possible to devise new methods of treatment.

The present investigation shows that the behaviour of muscles may be accurately studied in the undisturbed human body without injury or discomfort to the individual, and without employing any other method of stimulation except that for which the muscles are primarily adapted. Much previous

knowledge has been obtained from experiments on animals under anæsthetics and other abnormal conditions. The new method eliminates the necessity for some at least of these investigations and provides the means of studying the system under normal conditions.

—*(Investigation under the direction of Prof. F. Allen, University of Manitoba.)*

Parathyroid Gland Extract

Co-operating Organization:

University of Alberta.

The discovery of insulin has greatly stimulated the effort to find other extracts which may be similarly utilized in the treatment of human disease. The benefits which such a discovery may confer on mankind are so great as to justify the most intensive research.

The present investigation has been confined to a study of the parathyroid gland and the possible preparation of valuable extracts from it. It was discovered that a crude extract made by weak acid hydrolysis of the fresh parathyroid glands of cattle could be successfully used to prevent or control parathyroid tetany in experimental animals. The next problem was to prepare purified extracts of these glands which would have a like effect and could at the same time be safely used on human subjects suffering from parathyroid tetany.

After much experimental work a method has been developed for the preparation of a parathyroid extract which is both safe and effective. Means have also been devised for the standardization of the purified extract, making possible a fairly accurate assay of parathyroid gland extracts which are to be used on human subjects.

The essential points in the purification of the hormone are:—

(1) Weak acid hydrolysis of the fresh glands.
(2) Salting-out of the hormone, made possible by its insolubility in acid sodium chloride solution.
(3) Iso-electric precipitation of the hormone.
(4) Solution of the hormone in grain alcohol of high strength.
(5) Precipitation from alcohol by the addition of ether.

The standardization of the final product is effected by noting the power of the extract to increase the calcium content of the blood of a normal dog. One clinical unit is defined as one one-hundredth of the amount which will cause an increase of 5 mg. in the calcium content of the blood serum of a dog of 16 kilos weight in 16 hours. Several tests are made and the average taken.

The exact chemical nature of the hormone has not yet been determined. It has many properties analogous to insulin, and is probably either a protein of a complex nature or is so closely associated with such a substance that the means of separation have not yet been found.

—*(Investigation under the direction of Prof. J. B. Collip, University of Alberta.)*

The Nature and Physiological Action of Liver Extracts

Co-operating Organization:

University of Western Ontario.

Within the last few years several very important discoveries have been made of the physiological action of extracts of the glands of animals. One of these discoveries is the effect of liver extract. Its most marked action is to appreci-

ably depress the blood pressure, but other unmistakably good results have also been obtained. It is claimed to clear up all symptoms of headache and giddiness, to be beneficial in eclampsia, in anæmia and in toxic forms of psychosis. These various effects have not yet been fully investigated and final clinical proof requires further trial.

The early work with this extract indicated that it was of a chemical nature hitherto unknown. Recent efforts have been towards further concentration and purification and a more thorough study of its physiological action.

Improved methods of extraction and concentration have now been worked out, and the latest solutions prepared have been found to retain their potency for long periods when adjusted to proper acidity. Purification presents a difficult problem, which has not yet been completely solved. It is therefore impossible to obtain reliable information as to its chemical structure. Some investigators have thought that its action was due to the presence of histamine, but histamine is almost certainly not present in the extract as prepared in this investigation, and there is also considerable evidence that the compound is chemically different from histamine. There is strong reason for believing that it belongs to the aliphatic group of compounds.

The physiological action of the extract has been tried on the blood pressure of experimental animals; on perfused mammalian hearts; on the heart beat of experimental animals, as shown by the electro-cardiograph; on the volume of limb, kidney and spleen of the dog; on the smooth muscle of the small intestines and uteri of rabbits.

The observed fall in blood pressure may be due to three causes: (1) the diminution in amplitude of the beat of the perfused heart; (2) the slowing of the rate of heart beat, as recorded by the electrocardiograph; (3) the dilation of the blood vessels, shown by the increase in limb volume. The action on strips of intestine and uteri indicate that the liver extract does not contain histamine or choline. Further study of physiological action is required.

—*(Investigation under the direction of Prof. A. A. James, University of Western Ontario).*

The Deterioration of Concrete in Alkali Soils

Co-operating Organizations:

University of Saskatchewan.
Province of Alberta.
Canada Cement Company.
Canadian Pacific Railway Company.
City of Winnipeg.
Engineering Institute of Canada.

Much research has been carried out in many different countries on cement because of its great and constantly increasing importance in construction. New demands are being made on chemists and chemical engineers for cements adapted for special purposes. In general the requirements of the trade have been well met.

One problem, however, has not yet been satisfactorily solved. In certain sections of the West concrete deteriorates rapidly, necessitating large expenditures for repairs and replacements. It has long been believed that the trouble was due chiefly to the action of alkali in the soil, and some experiments have been tried to determine the cause of it, but until the present investigation was begun there was no really systematic attempt made to solve this serious problem.

This work was first organized under a committee of the Engineering Institute of Canada. It was early realized that it would be necessary to first determine the fundamental nature of the deterioration taking place and then in the light of the knowledge obtained to formulate plans for the production of resistant cements. Acting on this idea there was first prepared in pure form a quantity of each of the three principal constituents of cement,—tricalcium aluminate, tricalcium silicate and dicalcium silicate. Most of the experiments undertaken were performed separately on these compounds to determine how they were affected by different salts, since it was seen that corrosive action would not necessarily be the same on all three. The wisdom of this method of attack has been amply demonstrated.

A physical method of determing the rate of attack by alkaline solutions was sought, and it was established that accurate measurement of the expansion of specimens under test would reveal the progress of deterioration months or even years before specimens showed appreciable surface attack.

The action of sodium and magnesium sulphates on pure cement constituents was first studied by chemical and petrographical methods.

It was discovered that the action of sodium and magnesium sulphate were essentially different. The former apparently attacks only the tricalcium aluminate. Both silicates, and to a lesser extent the aluminate, disintegrate under the attack of magnesium sulphate.

The cause of the deterioration having been at least partly determined, protective measures were sought. Experiments were tried in steam curing and it was found that this treatment almost completely immunizes tricalcium aluminate from sulphate attack. It thus confers practically complete protection against sodium sulphate. A study is now being made of chemical changes which tricalcium aluminate undergoes in steam treatment in the hope that commercial methods of treating cement to at least partly immunize it from sulphate attack may be discovered.

Another method of attack on this problem has been by the addition to cement of substances which are good adsorbents for free lime. Silica gel is such a substance, but while it is fairly effective it does not confer complete immunization to sulphate attack, and appears to be too expensive for commercial use. The action of certain natural substitutes of a similar nature is now being studied.

Cements high in alumina have been made the subject of many experiments. Since they contain much tricalcium aluminate they may be expected to yield readily to the attack of sodium sulphate but to be more resistant to magnesium sulphate. This has proved to be true in practice and they have therefore been treated with steam in an effort to make them completely resistant. Some success has been attained, but it has been found that cements of recent manufacture are less resistant than those used in the first experiments.

To date seven papers have been published giving details of the above and other experiments carried out. Other papers will be published as the work makes further progress. The investigation is now being prosecuted on several of the major problems in which progress has already been made and on the following minor projects:—

(1) A study of the effect, on sulphate action, of the extraction of free lime from hydrated cement mortar.

(2) The effect of the presence of free lime in cement on sulphate resistance.

(3) Comparison of the sulphate resistance of Portland cements manufactured in various points in Canada.

(4) A study of sulphate action on slag cements.

(5) A study of the action of sulphates on "super cement."

(6) A study of the action on cement of various sulphates not commonly found in the soil.

(7) A further study of the effect of the presence of other salts on sulphate action.

(8) A study of the effect of quantity of mixing water on sulphate resistance.

(9) Testing out of various remedies and cements suggested by the engineering profession and especially by the officers of the Canadian Pacific Railway, who are vitally interested in this work. This has included mortars impregnated with sulphur, several surface coatings and some special cements. A detailed account of these investigations will be postponed to a later date.

—(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 Vulcanization of Rubber

Co-operating Organizations:

McGill University,
Imperial Institute, London, England.

In recent years there has been an enormous development of the rubber industry, but in spite of the expenditure of large sums on research the chemistry of rubber manufacture is as yet very imperfectly understood. Not only is there no generally accepted theory of the constitution of the rubber molecule, but much remains to be learned of the part played by the minor constituents of raw rubber in vulcanization and other processes.

Raw rubber contains, in addition to the actual rubber substance, about 3 per cent of resin. Approximately half of this resin consists of the fatty acids,—stearic, oleic and linoleic. It has been learned in the early part of this investigation that these acids are of the greatest importance when vulcanization of the rubber is carried out with the aid of many of the " accelerators " now universally used in rubber manufacture. Some of the most powerful accelerators are entirely inactive in the absence of these acids or of artificial substitutes for them. On the other hand, some of the milder accelerators are fairly independent of fatty acids if sufficient zinc oxide is present in the rubber mixture.

A particularly striking illustration of the action of the fatty acids is found in the vulcanization of caucho ball and Ficus rubber. These wild rubbers have naturally a rather low content of acid, and the addition of fatty acids greatly improves the quality of their vulcanized products. Analyses of plantation rubber have shown a considerable variation in acid content, and it has been proved that this variation is the factor primarily responsible for the irregularities which different rubbers show in vulcanization. These results at once suggest the proper remedy to apply where there is a deficiency of fatty acid in any raw rubber.

A preliminary report embodying these earliest results of the investigation has already been published, and the industry has been quick to take advantage of it. The addition of stearic acid to raw rubbers naturally low in the fatty acid group is now being widely adopted as regular commercial practice.

When raw rubber has been kept over a period of years it has been noted that vulcanization proceeds irregularly. Analysis reveals the fact that during storage a portion of the acid content gradually undergoes a change. This therefore points to the cause of the irregularities observed. On the other hand, it has been determined that in the vulcanization of reclaimed rubber the resin acids are of little or no importance.

Of the other resin constituents whose effect on vulcanization has been studied phytosterol appears to be of the greatest importance, although the part it plays is not as great as that of the acids. Its action appears to be to retard vulcanization by reacting with the free fatty acids. Their active mass is thus reduced. The phytosterol ester which occurs in rubber resin seems to have little or no effect on rubber vulcanization.

—(Investigation under the direction of Prof. G. S. Whitby, McGill University.)

The Chlorination of Methane

Co-operating Organization:

University of Toronto.

In the great quantities of natural gas which are daily going to waste in Alberta there is a very high percentage of methane. This is an excellent gaseous fuel, and may in time be entirely used in this way, but if it be possible to convert it by some chemical process into a valuable commercial material such a course is to be greatly preferred. Chlorination offers one possibility of such conversion, and this method of conversion has therefore been investigated.

Many attempts have been made by different investigators to commercially chlorinate methane, as well as the higher members of the methane series. The difficulty encountered has been that chlorination proceeded too far, and the products desired were not obtained in sufficient amount to make the process a profitable one. What is probably needed is a more suitable catalyst. On theoretical grounds it has appeared that certain types of catalysts offered greater possibilities than those employed by previous investigators, and these types have therefore been made the subject of the present series of experiments. Methane has been exclusively used in these tests, but it is believed at the same time that if the conversion of methane proves successful it will be comparatively easy to modify the method in such a way as to make it applicable to the higher hydrocarbons of the same series.

In beginning this work it was decided to confine the preliminary tests to very small quantities of the gas, since the effect of changes of temperature, concentration and other conditions could be more readily determined. This involved, however, the development of analytical methods for accurately determining the nature of small amounts of the products. This work was delayed by unexpected difficulties, the chief of which was the preparation and satisfactory storage of pure methyl chloride, but satisfactory methods were finally devised.

The chlorination experiments consisted in passing measured amounts of chlorine and methane over a specially prepared catalyst. The catalyst first used was in a reduced condition, resulting in a low yield of products, which, however, contained a relatively high percentage of the desirable methyl chloride. This low yield was evidently due to the chlorination of the catalyst itself, a reaction which reduced the proportion of chlorine to methane to too low a figure. Upon using a previously chlorinated catalyst with the same mixture of chlorine and methane a much larger yield was obtained, the increase being particularly in the higher chlorinated products, methylene chloride, chloroform and carbon tetrachloride. To preserve the high proportion of methyl chloride obtained in the first test it was evidently desirable to use a reduced catalyst. This was secured and maintained in this condition by adding water vapour to the gases. A somewhat better yield of methyl chloride was then obtained.

The effect of temperature was then studied. In the first experiments a temperature of 450 deg. C. had been employed and this was found to give a higher percentage of methyl chloride than either lower or higher temperatures.

In all the experiments in which water vapour was used some hydrogen was found in the residual gases and the proportion of hydrochloric acid was higher than expected. The hydrogen was probably a product of the chlorination reaction itself, although another possible source would be a reaction between the methyl chloride and lime used to hydrolyze the chlorinated products. These unexpected results are an indication that in the apparatus the effective concentration of chlorine was higher than 1:1. Tests will therefore be run with a lower proportion of chlorine.

In none of these experiments was there any difficulty in getting chlorination to take place. The chlorine passed was in almost every instance entirely consumed. It would probably be possible to secure complete consumption of the methane as well, but this would be likely to lead to a still greater production of the higher chlorine derivatives. It is therefore expected that the best results will be obtained by reduced concentrations of chlorine.

—(Investigation under the direction of Prof. M. C. Boswell, University of Toronto.)

The Crystallization of Sodium Carbonate

Co-operating Organization:
University of Montreal.

In the Solvay process for the manufacture of sodium carbonate carbon dioxide is made to react in towers with an ammoniacal brine. Ammonium bicarbonate is first formed, and this reacts with the sodium chloride to form sodium bicarbonate, which crystallizes out. This is finally converted to the normal carbonate by calcination.

These reactions appear comparatively simple. It has been shown in this investigation, however, that they are in reality more complex, for there have been found crystals of normal ammonium carbonate, of ammonium bicarbonate, of sodium bicarbonate, and, in all probability, of a 4:3 carbonate.

The different plants using the Solvay process do not always succeed in preparing sufficiently large crystals of bicarbonate. Small crystals render filtration difficult, the crystals retain much ammonia and the apparatus rapidly fills up. These difficulties are due in part to a lack of knowledge of the proper conditions for the formation of large crystals.

The method adopted in this investigation has been to make a current of more or less concentrated carbon dioxide pass into an ammoniacal brine of definite composition at various temperatures. It has been determined that the size of the crystals depends in part upon the composition of the ammoniacal brine. In very concentrated solutions there first form very small and abundant crystals consisting in the main of normal ammonium carbonate. These crystals are slowly transformed into others considerably larger, frequently visible to the naked eye, and of different crystalline form. It has not yet been possible to isolate them for the purpose of determining their composition. Another factor which governs the growth of crystals is temperature. The crystals are notably larger between 22 and 32 deg. C. It has been determined that the speed of precipitation greatly influences the size of the bicarbonate crystals. The composition of the gaseous mixture also plays an important part in the production of large crystals.

In operating at 20 deg. C. crystals are obtained 0.75 to 1.25 mm. long and 0.01 to 0.03 mm. in diameter. At 30 deg. C. the crystals are practically as large, but they are less numerous. This procedure gives the maximum size of the crystals measured, but it does not give their mean volume, for there are formed at the same time in great numbers crystals which measure scarcely 0.1 mm. in length and 0.02 in diameter. Different methods are being used to determine crystal volume. All measurements of crystals have been made under the microscope.

—(Investigation under the direction of Prof. P. Riou, University of Montreal).

Catalytic Action of Ultra-Violet Light

Co-operating Organization:

University of Montreal.

One of the remarkable properties of ultra-violet light is its power of promoting certain chemical reactions. This is not only of the greatest scientific interest but may also be of some idustrial importance in certain fields. This catalytic action deserves the closest study, in order that advantage may be taken of any valuable information which may thereby be discovered.

In a previous investigation the action of ultra-violet light was shown to be appreciable in the catalysis of several reactions of oxidation. The same reactions have now been more closely studied under a variety of conditions, the primary object being to determine those which would result in the maximum yield. The conditions investigated included the following: liquid reagents, gaseous reagents, solutions, atmospheric pressure, reduced pressure, variation of the solvent, variation of the radiant energy, influence of successive exposures.

Experimenting with the oxidation of methyl alcohol to formaldehyde it has been found that the reaction proceeds from six to eight times as fast in the gaseous as in the liquid state. In aqueous solution the concentration has a great influence on the rate, the most favourable concentration being 13 to 20 per cent of methyl alcohol. The yield at reduced pressure is no greater than at atmospheric pressure. Doubling the radiant energy rather more than doubles the rate of the reaction. Successive exposures of the same reacting mixture to ultra-violet light increase the yield.

A series of experiments was also tried on the oxidation of acetylene to acetic acid, using acetone as the solvent. This reaction takes place in two stages, hydration changing the acetylene into acetaldehyde which is subsequently oxidized to acetic acid. In this case the yield found at atmospheric pressure was more than double that at the reduced pressures used. Doubling the radiant intensity again more than doubled the yield.

—(Investigation under the direction of Prof. L. Bourgoin, University of Montreal).

Low Temperature Research

Co-operating Organizations:

University of Toronto.
Carnegie Corporation.

Methods for the liquefaction of gases have in recent years been so developed that a very large field has been opened for scientific research at low temperatures. The use of helium, the last of the gases to be liquefied, has made possible the attainment of a temperature of -272° C., within approximately 1° of absolute zero.

The installation of elaborate cryogenic equipment in the physical laboratory of the University of Toronto now makes continuously available liquid air, hydrogen and helium, and the physical properties of substances can be readily investigated over the corresponding low temperature range. During the year under review the new additions to equipment include two large gasometers installed in a specially constructed building for the storage of purified hydrogen, which would otherwise be lost. The hydrogen liquefier has been largely reconstructed and a new and greatly improved pump for compressing helium has been installed. Researches have been carried out on the following subjects:—

1. *The Electrical Conductivity of Metals*

In addition to the repetition of measurements formerly made on the metals lead, indium and cadmium, resistance-temperature curves have been obtained for beryllium, chromium, rubidium and barium, down to liquid helium temperature, and for an alloy of sodium and potassium down to the temperature of liquid hydrogen. Lead and indium alone show superconductivity.

2. *The Crystal Structure of Solidified Gases*

(*a*) *Oxygen and Nitrogen.*—It has been shown that oxygen crystallizes in a body-centred orthorhombic system with axial ratios a:b:c = 1.44:1:0.9. The sides of the unit cell are: a = 5.50 A.U., b = 3.82 A.U., c = 3.44 A.U., and the density is 1.46. Two molecules are associated with a unit cell.

The work on crystallized nitrogen is still in progress and is being facilitated by the use of a series of graphs prepared for a study of oxygen and other crystals belonging to the orthorhombic system. These graphs supplement the ones prepared by Davey for the cubic system.

(*b*) *Hydrocarbons.*—The three paraffines n-pentane, n-hexane, and n-octane have been found to crystallize in one of two forms, an orthorhombic or a monoclinic modification with at least one molecule per unit cell for either form. The "long spacings" for the rhombic form (n-octane 15.0 A.U., n-hexane 11.6 A.U., and n-pentane 10.3 A.U.) correspond almost exactly to a chain of carbon atoms arranged end to end in a straight line with a hydrogen atom at each extremity, for example, in n-octane:

$$8(1.54) + 2(1.30) = 14.9 \text{ A.U.}$$

where the "interatomic distance" between two carbon atoms is 1.54 A.U., and that between two hydrogen atoms is 1.30 A.U.

As for the "side spacings", the value of 4.3 A.U. supports the view usually held that the hydrogen atoms are attached laterally to the carbon chain.

3. *Experiments with High-speed Electrons from a Coolidge Tube*

(*a*) The phosphorescence spectrum of solid nitrogen irradiated with high-speed electrons from a Coolidge tube and an alloy window of chromium, nickel, silicon and iron has been more fully investigated and has been found to consist of one group of bands with mean wave-lengths, 5240, 5235, 5229, 5224, 5220, 5214, 5210, and 5204 A.U., and another group with mean wave-lengths 5944.47, 5938.8 and 5932.0 A.U. The origin of this phosphorescence of an apparently simple substance is being investigated still further.

(*b*) An investigation has been initiated to determine the limits to the use of high-speed electrons for bringing about the dissociation of complex gases or the synthesis of simple ones. The gases being operated upon are oxygen, hydrogen and nitrogen and a series of hydrocarbons.

4. *The Magnetic Susceptibility of Alkali Metals*

The specific susceptibilities of highly purified specimens of the alkali metals, sodium, potassium, rubidium and caesium, have been investigated at room

temperature. The values found are $+0.59 \times 10^{-6}$, $+0.45 \times 10^{-6}$, $+0.17 \times 10^{-6}$, and $+0.18 \times 10^{-6}$, respectively. Sodium and caesium have been investigated down to the temperature of liquid air and their susceptibilities have been shown to be constant over that range.

5. *Intensities of the Secondary Spectrum of Hydrogen at Various Temperatures*

The intensities of most of the lines measured by Merton and Barratt in the secondary spectrum of hydrogen have been measured by means of a microphotometer with spectrograms obtained with the gas tubes kept at room temperature and at the temperature of liquid air. The lines include the greater part of Richardson's series system and for these the change of intensity with temperature has been found to be in good agreement with theory. The alteration of intensity between odd and even numbers of the series has been clearly brought out and shown to be further affected by the change of temperature. New regularities found in this spectrum will be further investigated.

6. *Photoelectricity*

The photoelectric emission from potassium in a high vacuum has been investigated in a preliminary way at various temperatures down to that of liquid hydrogen. Light for stimulating the emission was selected from the red-green and blue-violet spectral regions. For room temperatures and for temperatures down to –180°C. the results of Ives have been confirmed. The work with liquid hydrogen and liquid helium is still in progress.

—*(Investigation under the direction of Professor J. C. McLennan, University of Toronto).*

The Aurora and Its Spectrum

Co-operating Organization:

University of Toronto.

The object of this research is to ascertain as far as possible what can be learned regarding the constitution of the upper atmosphere from a study of the spectrum of the auroral light. Spectra of aurorae always contain a set of bands that show that one of the main constituents of the upper atmosphere is nitrogen. These spectra also contain a narrow sharply-defined green line near wave-length = 5577 A.U., whose origin, for long in doubt, has recently been traced in this investigation to oxygen in the atomic form.

The exact wave-length of the radiation producing the green auroral spectral line in question was found by Babcock of Mount Wilson Observatory to be wave-length = 5577.35 A.U. Measurements on the wave-length of the same line as found in the spectrum of oxygen at low pressures in the Physical Laboratory of the University of Toronto have given the value wave-length = 5577.341 A.U. This practical equality of the two values of the wave-length may be taken as establishing beyond question that the line found in the auroral spectrum is identical with that shown to be present in the spectrum of atomic oxygen. Additional evidence in support of this conclusion is found in the fact that the width of the oxygen green line has been shown to be 0.030 A.U., in good agreement with 0.035 A.U., found by Babcock for the width of the auroral green line.

The wave-length determination referred to was made with a special interferometer of the Fabry and Perot type and a fixed focus camera that went with it. The "étalons" used in the interferometer were three plates of glass whose surfaces were optically plane parallel and half silvered. The thicknesses of the plates were such as to give orders of interference of approximately 25000, 65000, and 85000.

Since the spectrum of the aurora has been shown to include in addition to a portion of the first negative band spectrum of nitrogen, one of the constituent wave-lengths of the line spectrum of oxygen, the investigation has made it quite clear that in the upper atmosphere in a region commencing at about 80 kilometres and extending at least as high as 700 kilometres, there must be nitrogen in the molecular form and oxygen in the atomic form, both gases being at very low pressures.

The result of the investigation has a theoretical value in that it throws light on the problem of the structure of oxygen atoms and of that of the atoms of elements allied to oxygen. From a practical point of view the investigation is of value in that the knowledge of the constitution of the upper atmosphere we have thus acquired can be used immediately in the solution of a number of problems that have been brought forward by those investigating the transmission of either waves in radio telegraphy and telephony.

There is an added interest in the radiation producing the green line, wave-length = 5577.341 A.U., of the auroral spectrum in that it is the main, if not the only constituent of the light of weak intensity that comes to the earth from the moonless, cloudless night sky, whether any polar aurora is in evidence or not. The origin of the green light under these circumstances is now being investigated.

—(Investigation under the direction of Prof. J. C. McLennan, University of Toronto).

Ultra-Sonics

Co-operating Organization:

University of Alberta.

Sound waves, like those of light, vary much in frequency. In both cases the human senses can perceive them over a limited range. In light waves the range extends from the red to violet, but beyond these limits there are the infra-red and the ultra-violet, respectively, fields in which much important scientific research has been done in recent years. In sound waves there has recently been found a large field in which the frequencies are more rapid than those perceptible by the human ear, and to this field the name "ultra-sonics" has been applied. It is one of the newest fields in science, but already in this investigation there have been discovered facts of great scientific and considerable industrial importance. Some of these discoveries have been discussed in previous reports.

Like ordinary sound waves in air or other medium, ultra-sonic waves can be made to show nodes and loops, the former appearing as cavities or bubbles distributed at regular intervals through the conducting liquid. In naphtha or other liquid with high vapour pressure this phenomenon may be shown particularly well, appearing at comparatively low voltages and energies. The bubbles observed have been found to consist mostly of air. Incidental phenomena accompanying cavitation, connected with the reflection of the beam and the formation of stationary waves, are also being studied.

From theoretical considerations it may be expected that when ultra-sonic waves are passed through partitions placed in their path reflection will be at a maximum and transmission at a minimum for thicknesses equal to an odd number of quarter wave-lengths, and reflection will be at a minimum and transmission at a maximum for thicknesses of an even number of quarter wave-lengths. This question has been investigated by means of measurements with a torsion pendulum, and the theory has been fully substantiated. The results throw light on the problem of reflection from and transmission through partitions by sound waves of ordinary pitch incident upon them, and should have a

bearing on the practical problems of sound insulation and architectural acoustics.

The theory outlined contains no terms for absorption of the sound energy in the material of the partition. In the case of paraffin, which is a relatively poor conductor of ultra-sonic energy, the effect of absorption has been demonstrated. This effect is not evident in the case of metals, since their reflecting power is high and transmission small.

—*(Investigation under the direction of Dean R. W. Boyle, University of Alberta).*

Problems of Hygroscopy

Co-operating Organizations:

McGill University.
Dominion Department of Mines.

The importance of controlling the amount of moisture in the atmosphere has not in the past been generally appreciated. Recently, however, medical men and specialists in ventilation have pointed out that it is essential to our health and comfort that the percentage of moisture in the air we breathe be within reasonable limits. Moreover, in certain of the industries, such as textile and paper manufacture, the maintenance of the correct humidity is an important factor in the control of operations.

Unfortunately, quick and accurate methods of determining humidity and satisfactory means of humidity control have not been available. Many investigators have worked in this field but the problems involved are complex and much work of a fundamental character is still required. The present investigation has been undertaken to work out certain important phases of this problem.

Certain industrial operations require the accurate determination of vapour tension at intervals of a few minutes. Except over limited ranges none of the available hygrometers have been able to do this to an accuracy of much better than 2 per cent. An absorption hygrometer first developed by Rideal and Hannah has been modified in this investigation to secure greater accuracy, and it can now be used to measure humidity ranging from saturation at –40 deg. F., to saturation at 92 deg. F., with an accuracy of one part per thousand. This instrument is more rapid in operation than any other hygrometer now in use. A further advantage is that it can be used for small samples of gas. Its accuracy is believed to be greater than that of any other hygrometer except those of the standard chemical type operated with exceptional care over a long period, and using large quantities of gas.

In this investigation a large hygrostat supplied by the Dominion Department of Mines has been remodelled for use, in order that standard humidity conditions may be readily maintained for the experiments. This hygrostat is based upon the system of feeding calcium chloride solution to wicks which bring the solution into contact with the circulating air.

A difficult problem which has been investigated is that of the measurement of dry and moist surface temperatures. Most of the methods now in use for this work are very defective, the recorded temperature frequently being either above or below the real surface temperature, according to conditions. In these methods some form of thermocouple is ordinarily used, but errors are introduced because of the heat conducted away by the wires and on account of the fact that a thermocouple touching the surface itself forms a part of a system in which the temperature gradient is steep. A method has been developed in which the terminals of the thermocouple wires do not touch each other, but are separated, and are either soldered to or embedded in a metallic surface. The

principle is not new, but it has not previously been developed to a practical method of measurement. The corrections required have not been entirely eliminated, but they have been made capable of calibration, so that the true temperatures can be determined.

The measurement of temperatures of moist surfaces is attended with still greater errors than those of dry surfaces. The larger errors are due to the poor heat conductivity of the material under test, to the considerable temperature fluctuations of moist surfaces and to the fact that a couple compensated by a heating coil is impracticable, since it screens that portion of the surface whose temperature is being measured and thus interferes with ordinary radiation and convection effects. The new method developed is to solder the ends of the severed couple to a length of much thicker wire which is embedded in the surface.

A number of other problems will be studied as the investigation progresses.

—(Investigation under the direction of Prof. A. N. Shaw, McGill University).

Alternating-Current Electrolysis

Co-operating Organization:

University of Manitoba.

Hydro-electric development in Canada is proceeding at a very rapid rate. In many cases when new plants are constructed they are on a scale which is in part an anticipation of a large future demand, and uses are then sought for the surplus power, which is obtainable at a very low rate. Exceedingly cheap off-peak power is also available at many points. Frequently advantage has been taken of such a situation to generate steam for plant operation or for industrial and domestic heating.

The heaters installed for this purpose are usually of the water-resistor type, in which the electric current passes through the water from one electrode to another, and the resistance of the water is responsible for the generation of heat. In installations of this kind direct current cannot be used, since electrolysis of the water would take place, with the generation of hydrogen and oxygen. Alternating current has, however, been used in such heaters on a considerable scale. A few years ago in the city of Winnipeg a boiler of this type exploded, completely wrecking the house in which it was installed, and the question arose as to whether the explosion might not have been due to the generation of an explosive mixture of hydrogen and oxygen by the alternating current used. An inspection of several similar installations revealed the fact that all were generating explosive gases in small quantity, and an investigation was therefore undertaken to determine the conditions under which these gases are generated. It was hoped that the information secured might also make possible the design of boilers in which electrolysis would not take place.

It has been found that the primary factor in alternating-current electrolysis is current density. From theoretical considerations it appears that if the quantity of gas generated in the brief time interval during which the alternating current flows in one direction can be retained until the current is reversed, the oxygen and hydrogen will recombine, and no gas will be liberated. If the current exceeds this limit some gas will be set free. Obviously, the power of the electrode to retain gas will increase if corrosion takes place, since such action not only increases the effective area but also provides a rough surface for the adherence of the gas. The quantity of gas set free in the uni-directional period will vary not only with the current density, but also with the elapsed time, that is, with the frequency. It may also be expected that temperature will have some influence.

In practice all these factors play a part. Under any given set of conditions it is found that there is no appreciable generation of gas up to a certain current density, but above that critical value the volume of gas generated varies directly with the current increase, as in Faraday's law for direct current. Polished metallic electrodes have a comparatively low critical current density, corroded electrodes a considerably higher value. The critical value is lower for high than for low frequency. It rises with increasing temperature to about 80 deg. C., and then falls off rapidly.

In the design of commercial heaters it is essential that the working current density should be well below the critical value. It is not sufficient, however, to provide for a satisfactory *average* current density. If the electrodes be of such a form that there are sharp edges exposed there is almost sure to be a concentration of current in such places, and the critical density may easily be exceeded. Correct design should provide electrodes with no exposed edges, so that the current density may be uniform over the whole surface.

—(Investigation under the direction of Prof. J. W. Shipley, University of Manitoba).

The Elimination of Magneto Noises from Air-Craft Receiving Sets

Co-operating Organization:
University of British Columbia.

Radio has provided a very necessary means of communication between aeroplane operators and parties on the surface of the earth. This is of importance alike in peace and war. Unfortunately, however, it is found that the operation of the magneto is responsible for much interference in the radio receiving sets, particularly at the short distances at which is is customary to operate them.

Attempts have been made in many countries to overcome this difficulty. In Germany some success has been claimed by substituting special chains for the ordinary leads connecting the magneto and the spark plugs. This method weakens the spark somewhat. In other countries reliance is placed on the use of balanced circuits, or on screening both the receiving sets and the leads to the plugs. Attempts to duplicate these methods have indicated that they are only partially successful, due perhaps to the large number of harmonics present in the wave form of the current.

The best way to solve this problem would appear to be by eliminating the cause of the interference. For this purpose a new method has been tried in this investigation. It consists in the use of concentric leads between the magneto and the engine. These are obtained by passing the current to the engine along a central wire and returning it by an annular conductor surrounding the wire. A trial of this method showed a very marked improvement in reception, although there was still some interference. On investigation this was found to be due to the short length of conductor at the junction of the leads to the magneto, where it is necessary to separate the conductors from the true concentric position. Steel casings were then made for the whole magneto and the concentric leads were taken through these. Some further improvement was thus obtained. Further work will be done in altering the inductance and capacity in the leads with the object of raising or lowering the frequencies to points outside the audible range.

—(Investigation under the direction of Prof. H. Vickers, University of British Columbia).

The Use of Radium Emanation

Co-operating Organizations:

Dalhousie University.
King's College.

Radium was first used for therapeutic purposes in the form of salt sealed permanently into small glass tubes. This method is gradually being abandoned in favour of the use of radium emanation, for the radium may then be kept in a safe place while the gaseous emanation is regularly pumped off, freed from impurities and sealed into glass tubes. Further advantages in using the emanation lie in the fact that it can be divided in any desired way and distributed where needed, and in its greater concentration, permitting the use of smaller tubes.

The gases pumped off regularly from the solution are only a few cubic centimetres in volume. They, however, contain only one five-thousandth of pure emanation, which must be concentrated before it can be put in the tiny "seeds" used in radium therapy. The technique of this method is very difficult, involving complicated apparatus and highly skilled manipulation. An attempt is being made to develop a method which may be far simpler than those now in use, not involving the use of any solutions at all. If the effort be successful it should lead to a largely increased use of radium emanation.

—(Investigation under the direction of Prof. D. McIntosh, Dalhousie University and Prof. G. H. Henderson, King's College).

The Measurement of Pressure Variations in Internal Combustion Engines

Co-operating Organization:

McGill University.

With the increasing use of internal combustion engines it is imperative that the most efficient use should be made of the limited supplies of liquid fuel. The proper design of internal combustion engines is a first essential, and in order to design properly one must be able to determine with considerable accuracy the pressure variations during the cycle in the cylinders of such engines operating under different conditions. With the object of radically improving the present methods of measuring and recording such pressure variations this investigation has been undertaken. When the new methods have been fully worked out they will be used in a study of the action of anti-knock compounds, new fuels and fuel mixtures.

All methods at present in use for measuring pressure variations in internal combustion engines involve the inertia of a diaphragm. The method developed in this investigation, however, makes use of a massless indicator, and consists in the utilization of the piezoelectric properties of certain crystals such as tourmaline and quartz, cut in a definite way, to transform pressure changes into variations in electric charges. There is thus avoided any intervening inertia effect. The electric variations which take place in the crystals, after uniform amplification by a thermionic valve, are recorded on a cathode ray oscillograph.

A crystal detector of this kind has been constructed and an adapter has been made so that it may be screwed into the usual spark plug opening of an engine. A special calibrating device has been constructed to calibrate the piezo-electric indicator with static pressures. In the course of experiments on an engine it was found that the detector could be calibrated dynamically, and plans are now under way for the construction of such a calibrating device.

Records, both visual and photographic, have been taken on a cathode ray oscillograph of the maximum pressures developed during a cycle. In order to

obtain the regular indicator diagram form of time-pressure curves, it will be necessary to arrange a time scale to synchronize with the running of the engine, so as to give at any instant the position of the piston and the corresponding pressure. Three different methods of accomplishing this are being studied and the most accurate one will be adopted.

The experiments which have been carried out on a Ford engine show that this piezoelectric indicator records all the minute variations of pressure not revealed by other types of instrument. It will therefore be of the greatest use in making a detailed study of the action of different fuels in internal combustion engines.

—*(Investigation under the direction of Prof. D. A. Keys, McGill University).*

Series Spectra of Atoms Homologous with Silver

Co-operating Orzanization:
University of Alberta.

The spectroscope has furnished science with the means of studying whole new fields in physics and related branches. Although the construction of magnifying apparatus sufficiently powerful to reveal atoms and molecules is still apparently far in the future it is nevertheless possible to learn through the spectroscope much about the internal structure of these submicroscopic units. Moreover, the measurements which it is possible to make in this particular field are determined with the very highest degree of accuracy. Spectroscopy therefore deals in a very precise way with the very fundamentals upon which all science is based.

It is consequently of great scientific importance that the spectral lines of the elements be determined with the greatest possible accuracy, and that their relation to each other should be given the most careful study. This investigation has been undertaken to make such determinations and to study such relations for those elements in the periodic system in the same series with silver. The region in which this study is being made is the extreme ultra-violet.

The vacuum spectrograph used has a grating of two metres radius of curvature, and is ruled with 30,000 lines to the inch. The source of light is a high-potential spark in vacuo. The instrument gives approximately four times the dispersion previously obtained in this region, with a correspondingly higher accuracy. It is satisfactorily used in the field down to about 1,000 A.U., below which it is necessary to use a grating of 15,000 lines to the inch, giving only one half of the dispersion.

There have been found in this series of experiments the first two spectral lines of the sharp series of indium III, the first members of the sharp, diffuse and fundamental series of tin IV, the first members of the principal, sharp, diffuse and fundamental series of antimony V and the first principal doublet of tellurium VI. Some work has also been done on scandium III, and titanium IV.

—*(Investigation under the direction of Professor R. J. Lang, University of Alberta).*

Power Losses in Dielectrics

Co-operating Organization:
University of Alberta.

Canada's present hydroelectric power development per capita is second only to that of Norway. Her aggregate development, some 5,000,000 horse-power, is second only to that of the United States. When it is remembered that the present

turbine installation is only about 12 per cent of the total water power available the possibilities of the further growth of electrical industries become evident.

With the rapid development of electrical industries the question of dielectrics becomes of increasing importance. Considerable research has already been done in this field, but our knowledge is still all too limited. The great interest of electrical companies in this subject is shown by the appointment of a Committee on Electrical Insulation of the Division of Engineering and Industrial Research of the National Research Council of the United States. A report of this committee recently presented before a convention of the American Institute of Electrical Engineers in New York reviews the work already done and the theories that have been advanced to explain the phenomenon of dielectric absorption. This report refers to the work done some years ago at Harvard University by the director of the present investigation and concludes by emphasizing the need for further study of the phenomenon of absorption.

The present investigation is an effort to determine the variation with frequency of the power loss in condensers. In the early experiments losses were measured on a special type of bridge. In continuing the investigation it was decided to first increase the range of the bridge in view of the facts brought out in the report above mentioned. The difficulty was to obtain a sensitive method of detecting a balance in the bridge with frequencies above those which are audible in a telephone.

Two methods of accomplishing this were tried. One of the most sensitive methods is that of the heterodyne. This, however, did not prove successful on account of the fact that the leads to the bridge acted as antennae even when the bridge was balanced. Before this method can be adopted provision will have to be made for very complete shielding.

A second method consisted in an interruption of the current in the bridge leads at about 1,000 cycles per second. This was done by means of various types of toothed wheels and by a piece of steel vibrating like an electrically operated tuning fork. For use with very rapid frequencies, above 3,000 cycles, it is essential that the shielded input transformer should not have too high an impedance, and since these are not available on the market one had to be built.

It has not yet been possible to carry out an extended series of experiments with the improved apparatus, but an endeavour will be made to do this in the near future. It is intended that the range of work covered should be wide enough to make possible at least a partial interpretation of the results obtained.

—*(Investigation under the direction of Mr. H. J. MacLeod, University of Alberta).*

The Magnetic Susceptibility of the Alkali Metals

Co-operating Organization:
McGill University.

All substances are more or less magnetic. Iron, cobalt and nickel, which are strongly attracted by the magnet, are called ferromagnetic. Those substances other than the above which are attracted to the stronger parts of a magnetic field are known as paramagnetic, while those which are repelled to the weak parts of a magnetic field are diamagnetic. According to Langevin's theory, the atoms of paramagnetic substances are permanent small magnets, while those of diamagnetic substances are not, hence their behaviour.

The alkali metals, according to Bohr, are composed of atoms which consist of two parts, a non-magnetic core and a single valency electron. These single electrons are much more lightly bound than the others, and account for the

chemical behaviour of this group of elements. There is also much evidence to show that they become, in the solid form, the electrons responsible for electrical conduction. The cores of these elements will be diamagnetic, and such magnetic susceptibility as they possess will therefore be accounted for by the single outer electrons, if, as believed, these are constantly rotating. The accurate determination of the magnetic permeability of the alkali metals consequently becomes very important in determining whether such rotation actually takes place.

Previous determinations of the susceptibility of the alkali metals, by other investigators, have varied widely. The discrepancies may perhaps be accounted for in part by the varying purity of the metals, since even traces of iron would greatly increase the observed susceptibility. In this investigation, which has been up to the present confined to potassium, the metal has been throughly purified by triple distillation in a vacuum. Analysis showed it to contain only one part of iron in 12,000,000. All samples were for purposes of the experiments enclosed in sealed glass tubes, since potassium oxidizes rapidly when exposed to the air.

A sample was suspended for test between the poles of an electromagnet and the pull upon it in a definite magnetic field was determined by means of a sensitive balance. Air currents were eliminated by building an aluminum housing around the specimen. A lead trough containing sulphuric acid was placed inside to prevent disturbances due to moisture. The magnetic field was measured by means of a ballistic galvanometer and this measurement was checked by means of a bismuth spiral. Corrections were also made for the glass containing the specimen. Using these precautions the specific susceptibility of potassium has been determined at 0·00000054. The purity of the metal is indicated by the fact that this value remains constant in fields of different strength. There is still some considerable discrepancy between theoretical and experimental determinations of susceptibility.

—*(Investigation under the direction of Prof. E. S. Bieler, McGill University.)*

The Surface Energy of Sodium Chloride

Co-operating Organization:

McGill University.

The surface energy of solids is not susceptible of direct measurement as in the case of liquids. A few attempts have been made by the use of indirect methods to obtain some idea of the magnitude of this surface energy, but the methods used previously have been restricted to very limited classes of substances. Moreover, the theories on which the calculations are based are usually of very doubtful applicability, and the errors involved in the measurements have in many cases been such as to render the results almost valueless.

Amorphous solids resemble liquids in some respects, and a few measurements on these have been made. For crystalline substances, however, the problem is more complex, since there is a regular spacing of the atoms and no displacement takes place in favour of minimum surface. In this research, intended to measure the surface energy of crystalline sodium chloride, an attempt has therefore been made to determine the difference between the heats of solution of coarsely crystalline and finely divided material. Sodium chloride has been used since it is a substance which crystallizes only in the isometric system, is easily purified, and has a heat of solution of a magnitude which is readily measured. The procedure used, however, is applicable with little modification to almost any soluble salt.

Since the heats of solution of coarse and fine crystals of any material were known to be very nearly equal it was evident that very exact methods of heat

measurement would have to be used. This involved the design and construction of a calorimeter of new type, with an accuracy much greater than that of any previously made. After numerous experiments a completely closed calorimeter was finally constructed. The usual stirrer was dispensed with by rotating the calorimeter, and the thermocouple, consisting of an eleven-junction thermel of special design, was placed outside. With the apparatus developed it was found possible to read the temperature to 0·0001 deg. C., which made possible duplicate readings with an agreement within 0·05 per cent.

The salt used was purified by repeated crystallization and was then completely freed from moisture. Minute crystals were prepared by sublimation of the purified salt in a platinum retort, the vapour being collected in a large settling box. The size of the crystals used was measured by a photomicrographical method under high magnification, and was found to correspond to an average diameter of 0·0010 mm.

Using the utmost precautions the difference between the heats of solution of fine and coarse salt was measured repeatedly. Results checked satisfactorily, showing a uniform difference between the coarse and fine salt of 15·3 calories per mole. This is equivalent to a surface energy of solid sodium chloride of 386 ergs per square centimetre. It is believed that the experimental error is not over 10 per cent.

—*(Investigation under the direction of Prof. F. M. G. Johnson, McGill University.)*

The Impact Resistance of Iron and Steel at Low Temperatures

Co-operating Organizations:

University of Alberta.
University of Manitoba.

Where machinery is operated under widely varying conditions, such as the temperature changes experienced in Canada, it is evident that it will be required to resist severe stresses. From midsummer heat to lowest winter temperature there may be an extreme variation of as much as 160° F., and it is of great importance both industrially and from the point of view of public safety that machinery should be so designed and constructed as to fully meet the severe requirements of use.

Information has been obtained from several cities in Western Canada indicating that the breakage of street car axles, car wheels, connecting rods and various steel castings are considerably greater in cold than in warm weather, and are particularly frequent during the months of December and January. This may not be due entirely to the low temperature prevailing at such times. Other possible factors are poor lubrication in cold weather and defective materials, but the evidence is fairly conclusive that there is some definite relation between such failures and sub-zero temperatures. The careful consideration of the stresses involved leads to the conclusion that these failures are more probably due to impact than to fatigue.

The possible effects of low temperatures upon the physical properties of metals have been recognized and studied by several investigators in England, Germany, and the United States. The general conclusion from the experimental work performed is that the toughness of many steels decreases materially as the temperature falls. The changes do not appear to take place uniformly, but are particularly great within certain temperature ranges.

Impact Resistance of Rolled Steel

For this investigation three plain carbon steels were selected, the compositions being approximately those required for structural steel, for locomotive steel, for car axles and rail steel, respectively. Each of these steels was subjected to five different heat treatments and was tested by the Charpy impact test, which gave by comparison the relative resistance to shock at six different temperatures varying from 68° F., above zero to 28° F., below zero. In all, 360 specimens were made, given the proper heat treatment and broken. A series of tensile tests for purposes of comparison was begun. The fractures of the broken specimens were studied, and photomicrographs were prepared in order to show the structure of the metal in each case.

For the heat treatment a special electric resistance furnace was constructed. This furnace gave very uniform heating of all specimens and permitted duplication of heat treatments to within 25° F.

While the investigation is not yet complete the following general conclusions have been tentatively reached:—

(1) At low temperatures low-carbon steels are superior to high-carbon steels in impact resistance.

(2) Suitable heat treatment can greatly increase the resistance of steel to shock at low temperatures. Such a heat treatment is proper quenching followed by drawing at 1,100° F.

(3) Any heat treatment other than annealing or normalizing leaves low and medium carbon steels much more resistant to shock than those which have been normalized. The increased resistance varies from three to ten times as great, the higher figure being reached with low-carbon steels.

(4) In the case of plain high-carbon steels (about 0.7 per cent carbon) it is necessary to give the heat treatment specified in (2) in order to secure any considerable resistance to shock at low temperatures.

(5) Plain low-carbon steel is a suitable material to withstand shock when properly treated. This applies particularly to steels used in the manufacture of axles for railway cars, rails, and metal parts of locomotives, automobiles and aeroplanes.

—*(Investigation under the direction of Professors A. E. Cameron and I. F. Morrison, University of Alberta).*

Impact Resistance of Castings

The following castings were subjected to test:—

(1) Cast iron made in the electric furnace.
(2) High-silicon cupola cast iron.
(3) Ordinary cupola cast iron.
(4) Ordinary electric furnace cast steel.
(5) High-carbon electric furnace cast steel.
(6) Heat treated electric furnace cast steel.
(7) Electric furnace vanadium steel castings.

The results so far obtained indicate that the resistance to impact at ordinary room temperatures of electric furnace cast iron, high-silicon cast iron and ordinary cupola cast iron is very low, being from two to six foot-pounds per square inch of the specimens tested. At a temperature of 4° F. below zero the resistance to impact was so low in most cases that the results were not recorded.

Ordinary electric furnace steel castings gave an average impact resistance of 131 foot-pounds per square inch at room temperature, but only 35 foot-pounds at 4° F. below zero. High-carbon electric furnace cast steel gave

impact resistances of 64 and 29 foot-pounds per square inch, respectively. The electric furnace cast steel was heat-treated and air-cooled from 1,300° F. At room temperature its resistance was 182 foot-pounds per square inch, and at 4° F. below zero, 100. Vanadium steel castings not heat-treated gave corresponding results of 135 and 43 foot-pounds, respectively.

The results indicate that even those temperatures well within the range of ordinary atmospheric conditions have a marked effect upon castings subjected to impact. The investigation will be continued and further information will be secured.

—*(Investigation under the direction of Professor R. W. Moffatt, University of Manitoba).*

The Efficiency of Screening

Co-operating Organization:

McGill University.

In the year 1923 the Committee on Milling Methods of the American Institute of Mining and Metallurgical Engineers placed an investigation of screening first on its list of needed ore-dressing researches. The subject had for some time formed a part of the research program of the Mining Department of McGill University, and it was at this time definitely assigned as a basis for post-graduate study. Large additions were made to the laboratory equipment available, until the department possessed the most complete equipment for screening research of any ore-dressing laboratory on the continent.

The use of screens of one type or another is almost indispensable to modern ore-dressing operations. In recent years there has been a large development of mechanically agitated screens, the object of the vibration imparted being chiefly to remove from the screen openings those particles which are just too large to go through, and which tend to fill up the openings and keep from passing through many fine particles which definitely belong with the undersize. The periodic removal of these grains therefore not only greatly increases screen capacity but also improves the separation.

The first part of this research consisted of an extensive series of large-scale tests on a well known make of electrically vibrated screen, chiefly to investigate the blinding of screens by difficult grains. There was also used a complete series of small screens designed especially for the investigation in order to make accurate screen analyses of samples under test. In all these tests an attempt was made to vary only one factor at a time in order that the effect might be determined as accurately as possible. The results throw considerable light upon the proper design of mechanically vibrated screens.

The second series of tests was planned to determine the relation existing between screen capacity and particle size. From theoretical considerations it may be readily deduced that large particles should pass through large openings at a greater number of pounds per minute than small particles through small holes. When the capacities are plotted for many sizes of particles and openings no straight-line relation is observed, however. In fact, many marked irregularities are found, the nature of these depending upon the characteristics of the sample under test. A theory has been advanced to account for the observed variations. Proof has also been obtained of the incorrectness of the Warner theory of difficult grains.

—*(Investigation under the direction of Prof. J. B. Porter, McGill University.)*

The Tar Sands of Northern Alberta

Co-operating Organization:
University of Alberta.

The development of methods for the utilization of the great deposits of tar sands in northern Alberta is a matter of great importance to Canada. Some progress is being made, but a knowledge of the chemical constitution of the bituminous portion of these sands is essential to any scientific attack upon the problem. It is to secure information as to the chemical nature of the oils found in the tar sands that this investigation has been undertaken.

A sample of tar sand was obtained from a shaft, at some distance from the surface, and repeated extractions of the contained oil were made with petrolic ether. Great difficulty was obtained in filtering it, so it was re-extracted repeatedly with 95 per cent ethyl alcohol, petrolic ether being added from time to time. The alcohol was then removed by evaporation on a water bath at a pressure of 25 mm. The residue obtained was subjected to distillation at a pressure of about 1 mm., the temperature being carried up to 220 deg. C. Much frothing and bumping took place in spite of all possible precautions being taken.

The distillate obtained was redistilled a number of times, with gradually decreasing trouble from bumping, and four fractions were made. That distilling between 85 and 120 deg. C. at 20 mm. pressure was analyzed and gave the following results: carbon, 83.8 per cent; hydrogen, 14.2 per cent; sulphur, 1.5 per cent. The hydrocarbons in this oil evidently correspond closely to the formula C_nH_{2n}.

The four fractions produced were then fractionally distilled several times, with the formation of twelve different products. These are now being extracted with liquid sulphur dioxide, and they will later be analyzed. Their composition and properties will be carefully compared with those obtained from oils distilled from an outcrop of oil shale, to see if the oils are identical.

—*(Investigation under the direction of Prof. A. Lehmann, University of Alberta.)*

The Precipitation of Iron and Silica under Natural Conditions

Co-operating Organization:
University of Toronto.

The science of geology has in recent years been of the greatest service in the location of new mineral deposits and in determining the extension of known deposits, as well as in furnishing information of value in connection with the mining and beneficiation of ores. In spite of the rapid development of this science, however, there are many branches of the subject in which our knowledge is yet very deficient. Many theories have been advanced to account for the formation of mineral deposits as they exist to-day, but owing to the great difficulty of duplicating natural conditions little has been definitely determined regarding the nature of mineral deposition.

This investigation has been undertaken for the special purpose of throwing light upon the origin of the pre-Cambrian iron formations. It is also hoped that it may serve to clear up many of the contradictory statements which appear in the literature dealing with the deposition of silica in nature. The investigation is as yet only in its early stages, but it has already given much information regarding the processes involved.

A considerable amount of iron has in the past been mined from certain bog lakes in Ontario and Quebec and there is considerable evidence that in some

cases the deposition of iron ore is still going on. A number of samples of water from these lakes have therefore been analyzed. It has been found that very little iron is now being carried in solution in, or is being precipitated from the water of Lac-à-la Tortue and Calumet lake in the province of Quebec. In the former of these two lakes only 1.8-2.5 parts per million of iron oxide are carried in solution compared with 3.8 parts per million in Hematite lake, Ontario, where iron oxide is still collecting in concretions on the bottom of the lake. In the water of Calumet lake there are only 1.3 parts per million of iron oxide in solution. Certain streams flowing into these lakes contain more iron oxide, however; thus we have for water entering Hematite lake 14.4 parts per million, Lac-à-la Tortue, 6.6, and Calumet lake, 2.2. It thus appears that owing to changes in water level or to the exhaustion of the iron supply in the sands through which the spring water percolates, the bog lakes, from which so much iron was obtained in the early history of the mining industry in Quebec, are not now depositing any appreciable amount of iron.

It has been observed that in any given area the proportion of iron carried in solution is largely dependent upon the amount of organic matter in the water. This organic matter serves as a peptizing agent in preventing precipitation. On the other hand the proportions of carbonates and bicarbonates of lime and magnesia do not materially effect the quantity of iron carried.

Experiments with various salts of iron show that the oxide is quickly precipitated when the water is inoculated with unsterilized muck from stream bottoms. It is not precipitated by the same material when it has been sterilized, thus showing the influence of bacteria on iron precipitation. The rate of precipitation does not appear to be affected by the presence or absence of light, oxygen or carbon dioxide. Iron oxide is quickly precipitated when coming in contact with the electrolytes of sea water, while the silica comes down slowly from similar solutions. This indicates how banded iron formations may develop, for the silica in such a mixture would be distributed from top to bottom of the deposit, while the iron would be concentrated into layers, as frequently found in nature.

The iron precipitated from inoculated solutions is granular and generally resembles in character the common brown and yellow ore limonite. It is very different from the iron precipitated by hydrolysis, which forms red flocculent deposits similar to those obtained by the precipitation of iron with ammonia.

Previous work by other investigators on the deposition of silica has been carried out with silica concentrations far in excess of those found in natural waters. In this investigation, however, experiments have been largely confined to those proportions of silica which are found in natural waters and the results are strikingly different from those obtained from concentrated solutions.

When water containing only 25 parts per million or less of silica is treated with magnesium sulphate it is completely hydrolyzed. On the contrary, when concentrated solutions of sodium silicate are treated with magnesium sulphate a heavy precipitate quickly forms. This has been mistaken by some geologists for colloidal silica, whereas it appears to be magnesium silicate.

Of all the facts bearing on the precipitation of silica that of time appears to be the most important. It is very much less important in the case of iron.

—*(Investigation under the direction of Prof. E. S. Moore, University of Toronto).*

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FINANCIAL STATEMENT FOR THE FISCAL YEAR ENDING MARCH 31, 1927

Receipts

Appropriation from Parliament	$150,000 00	
Grant from Sun Life Assurance Company for Tuberculosis Research	10,000 00	
Miscellaneous revenue, including refunds	3,332 37	
		$163,332 37

Expenditures

Grants in aid of research		$ 74,464 89	
Fellowships	$ 9,130 00		
Studentships	16,900 00		
Bursaries	15,075 00		
		$ 41,105 00	
Fees to International Research Council, its Scientific Unions, etc.		169 30	
Laboratory equipment and operation		4,768 56	
Publication of reports and bulletins and general printing		2,278 37	
Administrative expenses of Associate Committees		758 70	
General administration		5,364 91	
Travelling expenses of members of National Research Council and staff		8,690 11	
Travelling expenses of Associate Committees		2,651 70	
Salaries and honoraria		23,074 52	
			$163,326 06
Refund to Receiver General			6 31
			$163,332 37

APPENDIX A

Assisted Researches in Progress under Grants Awarded during 1926-27

Subject of Research	Grantee	Where carried on	Amount awarded
Tuberculosis in man and animals	Associate Committee on Tuberculosis Research	Seven co-operating laboratory groups	$25,000 00
Cereal Grain Rust	Associate Committee on Cereal Grain Rust.	Four co-operating laboratory groups	10,000 00
Problems of the Grain Industry	Associate Committee on Grain Research.	Four co-operating laboratory groups	3,000 00
Heating and insulation of buildings	Associate Committee on Heating and Insulation.	Three co-operating laboratory groups	4,500 00
Factors governing the milling and baking quality of wheat.	Dr. Robt. Newton	Dept. of Field Husbandry, University of Alberta, Edmonton, Alta.	3,700 00
Pressure variations inside the cylinders of the internal combustion engine.	Dr. D. A. Keys	Dept. of Physics, McGill University, Montreal, P.Q.	1,000 00
Ultra sonics (inaudible sound waves)	Prof. R. W. Boyle	Dept. of Physics, University of Alberta, Edmonton, Alta.	1,000 00
Destruction of wood piling by marin boring animals.	eAssociate Biological Committee.	Atlantic Biological Station of the Biological Board of Canada.	250 00
Engineering standardization	Associate Committee on Engineering Standards	Ottawa, Ont	5,000 00
Wireworms and false wireworms	Prof. E. H. Strickland	Dept. of Entomology, University of Alberta, Edmonton, Alta.	1,200 00
Investigation on concrete deterioration	Prof. T. Thorvaldson	Dept. of Chemistry, Univ. of Saskatchewan, Saskatoon, Sask.	6,000 00
Bacillary white diarrhoea in poultry	Prof. H. W. Hill and Prof. E. A. Lloyd	Dept. of Bacteriology, University of British Columbia, Vancouver, B.C.	1,200 00
Use of ultra short waves for direction indicating apparatus.	Dr. L. V. King	Department of Physics, McGill University, Montreal, P.Q.	1,220 00
The utilization of Canadian magnesite	Associate Committee on Magnesite.	Laboratories of the Department of Mines, Ottawa, Ont.	5,000 00
Storage of fruit in warehouses	Associate Committee on Fruit Storage.	Dalhousie University, Halifax, N.S.	3,000 00
The inheritance of sugar and starch in Indian corn.	Prof. H. F. Roberts	Department of Botany, University of Manitoba, Winnipeg, Man.	600 00
Generation of explosive gases in electric water heaters and boilers operating on A.C.	Prof. J. W. Shipley	Department of Chemistry, University of Manitoba, Winnipeg, Man.	700 00
Generation of electricity using a windmill as the prime mover.	Prof. A. R. Greig	Department of Mechanical Engineering, University of Saskatchewan, Saskatoon, Sask.	1,500 00
Rotary derivatives of a boat type seaplane.	Prof. J. H. Parkin	Aero Dynamic Laboratory, University of Toronto, Toronto, Ont.	1,800 00
Fog alarm research	Dr. L. V. King	Dominion Lighthouse, Prescott, Ont	1,200 00
The exploitation of high speed cathode rays.	Dr. J. C. McLennan	Department of Physics, University of Toronto, Toronto, Ont.	2,000 00
Radium emanation	Dr. G. H. Henderson and Dr. D. McIntosh.	Department of Physics, Dalhousie University, Halifax, N.S.	2,300 00
Dielectric losses in different classes of porcelain.	Prof. A. V. Wendling	Ecole Polytechnique, Montreal, P.Q.	2,000 00
Emission and absorption spectra in the infra-red and extreme ultra-violet regions.	Dr. J. C. McLennan	Department of Physics, University of Toronto, Toronto, Ont.	1,500 00
The spermatozoa of bulls and horses	Prof. A. Savage	Department of Animal Pathology, University of Manitoba, Winnipeg, Man.	750 00
Relation of silver ores to diabase	Dr. E. S. Moore	Department of Geology, University of Toronto, Toronto, Ont.	800 00
Investigation on the glucosides of plants indigenous to Western Canada.	Prof. A. T. Cameron	Department of Biochemistry, University of Manitoba, Winnipeg, Man.	450 00
Magnetic susceptibility of the alkali metals.	Dr. E. S. Bieler	Department of Physics, McGill University, Montreal, P.Q.	1,600 00
Experimental study of precipitation of iron and silica.	Dr. E. S. Moore	Department of Geology, University of Toronto, Toronto, Ont.	1,000 00
Effect of radiant energy on protoplasm	Prof. A. H. Hutchinson	Department of Botany, University of British Columbia, Vancouver, B.C.	1,000 00
Structural welding	Prof. P. Gillespie	Mechanics of Material Laboratory, University of Toronto, Toronto, Ont.	500 00
Surface energy of solids	Prof. F. M. G. Johnson and Dr. O. Maass.	Department of Chemistry, McGill University, Montreal, P.Q.	1,100 00
Vegetable resources and flora of Eastern Canada.	Fr. Marie-Victorin	Department of Botany, University of Montreal, Montreal, P.Q.	1,300 00
The habits and life history of the smaller mammalia of the Prairies.	Dr. C. H. O'Donoghue	Department of Zoology, University of Manitoba, Winnipeg, Man.	800 00
Properties of hygroscopic substances	Prof. A. N. Shaw	Department of Physics, McGill University, Montreal, P.Q.	1,500 00
Chlorination of methane	Prof. M. C. Boswell	Department of Organic Chemistry, University of Toronto, Toronto, Ont.	1,500 00
The effect of light on life processes	Prof. A. B. Klugh	Department of Biology, Queen's University, Kingston, Ont.	500 00
Catalytic action of ultra-violet light	Prof. L. Bourgoin	Ecole Polytechnique, Montreal, P.Q.	1,200 00
Effects of electric and magnetic fields. Stark effect in helium. Stark effect in molecular spectra.	Prof. J. S. Foster	Department of Physics, McGill University, Montreal, P.Q.	1,500 00
Further investigation on gas laws	Dr. O. Maass	Dept. of Chemistry, McGill University, Montreal, P.Q.	800 00
The alkaloids of the ragwort	Dr. R. H. F. Manske	Department of Chemistry, Queen's University, Kingston, Ont.	60 00
Investigation of mistletoe parasitic on Jack pine.	Miss E. S. Dowding	Department of Botany, University of Alberta, Edmonton, Alta.	750 00
Effects of certain reagents upon root tip sections of Trillium grandiflora.	Prof. R. O. Earl	Department of Biology, Queen's University, Kingston, Ont.	100 00

APPENDIX B

Additional Researches in Progress during 1926-27 under Grants Previously Awarded

Subject of Research	Grantee	Where carried on
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.
Reforestation experiments in cut-over and burnt-over lands of New Brunswick.	Associate Committee on New Brunswick Forest Problems.	Forestry Branch, Department of Interior, Ottawa, and Lands and Mines, Fredericton, N.B.
The nature of winter hardiness in crop plants.	Dr. Robt. Newton.....	Department of Field Husbandry, University of Alberta, Edmonton, Alta.
The chemistry of fish curing.....	Dr. A. B. Macallum.....	Department of Biochemistry, McGill University, Montreal, P.Q.
Utilization of Canadian iron ores.....	Sub-Committee on Iron Ores of the Assoc. Committee on Mining and Metallurgy.	Hamilton, Ont.
Best methods for obtaining accurate results in testing varieties, strains and treatments of grain.	Associate Committee on Accurate Plot Work.	Dominion Experimental Farms.
The life history and habits of the Tabanidae (Horseflies).	Prof. A. E. Cameron.....	Department of Zoology, University of Saskatchewan, Saskatoon, Sask.
Collecting, identifying, recording and mounting the Marine Algae of the Canadian Atlantic Coast.	Prof. H. P. Bell.....	Department of Botany, Dalhousie University, Halifax, N.S.
Chemical Separation: Identification and possible synthesis of antipressor substance from hepatic tissue.	Dr. A. A. James.....	Department of Biochemistry, University of Western Ontario, London, Ont.
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.
Researches in the field of low temperatures..	Dr. J. C. McLennan.....	Department of Physics, University of Toronto, Toronto, Ont.
Fog signalling.....	Dr. L. V. King.....	Department of Physics, McGill University, Montreal, P.Q.
X-rays.....	Dr. J. A. Gray.....	Department of Physics, McGill University, Montreal, Que.
The recovery of helium from natural gas.....	Associate Committee on Helium.	Department of Physics, University of Toronto, Toronto, Ont.
Laws governing the screening of crushed ores.	Dr. J. B. Porter.....	Department of Mining Engineering, McGill University, Montreal, Que.
Determining the elimination of magneto noises from aircraft receiving sets.	Prof. H. Vickers.....	Department of Electrical Engineering, University of British Columbia, Vancouver, B.C.
Effect of violet rays upon (1) laying hens, (2) breeding hens, (3) eggs for incubation, (4) growing chicks.	F. C. Elford.....	Dominion Experimental Farms, Ottawa, Ont.
Fungi.....	Dr. A. H. R. Buller.....	Department of Botany, University of Manitoba, Winnipeg, Man.
Further studies on the parathyroid hormone and a study of the blood chemistry in animals with the suprarenal glands removed.	Dr. J. B. Collip.....	Department of Biochemistry, University of Alberta, Edmonton, Alta.
The effect of temperature on the strength of castings.	Prof. R. W. Moffatt.....	Department of Civil Engineering, University of Manitoba, Winnipeg, Man.
Investigation of the mechanical properties of metals at low temperatures.	Profs. I. F. Morrison, and A. E. Cameron.	Department of Mining Engineering, University of Alberta, Edmonton, Alta.
Ultra-violet spectroscopy with vacuum-grating spectrograph.	Dr. R. J. Lang and Prof. Stanley Smith.	Department of Physics, University of Alberta, Edmonton, Alta.
Colour vision.....	Dr. F. Allen.....	Department of Physics, University of Manitoba, Winnipeg, Man.
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.
Grinding ore in ball mills and rock crushing by 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. Lehmann.....	Department of Chemistry, 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, P.Q.
The deterioration of rubber by oxidation and the nature of resin present in rubber.	Dr. G. S. Whitby.....	Department of Chemistry, McGill University, Montreal, P.Q.
The onion maggot.....	Dr. E. M. DuPorte.....	Department of Zoology, Macdonald College, P.Q.
Vitamines.....	Associate Food Research Committee.	Laboratory of Food Chemistry, University of Toronto, Toronto, Ont.
The Lake Agassiz clay deposit.....	Prof. R. C. Wallace.....	Department of Geology, University of Manitoba, Winnipeg, Man.
Bacteriology of certain sea fish.....	Dr. F. C. Harrison.....	Department of Bacteriology, Macdonald College, Que.

APPENDIX C

Assisted Researches completed Prior to 1926-27

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	. M. Dawson.
Surface tension in liquids and emulsions	Dr. J. C. McLennan.
Utilization of milkweed	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	Horace reeman.
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	Prof. 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.
The preparation (production) of metallic barium	Prof. H. E. Bigelow.
The resistance of plants to low temperatures	Prof. J. . Lewis.
The Biological origin of false wild oats	Prof. J. R. Fryer.
Oil from shales	Prof. A. E. Flynn.

APPENDIX D

Regulations governing 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 seven 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, and 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.

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 acknowledgment 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.

APPENDIX E

List of Scholarships held during the Year 1926-27

FELLOWSHIPS

Grantee	Graduated	Where held	Subject of Research Work
D. M. Morrison, Ramsay Memorial Fellowship.	B.Sc., University of British Columbia, M.Sc., Ph.D., McGill.	Department of Physical Chemistry, Cavendish Laboratories, Cambridge University, Cambridge, Eng.	Experiments on the chemical activity of helium.
R. S. Jane, British Empire Exhibition Scholarship.	B.A.Sc., University of British Columbia, M.Sc., Ph.D., McGill.	Department of Colloidal Chemistry, Sir John Cass Technical Institute, London, Eng.	Die Beobachtung der kataphorese in farblosen Solen.
W. H. Barnes.....	B.Sc., M.Sc., McGill.....	Department of Physical Chemistry, McGill University, Montreal, P.Q.	Some of the thermal properties of ice.
G. W. Holden.....	B.A., Bishop's College, M.Sc., McGill.	Department of Chemistry, McGill University, Montreal, P.Q.	Hydrogen peroxide as an oxidising agent in acid solution.
W. M. Martin.....	B.S.A., Alberta.....	Department of Plant Biochemistry, University of Alberta, Edmonton, Alta.	The nature of winter hardiness in crop plants.
M. J. Mulligan.....	B.A., M.A., Toronto.....	Department of Physical Chemistry, University of Toronto, Toronto, Ont.	The electrolysis of glass.
C. W. Sweitzer.....	B.A., M.A., Toronto.....	Department of Chemistry, University of Toronto, Toronto, Ont.	Light scattering in salt solutions.

STUDENTSHIPS

C. H. Bayley.....	B.A.Sc., M.A.Sc., M.A., Toronto.	Department of Chemistry, University of Toronto, Toronto, Ont.	Some properties of platinum hydrosols.
P. A. Berard.....	B.A., Joliette Seminary.....	Department of Chemistry, University of Montreal, Montreal, P.Q.	The rapidity of the absorption of the gas SO_2 in alkali solutions.
K. H. Butler.....	B.A., Dalhousie.....	Department of Chemistry, McGill University, Montreal, P.Q.	A study of hydrogen disulphide.
Miss M. L. Chalk.....	B.A., M.Sc., McGill.....	Department of Physics, McGill University, Montreal, P.Q.	Stark effect.
N. D. Clare.....	B.Sc., M.Sc., Manitoba.....	Department of Chemistry, University of Toronto, Toronto, Ont.	The supersaturation of gases in liquids.
R. N. Crozier.....	B.A., M.A., Univ. of B.C.....	Department of Chemistry, McGill University, Montreal, P.Q.	Constitution of caoutchouc with special reference to the mode of polymerization.
C. M. Jephcott.....	B.A., M.A., Toronto.....	Department of Chemistry, University of Toronto, Toronto, Ont.	Friedel and Craft's reaction on quinolinic anhydride.
S. G. Lipsett.....	B.Sc.,M.Sc., Manitoba, Ph.D., McGill.	Department of Chemistry, McGill University, Montreal, P.Q.	The heat of solution and surface energy of certain inorganic salts.
G. L. Matheson.....	B.Sc., M.Sc., McGill.....	Department of Chemistry, McGill University, Montreal, P.Q.	The properties of pure hydrogen peroxide.
J. H. McLeod.....	B.Sc., Sask., M.A., Toronto..	Department of Physics, University of Toronto, Toronto, Ont.	Nature of the auroral green line at λ 5577 AV.
C. D. Niven.....	B.Sc., Aberdeen, M.A., Ph.D., Toronto.	Department of Physics, University of Toronto, Toronto, Ont.	Conductivity of metals at low temperatures.
A. L. Patterson.....	B.Sc., M.Sc., McGill.....	Faserstoffechemie, Kaiser Wilhelm Institute, Berlin, Germany.	The determination of the size and orientation of the crystallite particles in cellulose fibres of various origin.
Wm. Rowles.....	B.Sc., Sask., M.Sc., McGill...	Department of Physics, McGill University, Montreal, P.Q.	The Stark effect.
W. W. Simpson.....	B.A., University of British Columbia, M.A., Ph.D., Toronto.	Department of Physiology, University of Toronto, Toronto, Ont.	Studies in intermediary carbohydrate metabolism.
F. R. Terroux.....	B.A., Laval, B.Sc., McGill....	Department of Physics, McGill University, Montreal, P.Q.	The absorption of radiation (from ultra-violet to the infra-red) by ice and water.
K. Thomson.....	B.A., M.A., W. Ontario.....	Department of Physics, University of Toronto, Toronto, Ont.	The luminescence of solid nitrogen under cathode ray bombardment.
J. O. Wilhelm.....	B.Sc., Sask., M.A., Toronto...	Department of Physics, University of Toronto, Toronto, Ont.	The crystal structure of solidified gases by means of X-rays.

APPENDIX E

BURSARIES

Grantee	Graduated	Where held	Subject of Research Work
L. V. Bell	B.Sc., Alberta	Department of Geology, University of Toronto, Toronto, Ont.	Effects produced by intrusion of igneous rock on the surrounding sedimentary rocks in the Kirkland Lake area.
G. B. Carpenter	B.A., University of British Columbia, M.A., McGill.	Department of Chemistry, McGill University, Montreal, P.Q.	Aberrations from the Ideal Gas Laws in system of one and two components.
C. C. Coffin	B.A., Dalhousie	Department of Physical Chemistry, McGill University, Montreal, P.Q.	The preparation and physical properties of φ, β and γ butylene and the reaction velocities when these substances are allowed to react with the halogen acids in liquid state.
Miss E. Cohen	B.A., Toronto	Department of Physics, University of Toronto, Toronto, Ont.	Study of the magnetic susceptibility of the alkali metals.
A. Durnford	B.A., M.A., W. Ontario	Department of Physics, University of Toronto, Toronto, Ont.	The Zeeman effect for platinum.
A. B. A. Evans	B.Sc., Birm., M.Sc., McGill.	Department of Chemistry, McGill University, Montreal, P.Q.	The study of the effect of non-caoutchouc constituents on the vulcanization of rubber.
H. Greenberg	B.Sc., McGill	Department of Chemistry, McGill University, Montreal, P.Q.	(a) Influence of protein on the vulcanization of rubber. (b) Study of the constituents of the serum of Hevea Latex.
J. L. Hart	B.A., M.A., Toronto	Department of Limnobiology, University of Toronto, Toronto, Ont.	Food and variations of the whitefish.
E. O. Houghton	B.Sc., McGill	Department of Chemistry, McGill University, Montreal, P.Q.	Cyclic acetal formation and polymerisation.
H. W. Johnston	B.Sc., McGill	Department of Chemistry, McGill University, Montreal, P.Q.	Preparations and properties of the sulphonic derivatives of unsaturated substances.
G. C. Laurence	B.Sc., Dalhousie	Department of Physics, Dalhousie University, Halifax, N.S.	Determination of the range of thorium and uranium alpha particles by the Wilson Cloud Track Method.
Miss M. E. Mackay	B.A., M.A., Dalhousie	Department of Physiology, Dalhousie University, Halifax, N.S.	Meaning of double innervation of the salivary glands. Part played by chlorine and histamine in the process of external secretion of digestive glands.
Leo Marion	B.Sc., Queen's	Department of Chemistry, Queen's University, Kingston, Ont.	Study of some reactions of β-substituted φ-cyanoacrylic acids and their esters.
C. F. Morrison	B.E., Sask	Department of Civil Engineering, McGill University, Montreal, P.Q.	Study of secondary stresses in certain roof trusses.
C. R. Peaker	B.Sc., Sask	Department of Chemistry, University of Sask., Saskatoon, Sask.	Thermo chemistry of the calcium silicates and aluminates (those found in cement clinker)
L. M. Pidgeon	B.A., Manitoba	Department of Chemistry, McGill University, Montreal, P.Q.	Formation and polymerization of acetals.
A. D. Robinson	B.A., Sask	Department of Chemistry, University of Sask., Saskatoon, Sask.	Protein quality of flour milled from Saskatchewan wheat.
E. W. Samson	B.Sc., M.Sc., Manitoba	Department of Physics, University of Manitoba, Winnipeg, Man.	Spectroscopy: (a) Electrically stimulated flames.
Miss M. Spence	B.A., M.A., Queen's	Department of Bacteriology, Queen's University, Kingston, Ont.	The toxin and antitoxin reactions of Bacillus-Welchii in connection with pernicious anaemia.
B. F. Sutherland	B.A.Sc., University of British Columbia.	Department of Chemistry, McGill University, Montreal, P.Q.	The viscosity of gases.

APPENDIX F

List of 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	Research Assistant, University of Toronto, Toronto, Ont.
N. J. Atkinson, B.Sc., M.Sc.	Saskatchewan	Assistant Entomologist, Canadian Department of Agriculture, University of Saskatchewan, Saskatoon, Sask.
W. F. Baker, B.A., B.Sc., M.Sc.	Manitoba	Graduate Student in Department of Economic Geology, University of Toronto, Toronto, Ont.
H. C. Bates, B.A., M.A.	Toronto	Research Physicist, Corning Glass Works, Corning, N.Y.
R. W. Beattie, B.Sc., M.Sc.	Queen's	Research Fellow, Northwestern University, Evanston, Ill.
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 Botany, Dalhousie University, Halifax, N.S.
G. H. Berkeley, 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	Geological Staff, Anglo American Corporation of South Africa, Broken Hill, Northern Rhodesia, Africa.
Miss E. L. Bishop, B.A., M.A.	Toronto	Georgetown High School, Georgetown, Ont.
L. L. Bolton, B.A., M.A.	British Columbia	Scientific Assistant to International Fisheries Commission (Can. and U.S.), Seattle, Wash.
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	Research Associate, United States Bureau of Standards, Washington, D.C.
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).
Paul Cartier, B.Sc., L.es Sc.	St. Hyacinthe	Professor of Chemistry, Ecole des Hautes Etudes Commerciales, Montreal, P.Q.
H. M. Cave, B.A., M.A.	Queen's	Holder 1851 Exhibition Scholarship, Cambridge, England.
G. C. Chamberlain, B.S.A.	Ontario Agricultural College.	Assistant Plant Pathologist, Dominion Laboratory of Plant Pathology, St. Catharines, Ont.
Miss H. D. Chataway, B.A., B.Sc., M.Sc., Ph.D.	Manitoba	Chemist, Northern Paint Company, Winnipeg, Man.
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	Chemist, Atlantic Experimental Station for Fisheries, 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	Physical Laboratory, University of Edinburgh, Edinburgh, Scotland.
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, Ont.
Miss A. E. Dempsey, B.A., M.A.	McMaster	Married (Mrs. M. Augustine), Research on Tuberculosis at Henry Phipps Institute, Philadelphia, Pa.
A. B. dePassillé, B.Sc.A , I.C.	Montreal	Professor of Chemistry, Ecole Polytechnique, University of Montreal, Montreal, P.Q.
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 Company, 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 Professor of Chemistry, Medical College, University of Virginia, Richmond, Va.
H. R. Foreman, B.A., M.A.	Toronto	President and Manager, H. R. Foreman & Co., Ltd., Oil Heating and Mechanical Refrigeration Engineers, 75 King Street, W., Toronto, Ont.
J. H. Fox, B.A., M.A.	Western Ontario	Teacher of Physics, Windsor Collegiate Institute, Windsor, Ont.

Grantee	University where undergraduate training received	Present occupation
Miss M. A. Fritz, B.A., M.A., Ph.D.	McGill	Geological Survey, Department of Mines, Ottawa, Ont.
Miss C. W. Fritz, B.A., M.Sc., Ph.D.	McGill	Timber Pathologist, Forest Products Laboratories, Montreal, P.Q.
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, P.Q.
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), Demonstrator, Department of Zoology, McGill University, Montreal, P.Q.
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.
W. E. Graham, B.A.Sc., M.A.Sc., M.A.	British Columbia	Assistant in Electro Chemistry, University of Toronto, Toronto, Ont.
C. Greaves, B.Sc., M.Sc., Ph.D.	McGill	Junior Chemist in Division of Wood Preservation, Forest Products Laboratories, Montreal, P.Q.
H. B. Hachey, B.Sc., M.Sc.	St. Francis Xavier	Professor of Physics, University of New Brunswick, Fredericton, N.B.
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 Co., Saskatoon, Sask.
W. H. Hatcher, B.A., M.Sc., Ph.D.	McGill	Assistant Professor of Chemistry, McGill University, Montreal, P.Q.
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.
C. Y. Hopkins, B.A., M.A.	Queen's	Holder of graduate fellowship at Northwestern University, Evanston, Ill.
W. V. Howard, B.A., M.Sc., Ph.D.	McGill	Instructor in Geology and Mineralogy, University of Illinois, Urabana, 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	Geology in Northwestern Quebec for Geological Survey, Department of Mines, Ottawa, Ont.
I. W. Jones, B.A., B.Sc.	Alberta	Research Assistant, Department of Geology, University of Toronto, Toronto, Ont.
Miss M. B. Kearney, B.A., M.A.	Toronto	Instructor in Mathematics and Physics, Converse College, Spartanburg, S.C.
E. J. King, B.A., M.A., Ph.D.	McMaster	Biochemist in the Department of Banting Medical Research, University of Toronto, Toronto, Ont.
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 Chemistry, University of Lennoxville, Lennoxville, P.Q.
P. Larose, B.Sc., M.Sc., Ph.D.	McGill	Professor of Physics and Physical Chemistry, Laval University, Quebec, P.Q.
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	Physicist, Synthetic Ammonia and Nitrate Ltd., Billingham, Stockton-on-Tees, Co. Durham, England.
S. Lehrman, B.A., M.A.	Toronto	No information.
A. H. Leim, B.A., Ph.D.	Toronto	Assistant Director, Fisheries Experimental Station, Halifax, N.S.
Miss M. Levi, B.A., M.A.	Toronto	Married (Mrs. M. Rotenberg).
F. R. Lorriman, B.A., M.A., Ph.D.	Toronto	Lecturer in Chemistry, University of Toronto, Toronto, Ont.
G. H. W. Lucas, B.A., M.A., Ph.D.	Toronto	Assistant Professor, Department of Pharmacology, University of Toronto, Toronto, Ont.
A. D. Macallum, B.A., M.Sc., Ph.D.	Toronto	Research Chemist, Roessler & Hasslacher Chemical Co., Perth Amboy, N.J.
P. A. Macdonald, B.Sc., M.Sc.	Manitoba	Research student, University of Manitoba, Winnipeg.
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, P.Q.
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	Research Chemist, Fuel Section, General Motors Corporation, Detroit, Mich.
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, Department of Agriculture, Ottawa, Ont.

Grantee	University where undergraduate training received	Present occupation
W. H. McCurdy, B.A., M.A., Ph.D.	Dalhousie	American National Research Fellowship at Johns Hopkins University, Baltimore, Md.
J. L. McDonald, B.A.	St. Francis Xavier	House Officer, Boston City Hospital, Boston, Mass.
S. R. McDougall, B.Sc., M.Sc.	British Columbia	Chemical Engineer, Northern Electric Company, Montreal, P.Q.
J. W. McKinney, B.Sc., M.Sc., Ph.D.	Alberta	Research Chemist, Ethyl Gasoline Corporation, Yonkers, N.Y.
C. G. McLachlan, B.Sc., M.Sc., Ph.D.	British Columbia	Metallurgist, The Moctezuma Copper Co. (Phelps Dodge Corp.), Macozari, Sonora, Mexico.
H. R. McLarty, B.A., M.A.	McMaster	Pathologist in Charge, Dominion Laboratory of Plant Pathology, Summerland, B.C.
A. B. McLay, B.A., M.A., Ph.D.	McMaster	Research Student, Department of Physics, University of Toronto, Toronto, Ont.
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, Albert College, Belleville, Ont.
Miss A. I. McPherson, B.A., M.Sc.	McGill	Teacher of Mathematics, Trafalgar Institute, Montreal, P.Q.
W. C. McQuarrie, B.A., M.A.	Toronto	Assistant Professor of 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	Professor of Chemistry and Physics, Memorial University College, St. John's, Nfld.
G. Molleur, I.C.	Montreal	Dam construction north of Maniwaki, P.Q.
D. D. Mossman, B.Sc., M.A.	McGill	Demonstrator in Chemical Engineering, University of Toronto, Toronto, Ont.
Miss B. K. E. Mossop, B.A., M.A., A.A.A.S.	Toronto	Assistant Pathologist, Queen Alexandra Sanatorium, London, Ont.
Miss I. Mounce, B.A., M.A., M.Sc.	British Columbia	Assistant Plant Pathologist, Experimental Farm, Ottawa, Ont.
L. A. Munro, B.A., M.A.	Dalhousie	Assistant Professor of Chemistry, Manitoba Agricultural College, Winnipeg, Man.
Miss D. E. Newton, B.S.A., M.Sc.	McGill	Department of Botany, University of British Columbia, Vancouver, B.C.
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	Sister M. Emerentia, St. Joseph's Convent, Toronto, Ont.
H. G. Oddy, B.A., M.A., Ph.D.	McMaster	Assistant Professor of Chemistry, Oregon State Agricultural College, Cowallis, Oregon.
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).
Miss I. J. Patton, B.A., M.Sc.	McGill	No information.
Miss L. E. Paynter, B.Sc., M.Sc.	Saskatchewan	Research Chemist, Fort Qu'Appelle Sanatorium, Fort San, Sask.
R. A. Pelletier, B.Sc., M.Sc.	McMill	Anglo-American Corporation of S. Africa, Broken Hill, Northern Rhodesia, Africa.
J. F. Phillips, B.A.Sc., M.A.	Toronto	Chemist for Gooderham and Worts Distillery, Toronto, Ont.
R. A. Prosser, B.Sc., M.A.	Acadia	No information.
H. N. Racicot, B.A.	McMaster	Pathologist-in-Charge, Dominon Laboratory of Plant Pathology, Ste. Anne de la Pocatiere, P.Q.
C. D. Reid, B.Sc., M.Sc.	Alberta	Assistant, Department of Physics, Harvard University, Cambridge, Mass.
Miss C. E. Robertson, B.Sc., M.Sc.	McGill	Married (Mrs. O. Maass), registered for 3rd year of Ph.D., course at McGill University, Montreal, P.Q.
H. L. Robson, B.Sc., A.C.I.C.	Saskatchewan	Chief Chemist, Burnham Chemical Co., Westend, San Bernardino Co., Calif.
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.
John Russell, B.A., M.Sc., Ph. D.	British Columbia	Assistant Professor of Chemistry, University of Western Ontario, London, Ont.
J. O. G. Sanderson, B.Sc., M.Sc.	Alberta	Research Assistant, Department of Geology, University of Toronto, Toronto, Ont.
J. E. Saunders, B.Sc., M.Sc.	McGill	Surveyor with the South American Gold Areas, Ltd., Sao Bento, E.F.C.B., Minas Gereas, Brazil.
D. A. Scott, B.A., M.A.	Toronto	Assistant 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.
B. Shaffer, B.A.Sc., M.A.Sc.	Toronto	No information.
Miss E. Shanly, B.A., M.Sc.	McGill	No information.
W. W. Shaver, B.A., M.A., Ph.D.	Toronto	No information.
G. M. Shrum, B.A., M.A., Ph.D.	Toronto	Assistant Professor of Physics, University of British Columbia, Vancouver, B.C.

Grantee	University where undergraduate training received	Present occupation
H. desB. Sims, B.A., M.A.	Toronto	Assistant in Department of Chemistry, University of Toronto, Toronto, Ont.
C. Sivertz, B.A.Sc., M.Sc., Ph.D	British Columbia	Instructor in Chemistry, University of Western Ontario, London, Ont.
V. Sivertz, B.S., M.S., Ph.D	Washington	Instructor in Chemistry, University of Washington, Seattle, Wash.
C. W. Small, B.Sc., M.A	Acadia	Instructor in Chemistry, Acadia University, Wolfville, N.S.
H. G. Smith, B.A., M.A	Toronto	Demonstrator and Research Assistant in Physics, University of Toronto, Toronto, Ont.
Miss J. D. Spier, B.A., M.Sc	McGill	Demonstrator, Department of Botany, McGill University, Montreal, P.Q.
H. D. Squires, B.A., M.Sc	New Brunswick	No information.
E. W. R. Steacie, B.Sc., M.Sc., Ph.D	McGill	Sterry Hunt Fellow in Chemistry, McGill University, Montreal, P.Q.
H. N. Stephens, B.A., M.A., Ph.D	McMaster	Assistant Professor of General Inorganic Chemistry, University of Minnesota, Minneapolis, Minn.
Miss E. M. Taylor, B.A., M.A., Ph.D	Toronto	Research Assistant, Connaught Laboratories, University of Toronto, Toronto, Ont.
W. W. Thomson, B.Sc., M.Sc	McGill	Industrial Research, Bennett's Limited, Chambly Canton, P.Q.
A. S. Townshend, B.Sc., M.Sc	Queen's	Demonstrator, Department of Chemical Engineering and registered as Ph.D. candidate, University of Toronto, Toronto, Ont.
Wm. Ure, B.A.Sc., M.A.Sc	British Columbia	Teaching fellow in Chemistry, California Institute of Technology, Pasadena, Calif.
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.
E. E. Watson, B.Sc., M.Sc	McGill	Moyse Travelling Fellowship, Cavendish Laboratory, Cambridge, England.
Miss M. Weinberg, B.A., M.A., M.Sc	Manitoba	No information.
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	Prevented from doing scientific work, at present at Kentville Sanatorium.
W. S. Yarwood, B.Sc., M.Sc	Manitoba	Assistant Professor of Geology, Macalester College, St. Paul, Minn.
F. H. Yorston, B.Sc., M.Sc	McGill	Holder of 1851 Exhibition Scholarship, at Battersea Polytechnic, University of London, London, England.
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	Assistant Professor of Physics, University of Manitoba, Winnipeg, Man.

APPENDIX G

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 professor 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 his 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 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.

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: 50 per cent on October 1; 40 per cent on February 1, or thereafter, on receipt of a satisfactory first half-yearly report; 10 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.

APPENDIX H

Classified Statement of Expenditures 1916-27

Year	Research Activities and Grants	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
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
1926–27	79,233 45	41,105 00	2,278 37	6,292 91	8,690 11	2,651 70	23,074 52	163,326 06
	445,833 87	284,668 66	20,929 61	56,118 00	54,581 00	27,555 87	203,582 09	1,093,269 10
Average shown in percentage	40·8%	26·0%	1·9%	5·1%	5·0%	2·5%	18·7%	100%

APPENDIX I

List of Papers covering Researches carried out with Assistance from the National Research Council

Title of Paper	Author	Where Published	Date Published
Anatomy			
The Rate of Growth of the Sea Mussel *(Mytilus edulis L.)* at St. Andrews, N.B., Digby, N.S., and in Hudson Bay.	Mossop, Miss B. K. E...	Trans. of the Royal Canadian Institute.	1922
A Study of the Sea Mussel *(Mytilus edulis Linn.)*.	Mossop, Miss B. K. E...	Cont. to Can. Biology.....	1921
Animal Husbandry			
A Statistical Study of the Head Length Variability of Bovine Spermatozoa and its Application to the Determination of Fertility.	Savage, A., Williams, W. W. and Fowler, N. M.	Trans. of Roy. Soc. of Canada, Sec. V.	1927
Methods of Determining the Reproductive Health and Fertility of Bulls: A Review with Additional Notes.	Williams, W. W. and Savage, A.	Ithaca, N.Y., Cornell Veterinarian.	Oct., 1927
Bacteriology			
Red Discolouration of Cured Codfish.....	Harrison, F. C. and Kennedy, Miss M.	Ottawa, National Research Council Report No. 11.	1922
Red Discolouration of Cured Codfish (Scientific Data).	Harrison, F. C. and Kennedy, Miss M.	Roy. Soc. of Can., Sec. V.....	
Discolouration, Smut or Blackening of Canned Lobster.	Harrison, F. C. and Hood, E. G.	Ottawa, National Research Council Report No. 12.	1923
Discolouration, Smut or Blackening of Canned Lobster. (Scientific Data.)	Harrison, F. C. and Hood, E. G.	Roy. Soc. of Can., Sec. V.....	
Bacteriology of Certain Sea Fish.....	Harrison, F. C., Perry, Miss H.M. and Smith, P. W. P.	Ottawa, National Research Council Report No. 19.	1926
Motility of Bacteria as Effected by Hydrogen Ion Concentration.	Reed, G. B. and MacLeod, D. J.	Journal of Bacteriology.....	March, 1924
Pigments of Pseudomonas Pyocyaneus.....	MacLeod, D. J.....	Thesis for M.A. degree Queen's University, Kingston, Ont.	April, 1923
Effects of Hydrogen-ion and Salt Concentration upon the Morphological Structure and upon Formation of Certain Bacteria.	MacLeod, D. J.....	Thesis for M.A. degree Queen's University, Kingston, Ont.	April, 1923
Discolouration in Canned Lobsters.....	Reed, G. B. and MacLeod, D. J.	Report of Biological Board of Canada.	1924
The Bacterial Content of Graded Butter.....	Sadler, W. and Vollum, R. L.	Trans. Roy. Soc. of Canada, Sec. V, pp. 105–110.	1923
An Attenuated Streptococcus Lacticus Strain (Kruse).	Sadler, W. and Vollum, R. L.	Trans. Roy. Soc. of Canada, Sec. V, pp. 111–113.	1923
The Relation of Bacteria to the Quality of Graded Butter.	Sadler, W. and Vollum, R. L.	National Research Council, Report No. 16, Ottawa.	1926
The Duration of B. Welchii Antitoxin Immunity in Rabbits.	Reed, G. B. and Spence, Miss C. M.	Journal of Infectious Diseases.	1927
The in vino Action of B. Welchii Toxin in Erythrocytes in Comparison with other Haemotoxins.	Reed, G. B., Orr, J. H., and Spence, Miss C. M.	Journal of Infectious Diseases.	1927
Biochemistry			
The Parathyroid Gland.....	Collip, J. B.....	Harvey Lectures for 1925–26..	1927
The Purification of Pepsin, its Properties and Physical Characters.	Forbes, J. C.....	Journal of Biological Chemistry.	Feb., 1927
Some Problems of the Fox-Raising Industry.....	Hunter, Andrew.....	National Research Council, Bulletin No. 8.	1920
The Antipressor Fraction from Liver Tissue and its Physiologic Action.	James, A. A., Laughton, N. B. and Macallum, A. Bruce.	American Medical Association Journal, Vol. 87, pp. 317–18.	July 31, 1926
Preliminary note on the Distribution of Glucosides in Western Canadian Plants.	McCullagh, D. Roy.....	Trans. Roy. Soc. of Canada, 1926, XX, Sec. V, pp. 331–8.	1926
Food Requirements of the Ranch Fox.....	Smith, G. Ennis.....	Ottawa National Research Council, Bulletin No. 9.	1921
The Enzymes of *B* coli communis.....	Young, E. G. and Gray, E. C.	Proc. Roy. Soc., London, Vol. 92, 135.	1921
On the Optical Rotatory Power of Crystalline Ovalbumin and Serum Albumin.	Young, E. G.....	Proc. Roy. Soc., London, Vol. 93, p. 15.	1922
The Coagulation of Protein by Sunlight.....	Young, E. G.....	Proc. Roy. Soc., London, Vol. 93, p. 235.	1922
Biology			
The Distribution and Economic Importance of Mollusca in Lake Nipigon.	Adamstone, F. B.....	University of Toronto Studies, Biol. Series No. 22.	1923
The Bottom Fauna of Lake Nipigon.....	Adamstone, F. B.....	University of Toronto Studies, Biol. Series No. 22.	1924

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Title of Paper	Author	Where Published	Date Published
BIOLOGY—*Con.*			
The Bottom Organisms of Lake Nipigon	Adamstone, F. B. and Harkness, W. J. K.	University of Toronto Studies, Biol. Series No. 24.	1923
The Distribution and Economic Importance of the Bottom Fauna of Lake Nipigon with an Appendix on the Bottom Fauna of Lake Ontario.	Adamstone, F. B.	University of Toronto Studies, Biol. Series No. 25.	1924
The Life History of Exeristes roborator Fab., a Parasite of the European Corn Borer, *Pyrausta nubilalis Hubn.*	Fox, J. H.	Ottawa, National Research Council, Report No. 21.	1927
The Origin of False Wild Oats	Huskins, C. L. and Fryer, J. R.	Scientific Agriculture	Sept., 1925
Genetical and Cytological Studies of the Origin of False Wild Oats.	Huskins, C. L.	Scientific Agriculture	May, 1926
An Investigation into the Question of Early Putrefaction of Eviscerated Fish in which the Gills have been left.	Gross, L.	Ottawa, National Research Council, Report No. 6.	1919
The Effect of Light at different Wavelengths on the Rate of Reproduction of Volpox dureus and Closterium acerosum.	Klugh, A. Brooker	New Phytologist 24: 186–190	1925
Ecological Photometry and a New Instrument for Measuring Light.	Klugh, A. Brooker	Ecology, 6: 203–237	1925
Light Penetration into the Bay of Fundy and into Chamcook Lake, N.B.	Klugh, A. Brooker	Ecology, 8: 90–93	1927
The Ecology, Food Relations and Culture of Freshwater Entomostraca.	Klugh, A. Brooker	Trans. Roy. Can. Inst., XVI: 15–98.	1927
A Land Model of the Ecological Photometer	Klugh, A. Brooker	Ecology 8: 174–176	1927
The Growth-rate of Certain Marine Algae in Relation to Depth of Submergence.	Klugh, A. Brooker and Marten, J. R.	Ecology 8: 221–231	1927
A New Cyclocypris from Eastern Canada	Klugh, A. Brooker	Trans. Roy. Can. Inst., XIV: 337–342.	1925
Marine Borers on the Atlantic Coast of Canada	M'Gonigle, R. H.	Ottawa, National Research Council, Report No. 15.	1925
Consideration of the Relation between the Distribution of Teredo Navalis and Temperature and Salinity of its Environment.	M'Gonigle, R. H.	Ottawa, National Research Council, Report No. 20.	1926
Inheritance of the Length of the Flowering and Ripening Periods in Wheat.	Thompson, W. P.	Trans. Roy. Soc. Can. 12: 69–87.	1918
Inheritance of Earliness and Lateness in Wheat	Thompson, W. P.	Trans. Roy. Soc. Can. 13: 143–162.	1919
Earliness in Wheat and its Inheritance	Thompson, W. P.	Scientific Agriculture	1921
Correlation of Characters in Hybrids of Triticum Durum and T. vulgare.	Thompson, W. P.	Genetics 10: 285–304	1925
The Life History of the Shad *(Alosa Sapidissima)* (Wilson) with Special Reference to the Factors Limiting its Abundance.	Leim, A. H.	Cont. to Can. Biology, N.S., Vol. II, p. 161–284.	1924
Cytological Conditions in Wheat in Relation to Rust Problem.	Thompson, W. P.	Scientific Agriculture 5	1925
Chromosome Behaviour in a Cross between Wheat and Rye.	Thompson, W. P.	Genetics 11: 317–332	1926
Chromosome Behaviour in Triploid Wheat Hybrids.	Thompson, W. P.	Journal Genetics 17: 43–48	1926
Preponderance of Dicoccum-like Characters and Chromosome Numbers in Hybrids between Triticum Dicoccum and T. vulgare.	Thompson, W. P. and Lillian Hollingshead	Journal Genetics 17: 283–307	1927
The Cytology of a Tetraploid Wheat Hybrid (Triticum spelta x T. monococcum).	Thompson, W. P. and Myrtle Melburn.	Amer. Jour. Bot. 14· 327–333	1927
The Cytology of Species Hybrids in Wheat	Thompson, W. P.	Scientific Agriculture	Sept., 1927
Characters of Common Wheat in Plants with Fourteen Chromosomes.	Thompson, W. P.	Trans. Roy. Soc. Canada	1927
BOTANY			
Fern Rusts of Abres	Bell, H. P.	Botanical Gazette	Mar., 1924
Seasonal Disappearance of Certain Algae	Bell, H. P.	Trans. of N.S. Inst. of Science.	Mar., 1927
Researches on Fungi, Vol. II	Buller, A. H. R.	Longmans, Green & Co., London, Eng.	1922
Researches on Fungi, Vol. III	Buller, A. H. R.	Longmans, Green & Co., London, Eng.	1924
Commercial Drug Plant Cultivation in British Columbia.	Davidson, John	Scientific Agriculture	April, 1923
Cultural Criteria for the Distinction of Wood-Destroying Fungi.	Fritz, Miss C. W.	Trans. Roy. Soc. of Canada and National Research Council Report No. 13, Ottawa.	1923
The Problem of Sex in Coprinus lagopus	Hanna, W. F.	Annals of Botany, Vol. XXXIX: 431–457.	1925
The Inheritance of Spore Size in Coprinus sterquilinus.	Hanna, W. F.	Trans. Br. Mycological Soc. Vol. XI: 219–238.	1926
The Fusarium Wilt of China Asters	Jackson, A. B.	Scientific Agriculture	Mar., 1927
Les Equisetinees du Quebec. XIV	Fr. Marie-Victorin	Cont. Lab. Bot. University of Montreal.	1927
Les Gymnospermes du Quebec. XIV	Fr. Marie-Victorin	Cont. Lab. Bot. University of Montreal.	1927
Sur un Botrychium nouveau de la flore americaine et ses rapports avec le B. Lunaria et le B. simplex.	Fr. Marie-Victorin	Trans. Roy. Soc. Can., Sec. V, 1927.	1927

Title of Paper	Author	Where Published	Date Published
BOTANY—*Con.*			
Homothallism and the Production of Fruit-bodies by Monosporous Mycelia in the Genus Coprinus.	Mounce, Miss I.....	Trans. of Br. Mycological Soc., Vol. VII: 187–217.	1921
Marine Spore Forming Bacteria.....	Newton, Miss D. E.....	Contr. to Can. Biology, N.S., Vol. I, part 3.	1923
The Bisexuality of Individual Strains of Coprinus Rostrupianus.	Newton, Miss D. E.....	Annals of Botany, Vol. XL, pp. 1–24.	1926
The Distribution of Spores of Diverse Sex on the Hymenium of Coprinus Lagopus.	Newton, Miss D. E.....	Annals of Botany, Vol. XL, pp. 891–917.	1926
Biologic Forms of Wheat Stem Rust in Western Canada.	Newton, Miss M.....	Proc. West. Can. Soc. Agron. 1: 34–35.	1920
The Occurrence of Biologic Forms of Wheat Stem Rust in Western Canada.	Newton, Miss M.....	Sc. Agriculture, 1: 213.....	1921
A Preliminary Note on the Occurrence of Biologic Forms of Wheat Stem Rust in Western Canada.	Newton, Miss M.....	Phytopath. 11: 202.....	1921
Studies in Wheat Stem Rust (Puccinia graminis tritici).	Newton, Miss M.....	Trans. Roy. Soc. Can. 3rd Series 16: 153–210.	1922
Colloidal Changes Associated with Protoplasmic Contraction.	Scarth, G. W.....	Quart. Jour. of Exp. Physiology, Vol. 14: 1 and 2.	April, 1924
The Action of Cations on the Contraction and Viscosity of Protoplasm in Spirogyra.	Scarth, G. W.....	Quart. Jour. of Exp. Physiology, Vol. 14: 1 and 2.	April, 1924
The Toxic Action of Distilled Water and Its Antagonism by Cations.	Scarth, G.W.....	Trans. Roy. Soc. of Canada, Vol. 18.	1924
The Penetration of Cations into Living Protoplasm.	Scarth, G. W.....	Am. J. Botany, Vol. 12: No. 3.	Mar., 1925
The Elasticity of Gelatin in Relation to pH and Swelling.	Scarth, G. W.....	Jour. Phys. Chem. 29.....	Aug., 1925
CHEMISTRY, GENERAL			
Precipitation of some of the Rare Earths by Creams of Insoluble Oxides and Carbonates, based on the Principle of Hydrolysis.	Neish, A. C. and Burns, J. W.	Can. Chem. Jour.....	1921
Milkweed, its Characteristics and Uses.....	Neish, A. C. and Burns, J. W.	Can. Chem. Jour.....	1921
The Acidity of the Soil from the Viewpoint of its Concentration of Hydrogen-ion.	Carleton, E. A.....	Sci. Agr. 3, 412–414.....	1923
A Comparison of the Jones Calcium Acetate Method for Lime Requirement with the Hydrogen-ion Concentration of some Quebec Soils.	Carleton, E. A.....	Soil Science 16, 79–90.....	1923
The Litmus Method for Detecting the Soil Reaction.	Carleton, E. A.....	Soil Science 16, 91–94.....	1923
Sur l'influence de quelques corps organiques sur la vitesse d'absorption du gaz carbonique par les solutions de carbonate neutre de sodium.	Riou, Paul and Cartier, Paul.	Comptes rendus de l'Academie des Sciences 7.	Feb., 1927
The Application of the Differential Pressure Method to the Estimation of the Benzene and the Total Light Oil Content of Gases.	Davis, H. S., Davis, Mary D., and MacGregor, D. G.	J. Ind. Eng. Chem. 10, 712...	1918
Studies in the Absorption of Light Oils from Gases.	Davis, H. W. and Mary D. Davis.	J. Ind. Eng. Chem. 10, 718....	1918
The Recovery of Vapours from Gases.....	Davis, H. S. and Davis, Mary D.	Ottawa, National Research Council, Report No. 2.	1918
Nicotine and Tobacco Waste.....	Hone, A. D.....	Ottawa, National Research Council, Report No. 4.	1919
The System Magnesium Sulfate-Sodium Sulfate-Water and A Method for the Separation of the Salts.	Archibald, E. H. and Gale, W. A.	Jour. of Am. Chem. Soc., Vol. XLVI, No. 8, pp. 1760–1771.	Aug., 1924
Disintegration of Portland Cement in Sulfate Waters.	Thorvaldson, T., Harris and Wolochow.	Ind. and Eng. Chem., Vol. 17, No. 5, p. 467.	May, 1925
The Properties of Pure Hydrogen Peroxide—I..	Maass, C. and Hatcher, W. H.	Jour. of Am. Chem. Soc., Vol. XLII, No. 12, pp. 2548–2569.	Dec., 1920
Hydrogen Peroxide as an Oxidising Agent in Acid Solution IV—Formaldehyde.	Holden & Hatcher.....	Trans. Roy. Soc. of Canada..	1926
Hydrogen Peroxide as an Oxidising Agent in Acid Solution V—Glyoxal.	Holden & Hatcher.....	Trans. Roy. Soc. of Canada...	1926
Hydrogen Peroxide as an Oxidising Agent in Acid Solution VI—Glycollic and Acetic Acids.	Holden & Hatcher.....	Trans. Roy. Soc. of Canada...	1926
Hydrogen Peroxide as an Oxidising Agent in Acid Solution VII—The Formation of Organic Peracids.	Holden & Hatcher.....	Trans. Roy. Soc. of Canada...	1927
The Electro-Viscous Effect in Rubber Sols.....	Whitby, G. S. and Jane, R. S.	2nd Colloid Symposium and Monograph, N.Y.	1924
Die Viskositat von Ammoniumoleat Losungen...	Hatschek, Emil and Jane, R. S.	Kolloid Zeitschrift, Vol. 38...	Jan., 1926
Untersuchungen uber den Schermodul und die Relaxation einiger sol.	Hatschek, Emil and Jane, R. S.	Kolloid Zeitschrift, Vol. 39...	1926
Die Viskositat von Suspensionem Starrer Teilchen und ihre Abhangigkeit vom Schergefalle.	Hatschek, Emil and Jane, R. S.	Kolloid Zeitschrift, Vol. 40...	1926
The Observations of Cataphoresis in Colourless Sols. 1. The Charge on Rubber in Benzene.	Humphry, R. H.....	Trans. of Faraday Soc. of London, Vol. 22.	1926
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On the Fluorescence of Aesculin	McLennan, J. C. and Cale, Miss F. M.	Proc. Roy. Soc. A., Vol. 102	1922
On the Absorption of λ5460.97 A by Luminous Mercury Vapour.	McLennan, J. C., Ainslie, D. S., and Cale, Miss F. M.	Trans. Roy. Soc. of Canada	Oct. 1922
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On the Liquefaction of Hydrogen and Helium, III Communication.	McLennan, J. C., and Shrum, G. M.	Trans. Roy. Soc. of Canada Vol. 17, p. 21.	1923
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The Secondary Spectrum of Hydrogen at very Low Temperatures.	McLennan, J. C. and Shrum, G. M.	Roy. Soc. Can. Vol. 18, p. 177.	1924
On the Luminescence of Nitrogen Argon, and Other Condensed Gases at very Low Temperatures.	McLennan, J. C. and Shrum, G. M.	Proc. Roy. Soc. London, A. Vol. 106, p. 138.	1924
An Extension of the Graphical Method of Determining Crystal Structures to the Orthorhombic System.	McLennan, J. C., and Wilhelm, J. O.	Trans. Roy. Soc. of Canada, Vol. 21.	1927
The Crystal Structure of Carbon Dioxide	McLennan, J. C., and Wilhelm, J. O.	Trans. Roy. Soc. Canada, Vol. 19, p. 51.	1925
On the Structure of the Mercury Green Line λ = 5460.74 A and of the Balmer Lines of Hydrogen.	McLennan, J. C. and Ireton, H. J. C.	Trans. Roy. Soc. of Canada, Vol. 19, p. 77.	1925

APPENDIX I

Title of Paper	Author	Where Published	Date Published
PHYSICS—*Con.*			
On the Origin of the Auroral Green Line λ = 5577 A and other Spectra Associated with the Aurora Borealis.	McLennan, J. C. and Shrum, G. M.	Proc. Roy. Soc. London, Vol. 108, p. 501.	1925
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Helium in Canada	McLennan, J. C.	Nature, p. 93	Jan. 1926.
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The Luminescence of Solid Nitrogen under Cathode Ray Bombardment.	McLennan, J. C., Ireton, H. J. C. and Thomson, K.	Proc. Roy. Soc. London, A. Vol. 116, p. 1.	1927
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On the Crystal Structure of Solid Oxygen	McLennan, J. C. and Wilhelm, J. O.	Phil. Mag. Feb. 1927	1927
Electrical Conductivity at Low Temperatures	McLennan, J. C. and Niven, C. D.	Phil. Mag. Aug. 1927	1927
The Crystal Structure of the n-Paraffins, Octane, Hexane and Pentane.	McLennan, J. C. and Plummer, W. G.	Trans. Roy. Soc. of Canada, Vol. XXI, p. 99.	1927
On the Emission and Absorption Spectra of Mercury.	McLennan, J. C. and Shaver, W. W.	Proc. Roy. Soc. London, A. Vol. 100, p. 200.	1921
The Infra-Red Spectra of Certain Elements	McLennan, J. C., Smith, H. G. and Peters, C. S.	Trans. Roy. Soc. Canada, Vol. 19, p. 39.	1925
The Spectrum of the Aurora and the Constitution of the Upper Atmosphere.	McLennan, J. C.	Roy. Inst. Lecture, June 11	1926
On the Luminescence of Solid Nitrogen and Argon	McLennan, J. C.	Nature	Jan. 10, 1925
The Auroral Green Line	McLennan, J. C.	Nature	Mar. 14, 1925
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On the Oxygen Spectral Line λ=5577.35 A.U.	McLennan, J. C., McLeod, J. H. and McQuarrie, W. C.	Nature	Sept. 25, 1926
On the Phosphorescence of Nitrogen	McLennan, J. C., Ireton, H. J. C., and Thomson, K.	Nature	Sept. 18, 1926
A Note on the Structure of the Arc Spectra of Elements of the Oxygen Group.	McLennan, J. C., McLay, A. B., and McLeod, J. H.	Phil. Mag	Sept., 1927
On the Wavelength of the Green Auroral Line in the Oxygen Spectrum	McLennan, J. C., and McLeod, J. H.	Roy. Soc. Proc. London, A. Vol. 115, p. 515.	1927
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On the Origin of the Auroral Green Line in the Oxygen Spectrum.	McLennan, J. C., Ruedy, Richard, and McLeod, J. H.	Trans. Roy. Soc. of Canada, Vol. 21, p. 27.	1927
On the Absorption and Series Spectra of Lead	McLennan, J. C., Young, J. F. T., and McLay, A. B.	Trans. Roy. Soc. of Canada, Vol. 18, III, p. 77.	1924
On the Absorption and Series Spectra of Tin	McLennan, J. C., Young, J. F. T., and McLay, A. B.	Trans. Roy. Soc. of Canada, Vol. 18, III, p. 57.	1924
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On the Tracks of φ-Ray in Helium and other Gases.	McQuarrie, W. C.	Trans. Roy. Soc. Can., V. 17.	1923
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Note on the Electrodeless Discharge in the Vapours of Phosphorous and Sulphur.	Shaver, W. W.	Trans. Roy. Soc. of Canada, Vol. 18, III, pp. 145–149.	1924

Title of Paper	Author	Where Published	Date Published
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The Doublet Separation of the Balmer Lines	Shrum, G. M.	Proc. Roy. Soc. London, A. Vol. 105, p. 259.	1924
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On the Critical Frequency of Pulsation of Tones.	Weinberg, Miss M., and Allen, Frank.	Phil. Magazine, Series 6, Vol. XLVII, No. 277.	Jan., 1924
On the Effect of Fatiguing the Ear with a Combination of Two or More Tones.	Weinberg, Miss M.	Phil. Magazine, Series 6, Vol. XVLII, No. 277.	Jan., 1924
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Survey of General Conditions of Industrial Hygiene in Toronto.	Assoc. Committee on Industrial Fatigue.	Ottawa, National Research Council, Report No. 7.	1921
Histamine and Salivary Secretion	MacKay, Miss M. E.	Am. Jour Physiology	1927
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The Hydromedusae of the West Coast of North America, with Special Reference to those of the Vancouver Island Region.	Foerster, R. E.	Contr. to Can. Biol. N.S., Vol. 1, pp. 219, 277.	1923
Studies in the Ecology of the Sockeye Salmon (Oncorhynchus Nerka).	Foerster, R. E.	Contr. to Can. Biol. N.S., Vol. II, Pt. 2.	1925
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Mosquito Control Investigations in British Columbia.	Hearle, E.	Sc. Agriculture	Feb., 1921
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Some Mosquito Problems of British Columbia	Hearle, E.	Ont. Ent. Soc., Rept. No. 51	1921
An Aerial Survey of Mosquito Breeding Places	Hearle, E.	Agr. Gazette, Ottawa, IX, 3	1922
A New Mosquito from British Columbia	Hearle, E.	Can. Entomologist	Jan., 1923
Mosquitoes of the Lower Fraser Valley, B.C., and Their Control.	Hearle, E.	Ottawa, National Research Council, Rept. 17.	1926
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ZYMOLOGY			
A Study of Bacterial Association.— (1) The Biochemistry of the Production of Lactic Acid.	Speakman, H. B., and Phillips, J. F.	Jour. of Bacteriology	March, 1924

APPENDIX J

Publications of the National Research Council

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 (Out of Print)	L. Gross, M.D.
7	Survey of General Conditions of Industrial Hygiene in Toronto	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 Lobsters	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	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, Esq., Steel Company of Canada, Hamilton Ontario, 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 Sadler, 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	Investigations on the Treatment of Nova Scotia Oil Shales	A. E. Flynn, A.R.S.M.
19	Bacteriology of Certain Sea Fish	F. C. Harrison, D.Sc., F.R.S.C.
20	Consideration of the Relation between the Distribution of Teredo Navalis and Temperature and Salinity of its Environment	R. H. M'Gonigle, B.A.

BULLETINS

Bulletin Number	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 with Reference to the Testing of Fog Signal Machinery	L. 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	The Heating of Houses, Coal and Electricity Compared (Out of Print)	A. S. L. Barnes.
7	The Manufacture of Ethyl-Alcohol from Wood Waste. (Out of Print)	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 Resumé 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.
12	Nitrogen in Industry	Nitrogen Fixation Committee, Prof. J. C. McLennan, Chairman.

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 (2nd edition).

B4 —1921—Standard Specification for Wire Rope for Mining, Dredging and Steam-Shovel Purposes.

A5 —1927—Standard Specification for Portland Cement (2nd edition).

A6 —1922—Standard Specification for Steel Highway Bridges.

D7 —1922—Standard Specification for Flexible Steel Wire Rope and Flexible 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 Gates.

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.

A19—1926—Standard Classification of Items of Highway Expenditure.

A20—1927—Standard Specification for Movable Bridges.

C21—1927—Standard Specification for Control Cable.

C22—1927—Canadian Electrical Code—Part I.

APPENDIX L

LISTS OF MEMBERS OF ASSOCIATE COMMITTEES

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Dominion of Canada

NATIONAL RESEARCH COUNCIL

THE HONORARY ADVISORY COUNCIL FOR
SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT of the PRESIDENT
AND
FINANCIAL STATEMENT

1927-28

OTTAWA, March 26th, 1929.

The Hon. JAMES MALCOLM,

Chairman, Sub-Committee of the Privy Council on Scientific and Industrial Research,

Ottawa, Ont.

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 31st, 1928.

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.

THE SUB-COMMITTEE OF THE PRIVY COUNCIL ON SCIENTIFIC AND INDUSTRIAL RESEARCH, 1927-28

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Minister of the Interior and of Mines.
Minister of Agriculture.
Minister of Customs and Excise.
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NATIONAL RESEARCH COUNCIL

I. REVIEW OF THE ACTIVITIES OF THE NATIONAL RESEARCH COUNCIL, 1927-28

The Research Council Act assigns to the National Research Council, in addition to its general responsibilities, the following specific duties:

To undertake in such a 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;

(viii) To 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.

(ix) To have charge of all matters affecting scientific and industrial research in Canada which may be assigned to it by the Committee of the Privy Council on Scientific and Industrial Research, and to advise the committee on questions of scientific and technological methods affecting the expansion of Canadian industries or the utilization of the natural resources of Canada.

Pending the erection of National Research Laboratories in Canada*, since many of the specific duties assigned to the Council especially in the fields of industrial research and standardization cannot possibly be effectively undertaken without laboratory facilities, the Council has during the year ending March 31st, 1928, as in previous years, confined its research activities to the co-ordination and stimulation of such work as could be carried out with the co-operation of members of the staff of existing laboratories and research organizations in Canada, especially the universities.

The work of the Council during the past year may be broadly divided under the following headings:

(1) The organization and stimulation of co-operative research work on major problems through associate research committees, thus utilizing to the fullest possible extent the scientific man power and the scientific equipment of universities and other laboratories in Canada.

*Since the close of the year under review, the sum of $750,000 was provided by Parliament as an initial vote for the erection of National Research Laboratories in Canada. Detailed plans for these laboratories are now near completion and it is expected to commence construction work early in 1929 and that the building will have been completed before the close of 1930.

(2) The stimulation of research work and the utilization of the scientific man power and equipment of Canadian laboratories in connection with individual research problems through the awarding of research grants for special equipment or technical assistance to qualified research men working in established laboratories.

(3) The post-graduate training of research workers through the awarding of graduate scholarships in science and research to university graduates who have completed a university course in science with distinction.

At comparatively small cost to the public treasury, the National Research Council has succeeded in building up in Canada, over a period of years, as active and as effective a research organization as it has been possible to establish on a voluntary service basis.

At the close of the year under review, there were organized under the Council twenty-four associate committees, with a total membership of three hundred and sixty-three persons. Some indication of the volume and scope of the work of these committees is given in the synopsis of their activities which begins at page 14 of this report.

During the same period, there were in active operation in laboratories spread from coast to coast one hundred and five specific investigations carried out under eighty-eight research grants, each of which was directed by a highly trained research worker specially qualified to undertake work on the particular problem entrusted to him.

These investigations were carried out in twenty-five divisions of science at ten Canadian universities and in twelve Government and industrial laboratories.

The departments of science in which these investigations were undertaken were as follows: Department of Physics, twenty-one investigations; Chemistry, sixteen; Botany, seven; Bacteriology, Field Husbandry and Mechanical Engineering, six investigations each; Pathology, Animal Pathology, Plant Pathology, and Plant Breeding, four investigations each; Biochemistry, Plant Biochemistry, Biology, Geology, Mining Engineering, and Electrical Engineering, three investigations each; Civil Engineering, two investigations; Biophysics, Entomology, Aerodynamics, Zoology, Oceanography, Pharmacology, and Ceramics, one investigation each.

The laboratories in which these investigations were carried out were as follows: Universities of British Columbia; Alberta; Saskatchewan; Manitoba; Western Ontario; Toronto; Queen's; McGill; Montreal; Dalhousie; Connaught Laboratories; Queen Alexandra Sanatorium; Fort Qu'Appelle Sanatorium; Federal Departments of Agriculture, Mines and National Defence; Board of Grain Commissioners, Winnipeg; Steel Company of Canada; Biological Board of Canada.

In addition to this, forty-eight post-graduate research scholarships were held under the auspices of the Council, these awards having been granted with the object of training outstanding university graduates in science and research, so as to build up in Canada a corps of men thoroughly qualified to undertake such work. Each such scholarship was held under the personal supervision of some approved member of the staff of the university where the grantee worked. Detailed information regarding these awards and the achievements to date through them, will be found beginning on page 70 of this report in Section IV which deals with scholarships.

The total research organization actively at work under the auspices of the National Research Council during the year 1927-28 numbered five hundred and seventy, and of this number four hundred and sixty-five persons served without remuneration.

No one realizes more clearly than does the National Research Council the extent of the contribution which is being made by these research directors and by the laboratories which they represent, in the development of scientific research in Canada. Without a genuine willingness on the part of the research men in the universities and in other laboratories to co-operate with the Council and to co-ordinate the research work carried out in Canada on related problems, a voluntary service organization, such as has been established, would be impossible.

The Council fully appreciates and desires to call attention to the fact that the greater part of the cost of the research work carried out has been provided by the co-operating laboratories which furnish without charge to public funds, accommodation for the work, all ordinary and much special laboratory equipment, the direction of the work, and in many instances, a considerable share of the special financial obligations connected with an investigation.

On consideration of all the foregoing facts it will be seen, that during the year under review the National Research Council carried out researches in every province of the Dominion where there were facilities available for such work. This is in accordance with the fixed policy of the Council to utilize to the fullest possible extent both the trained man power and the equipment of existing laboratories in Canada, in order to promote co-operative effort in research work and to co-ordinate and stimulate such work throughout Canada insofar as this may be possible with the facilities and financial resources which are available to the Council.

The total expenditure of the National Research Council during the year 1927-28 amounts to $201,485.08. It will be of interest to note the distribution of this expenditure among the various activities and services of the Council—55% of the total was expended in research work carried out by associate committees and under assisted research grants; 21% was expended on post-graduate scholarships; 1.5% was expended in the publication of scientific papers and the scientific library maintained by the Council; 2% was expended for travelling and other expenses in connection with meetings of associate committees; the entire administration of the Council including associate committees cost only 3.5% and slightly under 4% was expended on travelling expenses of the members and staff of the National Research Council; the balance amounting to 13% was expended on salaries of the staff of the Council.

On consideration of the above figures it will be seen, therefore, that approximately 80% of the entire expenditure of the Council was devoted directly to the prosecution and stimulation of research work in Canada, the remaining 20% being expended on general administration, travelling expenses and salaries. A classified statement of the expenditures of the Council from 1916-28 inclusive, will be found on page 13 of this report.

88 Researches in Progress During 1927-28

Subject of Research	Grantee	Where Carried On
Tuberculosis in man and animals	Associate Committee on Tuberculosis Research	Nine co-operating laboratory groups:— Dept. of Bacteriology, Univ. of Alberta; Dept. of Pathology and Bacteriology, University of Toronto; Connaught Laboratories, University of Toronto; Dept. of Bacteriology, Queen's University; Dept. of Bacteriology, McGill University; Faculty of Medicine, Univ. of Montreal; Queen Alexandra Sanatorium, London, Ont.; Fort Qu'Appelle Sanatorium, Fort San, Sask.; Federal Department of Agriculture.
Cereal grain rust	Associate Committee on Cereal Rust	Four co-operating laboratory groups:— Dominion Rust Laboratory, Dept. of Agriculture, Winnipeg, Man.; University of Manitoba; University of Alberta; Univ. of Saskatchewan.
Problems of the grain industry	Associate Committee on Grain Research	Four co-operating laboratory groups:— Board of Grain Commissioners, Winnipeg; University of Manitoba; University of Alberta; University of Saskatchewan.
Heating and insulation of buildings	Associate Committee on Heating and Insulation	Three co-operating laboratory groups:— Dept. of Mechanical Engineering, Queen's University; Dept. of Mechanical Engineering, Univ. of Toronto; Dept. of Mechanical Engineering, Univ. of Saskatchewan.
The utilization of Canadian magnesite	Associate Committee on Magnesite	National Research Council Laboratories, Ottawa; Federal Dept. of Mines, Ottawa.
Destruction of wood piling by marine boring animals	Associate Biological Committee	Atlantic Biological Station of the Biological Board of Canada.
Engineering standardization	Associate Committee on Engineering Standards	Ottawa, Ont.
Storage of fruit in warehouses	Associate Committee on Fruit Storage	Dalhousie University, Halifax, N.S.
Reforestation experiments in cut-over and burnt-over lands of New Brunswick	Associate Committee on New Brunswick Forest Problems	Two co-operating laboratory groups:— Dominion Forest Service, Dept. of the Interior, Ottawa, Ont.; Dept. of Lands and Mines, Fredericton, N.B.
Utilization of Canadian iron ores	Sub-Committee on Iron Ores of the Associate Comm. on Mining and Metallurgy.	Hamilton, Ont.
Best methods for obtaining accurate results in testing varieties, strains and treatments of grain	Associate Committee on Accurate Plot Work	Dominion Experimental Farms.
Problems of the wool industry	Assoc. Comm. on Wool	
Work on oceanography	Assoc. Comm. on Oceanography	Univ. of British Columbia, Vancouver, B.C.
Factors governing the milling and baking quality of wheat	Dr. Robert Newton	Dept. of Field Husbandry, Univ. of Alberta, Edmonton, Alta.
Pressure variations inside the cylinders of the internal combustion engine	Dr. D. A. Keys	Dept. of Physics, McGill University, Montreal, P.Q.
Ultra sonics (inaudible sound waves)	Prof. R. W. Boyle	Dept. of Physics, Univ. of Alberta, Edmonton, Alta.
Wireworms and false wireworms	Prof. E. H. Strickland	Dept. of Entomology, University of Alberta, Edmonton, Alta.
Investigation on concrete deterioration	Prof. T. Thorvaldson	Dept. of Chemistry, Univ. of Saskatchewan, Saskatoon, Sask.
Bacillary white diarrhœa in poultry	Prof. H. W. Hill and Prof. E. A. Lloyd	Dept. of Bacteriology, Univ. of British Columbia, Vancouver, B.C.
Use of ultra short waves for direction indicating apparatus	Major W. A. Steel	Dept. of National Defence, Ottawa, Ont.
The inheritance of sugar and starch in Indian corn	Prof. H. F. Roberts	Dept. of Botany, Univ. of Manitoba, Winnipeg, Man.
Generation of electricity using a windmill as the prime mover	Prof. A. R. Greig	Dept. of Mechanical Engineering, Univ. of Saskatchewan, Saskatoon, Sask.
Generation of explosive gases in electric water heaters and boilers	Prof. J. W. Shipley	Dept. of Chemistry, Univ. of Manitoba, Winnipeg, Man.
Rotary derivatives of a boat type sea-plane	Prof. J. H. Parkin	Aerodynamic Laboratory, Univ. of Toronto, Toronto, Ont.
Fog alarm research	Dr. L. V. King	Dominion Lighthouse, Prescott, Ont.
The exploitation of high speed cathode rays	Dr. J. C. McLennan	Dept. of Physics, Univ. of Toronto, Toronto, Ont.
Radium emanation	Dr. G. H. Henderson and Dr. D. A. McIntosh	Dept. of Physics, Dalhousie University, Halifax, N.S.
Dielectric losses in different classes of porcelain	Prof. A. V. Wendling	Ecole Polytechnique, Montreal, P.Q.
Emission and absorption spectra in the infra-red and extreme ultra-violet regions	Dr. J. C. McLennan	Dept. of Physics, Univ. of Toronto, Toronto Ont.

88 Researches in Progress During 1927-28—*Continued*

Subject of Research	Grantee	Where Carried On
The breeding efficiency of bulls and horses	Dr. A. Savage	Dept. of Animal Pathology, Univ. of Manitoba, Winnipeg, Man.
Relation of silver ores to diabase	Dr. E. S. Moore	Dept. of Geology, Univ. of Toronto, Toronto, Ont.
Investigation on the glucosides of plants indigenous to western Canada	Prof. A. T. Cameron	Dept. of Biochemistry, Univ. of Manitoba, Winnipeg, Man.
Magnetic susceptibility of the alkali metals	Dr. E. S. Bieler	Dept. of Physics, McGill University, Montreal, P.Q.
Experimental study of precipitation of iron and silica	Dr. E. S. Moore	Dept. of Geology, Univ. of Toronto, Toronto, Ont.
Effect of radiant energy on protoplasm	Prof. A. H. Hutchinson	Dept. of Botany, Univ. of British Columbia, Vancouver, B.C.
Structural welding	Prof. P. Gillespie	Mechanics of Material Laboratory, Univ. of Toronto, Toronto, Ont.
Surface energy of solids	Prof. F. M. G. Johnson and Dr. O. Maass	Dept. of Chemistry, McGill University, Montreal, P.Q.
Vegetable resources and flora of eastern Canada	Fr. Marie-Victorin	Dept. of Botany, Univ. of Montreal, Montreal, P.Q.
The Habits and life history of the smaller mammalia of the Prairies	Mr. F. Neave	Dept. of Zoology, Univ. of Manitoba, Winnipeg, Man.
Properties of hygroscopic substances	Prof. A. N. Shaw	Dept. of Physics, McGill University, Montreal, P.Q.
Chlorination of methane	Prof. M. C. Boswell	Dept. of Organic Chemistry, Univ. of Toronto Toronto, Ont.
The effect of light on life processes	Prof. A. B. Klugh	Dept. of Biology, Queen's University, Kingston, Ont.
Catalytic action of ultra-violet light	Prof. L. Bourgoin	Ecole Polytechnique, Montreal, P.Q.
Effects of electric and magnetic fields. Stark effect in helium. Stark effect in molecular spectra.	Prof. J. S. Foster	Dept. of Physics, McGill University, Montreal, P.Q.
Further Investigation on gas laws	Dr. O. Maass	Dept. of Chemistry, McGill University, Montreal, P.Q.
The alkaloids of the ragwort	Dr. R. H. F. Manske	Dept. of Chemistry, Queen's University, Kingston, Ont.
Investigation of mistletoe parasitic on jack pine	Miss E. S. Dowding	Dept. of Botany, Univ. of Alberta, Edmonton, Alta.
Effects of certain reagents upon root tip sections of Trillium grandiflora	Prof. R. O. Earl	Dept. of Biology, Queen's University, Kingston, Ont.
Winter hardiness in crop plants	Dr. Robert Newton	Dept. of Field Husbandry, Univ. of Alberta, Edmonton, Alta.
The chemistry of fish curing	Dr. A. B. Macallum	Dept. of Biochemistry, McGill University, Montreal P.Q.
Collecting, identifying, recording and mounting of the marine algae of the Canadian atlantic coast.	Prof. H. P. Bell	Dept. of Botany, Dalhousie University, Halifax N.S.
Chemical separation: Identification and possible synthesis of antipressor substance from hepatic tissue.	Dr. A. A. James	Dept. of Biochemistry, Univ. of W. Ontario, London, Ont.
Cultivation of medicinal plants in British Columbia	Dr. R. H. Clark and Prof. J. Davidson	Depts. of Chemistry and Botany, Univ. of British Columbia, Vancouver, B.C.
Researches in the field of low temperatures	Dr. J. C. McLennan	Dept. of Physics, Univ. of Toronto, Toronto, Ont.
Laws governing the screening of crushed ores	Dr. J. B. Porter	Dept. of Mining Engineering, McGill University, Montreal, P.Q.
Determining the elimination of magneto noises from aircraft receiving sets	Prof. H. Vickers	Dept. of Electrical Engineering, Univ. of British Columbia, Vancouver, B.C.
Fungi	Prof. A. H. R. Buller	Dept. of Botany, Univ. of Manitoba, Winnipeg, Man.
The effect of temperature on the strength of castings	Prof. R. W. Moffatt	Dept. of Civil Engineering, Univ. of Manitoba, Winnipeg. Man.
Investigation of the mechanical properties of metals at low temperatures	Profs. I. F. Morrison and A. E. Cameron	Dept. of Mining Engineering, Univ. of Alberta, Edmonton, Alta.
Ultra-violet spectroscopy with vacuum-grating spectrograph	Dr. R. J. Lang and Prof. Stanley Smith	Dept. of Physics, Univ. of Alberta, Edmonton, Alta.
Colour vision	Dr. F. Allen	Dept. of Physics, Univ. of Manitoba, Winnipeg, Man.
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	Dept. of Physics, Univ. of Toronto, Toronto, Ont.
Grinding ore in ball mills and rock crushing by rolls	Prof. H. E. T. Haultain	Dept. of Mining Engineering, Univ. of Toronto, Toronto, Ont.
Power loss in dielectrics	Dr. H. J. MacLeod	Dept. of Physical and Electrical Engineering, Univ. of Alberta, Edmonton, Alta.
The deterioration of rubber in oxidation and the nature of resin present in rubber	Dr. G. S. Whitby	Dept. of Chemistry, McGill University, Montreal, P.Q.
Earth's nocturnal radiation	Dr. H. T. Barnes	Dept. of Physics, McGill University, Montreal, P.Q.
Structure and growth of anchor ice	Dr. H. T. Barnes	Dept. of Physics, McGill University, Montreal, P.Q.
Processes leading to the utilization of natural gases	Dr. E. H. Boomer	Dept. of Physics, Univ. of Alberta, Edmonton, Alta.
Effects of velocity on reabsorption rates	Prof. O. S. Gibbs	Dept. of Pharmacology, Dalhousie University, Halifax, N.S.
Cathode rays	Dr. J. A. Gray	Dept. of Physics, Queen's University, Kingston, Ont.
Maple sugar and syrup	Dr. J. F. Snell	Dept. of Physics, Macdonald College,

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56 Additional Researches Completed in Previous Years

Subject of Research	Grantee
The inheritance of earliness and lateness in wheat	Dr. W. P. Thompson
Water requirements of crops in western soils	E. S. Hopkins
The relation of bacteria to the quality of graded butter	Prof. W. Sadler
Fungi	Dr. A. H. R. Buller
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
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
The resistance of plants to low temperatures	Prof. J. F. Lewis
The biological origin of false wild oats	Prof. J. R. Fryer
Life history and habits of the Tabanidae (horsefly)	Prof. A. E. Cameron
Study of the blood chemistry in animals with the super renal glands removed	Prof. J. B. Collip
Investigation of the life history of the onion maggot	Prof. E. M. DuPorte
Investigation to determine the effect of ultra-violet rays on eggs, chicks and laying hens.	F. C. Elford
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
De-tarring of gas by electrical precipitation	Dr. J. G. Davidson
Reduction of iron ores by gases	Dr. A. Stansfield
A method of smelting titaniferous iron ores	Dr. C. W. Drury and A. F. G. Cadenhead
The testing of oil shales in the field	Louis Simpson
The treatment of silver-lead-zinc ores	Horace Freeman
The preparation (production) of metallic barium	Prof. H. E. Bigelow
Oil from shales	Prof. A. E. Flynn
Alberta tar sands	Dr. A. Lehmann
Lake Agassiz clay deposits	Prof. R. C. Wallace
The microscopic examination of cement during hardening	F. M. Dawson
Causation of cracks in concrete protective coating on iron and steel structures	Prof. P. Gillespie
The corrosion of iron and steel in the soil	Prof. J. W. Shipley
Investigation on the utilization of the resources of helium in Canada	Associate Committee on Helium
The properties and liquefaction of helium	Dr. J. C. McLennan
Canadian waste sulphite liquor as a source of alcohol	Dr. V. K. Krieble
The discolouration of cured codfish	Dr. F. C. Harrison
The discolouration of canned lobster	Dr. F. C. Harrison
Artificial propagation of the sturgeon	Associate Biological Committee
The food relations of certain minute organism (Entomostraca) in the cultivation of fresh water fishes.	Prof. A. B. Klugh
Bacteria found in frozen fish	Dr. F. C. Harrison
Nicotine from tobacco waste	Arthur D. Hone
Utilization of milkweed	Dr. A. C. Neish
Problems of Industrial Fatigue	Associate Committee on Industrial Fatigue
The utilization of peat	Department of Mines
Channel interference in wind channel testing	Prof. J. H. Parkin
Interference in radio broadcast reception	Prof. T. R. Rosebrugh
Fog signalling	Prof. L. V. King
Vitamines	Food Research Committee
Surface tension in liquids and emulsions	Dr. J. C. McLennan
Chemical reactions at high pressures	Dr. J. C. McLennan
Conductivity and vapour pressure of salt solutions	Dr. A. N. Shaw
Crystalline shapes of bicarbonate of soda	Prof. Paul Riou
Investigation on Röntgen rays	Dr. J. A. Gray
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
The spectrum of infra-red rays	Dr. J. C. McLennan
The action of ultra-violet rays	Prof. L. Bourgoin
Intensity measurements in spectra	Prof. J. K. Robertson
The spectrum of tin	Prof. J. K. Robertson
Constitution of rubber	Dr. G. S. Whitby

Classified Statement of Expenditures 1916-28

Year	Research Activities and Grants	Scholarships	Library and Publication	Administration of Council and Committees	Travelling Expenses: Research Council and Staff	Travelling Expenses: Associate Committees	Salaries	Total
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
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
1926–27	79,233.45	41,105.00	2,278.37	6,292.91	8,690.11	2,651.70	23,074.52	163,326.06
1927–28	110,797.33	41,855.00	2,851.21	7,133.53	7,920.04	4,038.81	26,889.16	201,485.08
	$556,631.20	$326,523.66	$23,780.82	$63,251.53	$62,501.04	$31,594.68	$230,471.25	$1,294,754.18
Average shown in percentages.....	42.98%	25.23%	1.84%	4.88%	4.83%	2.44%	17.80%	100%

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II. SUMMARY OF ACTIVITIES OF ASSOCIATE COMMITTEES

Foreword

The National Research Council has established two classes of Associate Committees. The first class consists of a group of committees, which have been appointed by the Council for the specific purpose of organizing co-operative research work on major research problems and the stimulation of such work in Canadian laboratories. The main function of each of these committees is to undertake the direction of scientific research work on the specific problem assigned, but obviously these committees also serve in an advisory capacity in their own field of science.

At the close of the year under review, there were at work, under the auspices of the National Research Council, sixteen Associate Research Committees such as described above. These committees were working on the following major problems: cereal rust; field crop diseases; grain research; accurate plot work in agricultural research; storage of fruit in warehouses; tuberculosis in man and animal; aeronautics; heating and insulation; the development of Canadian helium resources; the utilization of Canadian magnesite; classification of Canadian coals; the development and utilization of Canadian wool; food research; the reseeding of burned-over and cut-over forest areas; the health hazard of spray-painting and oceanography.

Another group of Associate Committees appointed by the Council are mainly advisory in character. It is the function of each such committee to keep 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 it covers. These committees 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, or during the progress of work carried on under the auspices of the Council. Research work is, of course, sometimes carried on under the auspices of these Advisory Committees but research is not their main purpose.

It is customary for such committees to meet once a year at a time and place most convenient to the majority of the members of the committee and at this annual meeting to discuss problems relating to the work of the Council, to consider 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 and advisable.

The following eight Associate Committees of an advisory nature were in existence at the end of March 1928: Associate Committee on Physics and Engineering Physics; Associate Committee on Mining and Metallurgy; Associate Committee of Chemists; Associate Biological Committee; Associate Committee on Engineering Standards; Associate Library Committee; Associate Committee for British Columbia and Associate Committee on Nitrogen Fixation.

Twenty-four Associate Committees, such as described above, had been organized under the auspices of the National Research Council at the close of the year under review. The membership of these committees totalled three hundred and sixty-three persons, who gave freely of their time and experience in furthering the work of the Council. Some indication of the value of the service rendered will be found in the summarized reports immediately following.

Associate Committee on Grain Research

Co-operating organizations:

Board of Grain Commissioners for Canada.
University of Alberta.
University of Manitoba.
University of Saskatchewan.

The Canada Grain Act passed in 1925 requires that the Board of Grain Commissioners for Canada "shall maintain an efficient and adequately equipped laboratory for grain research work and for the purpose of assisting the chief inspector and the grain standards board in determining the grades and the milling value of grain." The advice and co-operation of the National Research Council was enlisted in connection with the establishment of this laboratory in order to ensure that the requirements of the section of the Grain Act quoted above might be carried out effectively.

The first step taken by the Council was to call a conference on grain research at which were present technical representatives of the Universities of Alberta, Saskatchewan and Manitoba, the three large wheat producing provinces of Canada, the chemist of the Western Canada Flour Mills and Dr. R. A. Gortner of the University of Minnesota, who is an outstanding authority in this field of research.

The task set for the conference was to draw up a definite concise programme of research work on grain which should be undertaken in Canada.

When this question had been discussed in all its phases, it was the unanimous judgment of the conference that after having set forth definitely the group of problems specially suited to the laboratory of the Board of Grain Commissioners, there was a second group of problems of a more fundamental nature which could only be satisfactorily undertaken on a co-operative basis in university laboratories by men who are specially trained for such work. It was therefore decided that the research programme must consist of two parts as follows:

Part. I. Problems to be investigated by the Research Laboratory of the Board of Grain Commissioners for Canada.

Part II. Problems which should be investigated in the laboratories of the universities.

On this basis, a definite programme of grain research work for the prairie provinces was drawn up by the conference and will be found in full in Appendix "B". The conference also passed a resolution calling attention to the necessity for the appointment by the National Research Council of an Associate Committee on Grain Research, for the purpose of giving general supervision to and ensuring the proper co-ordination of all research work undertaken under the research programme which had been drawn up.

In accordance with this recommendation, an Associate Committee on Grain Research (see page 99) was appointed by the National Research Council, and during the year under review this Committee has been actively at work.

One of the principal problems which has engaged the attention of the Committee was the great economic loss which occurs in the grain industry because of the almost complete lack of reliable scientific data as to the best methods for drying tough and damp grain, the obvious result being that a considerable amount of grain was injured through the use of improper drying methods with consequent lowering of grade. Furthermore, a sufficient amount of dried grain was being injured to cast suspicion on and lower the value of all dried grain.

A report on a preliminary investigation of this problem was prepared under the auspices of the Committee by Prof. Edgar Stansfield of the University of Alberta during the early part of the year under review. Since this preliminary report was prepared, work on this question has been continued and expanded to include all phases of the problem including:

(*a*) The investigation of problems related to methods of drying wheat. In connection with this work it was necessary for the Committee to design, construct and operate a small scale experimental dryer.

(b) The effect of commercial drying on the quality of grain.

(c) The effect of improper curing and damp storage of grain.

(*d*) Milling and baking tests, carried out in the laboratories of the three prairie universities and of the Board of Grain Commissioners so as to give a reliable check, from four Laboratories, on the results of these tests.

In October, 1927, the Committee presented to the Board of Grain Commissioners an interim report on the investigation of commercial drying of tough and damp wheat. This report, (see Appendix "C"), describes the investigations completed by the Committee at that date, the investigations still in progress, general and tentative conclusions reached by the Committee, and makes certain definite recommendations which it was thought might be of service to the grain industry.

All of the work undertaken by this Committee has been carried out with the closest co-operation, not only between the four laboratories where the work is in progress, but also with the various officers of the Board of Grain Commissioners, the Wheat Pool, and the elevator operators. The Committee desires to record its appreciation of this co-operation.

Associate Committee on Wool

As stated in the previous annual report of the Council, a preliminary survey of the wool situation in Canada, made at the request of the Canadian Woollen and Knit Goods Manufacturers Association, indicated the advisability of studying both wool growing and manufacture. The president of the Council therefore called a conference to which were invited, amongst others, representatives of the Canadian Woollen and Knit Goods Manufacturers Association, the Canadian Coöperative Wool Growers; the Live Stock Branch and Experimental Farms Branch of the Dominion Department of Agriculture, and the animal husbandry departments of Macdonald College, the Ontario Agricultural College and the Universities of Toronto, Saskatchewan and Alberta.

At this conference, which met at Toronto in May, 1927, there was a frank discussion of the problems of wool growing and manufacture. Emphasis was laid upon the fact that although Canada does not raise nearly enough wool for her own use she still finds it necessary to export more than half of her annual production. The growers present expressed the belief that they could raise any kind of wool which the manufacturers required, with the possible exception of the very finest grades, but they confessed that they did not know what degree of fineness and what length of staple were most in demand in this country. The manufacturers, on the other hand, considered that for some purposes Canadian wool was inferior to wool from other parts of the Empire, and stated that they had to go outside the country for a large part of their requirements.

It soon became evident that there were no statistics available to show the amount of wool of each grade produced and used in Canada. To secure this information the Canadian Coöperative Wool Growers agreed to tabulate the amount of wool of each grade which had been handled by them over a period of years, while the Canadian Woollen and Knit Goods Manufacturers Association offered to circularize the manufacturers to determine the quantity of each grade which was being used.

The conference also considered at some length, (1) the possibility of further improving the character of Canadian wool by breeding methods, (2) the relation between wool quality and conditions of climate and feed, (3) the problem of wool manufacture, and (4) the need of textile education in Canada. It was clear that to deal adequately with these and other problems would require a

carefully planned campaign extending over a period of years. It was therefore decided that after further study of these problems and the collection of information a second conference should be called to outline a programme of wool research.

Such a conference was held in the following October. Preliminary reports were presented of wool grown in Canada and used in Canadian mills. To deal further with this question and to make recommendations regarding the statistics of the wool industry collected by the Dominion Bureau of Statistics a Sub-Committee on Wool Statistics was appointed.

At the same conference the suggestion was made by Prof. J. P. Sackville, of the University of Alberta, that a survey should be made of the wool-growing industry in representative sections of Canada, in order to determine whether climatic and other conditions appreciably affected the quality of the wool and to enable the committee to determine more definitely the nature of the problems of wool growing in this country. Mr. W. H. J. Tisdale, of the Canadian Coöperative Wool Growers, offered to take a small committee with him for the purpose of making such a study at the time of his annual visit to the principal wool-growing sections of the West in the spring of 1928. He believed that a study of the breeding methods in use by different growers would result in securing much valuable information, and he also foresaw that the growers would themselves derive much benefit from a discussion of their methods with a committee of experts.

It was agreed that a laboratory investigation of wool was essential, particularly in view of the fact that the knowledge of the fundamentals of the chemistry, physics and biology of wool was very inadequate. At the same time it was felt that the first problems to be attacked were those of wool growing, and it was therefore arranged that a small sub-committee should give further study to this subject and report a little later to the main committee.

At the conference on wool statistics, held on Oct. 28, figures were presented showing the approximate quantity of each grade of wool produced and consumed in Canada. These figures indicated that wool of all grades was being used in Canada, and frequently in quantity much greater than was being produced, the most striking shortages being in the finer grades. It was evident that if the wool growers would produce a larger proportion of these finer grades they might considerably reduce the country's importations. Some of the mills were using Canadian wool in large quantity, but a few apparently did not fully realize its value. Grade for grade, Canadian wool was apparently stronger than the average of the imported wools. The manufacturers on the committee were also unanimous in their appreciation of the work done by the Canadian Coöperative Wool Growers in improving the condition of Canadian wool as placed on the market.

The committee gave careful study to the methods used by the Bureau of Statistics in making estimates of wool production in Canada. It is believed that the modified methods being introduced as a result of the committee's recommendations will considerably increase the accuracy of future statistics of wool production and consumption, and will at the same time give much-needed information as to wool quality.

The committee agreed that an effort should be made through the Department of National Revenue to secure information regarding the quality of wool and woollen goods imported. This is admittedly a difficult task, but the committee did not consider the obstacles in the way to be insuperable.

In November a conference of wool growers was held in Toronto to consider methods for undertaking a solution of the chief problems of wool growing. Information had been sought from representative manufacturers as to the chief defects of Canadian wool, with a view to making plans for their elimination. It was arranged that a committee should make a survey of the situation in the wool-growing sections of Alberta and British Columbia in the Spring of 1928. Prof. A. M. Shaw of the University of Saskatchewan offered the committee the results

of a similar survey which he had previously had made in that province. A small committee was appointed to endeavour to arrange for a special study of rams' fleeces in the domestic flocks of eastern Canada.

It was agreed that laboratory studies should follow the field surveys which had been planned. A sub-committee was therefore appointed to investigate this question and present a report at a later meeting of the full committee.

A letter was read from one of the prominent wool manufacturers offering the committee the use of the facilities of three factories for experimental work on wool manufacture, when that stage of the investigation should be reached. The committee expressed its appreciation of this generous offer.

At a subsequent meeting of the National Research Council there was appointed an Associate Committee on Wool to carry out the recommendations made at the four conferences previously held. The personnel of this committee appears on page 99 of this report. The Council also voted a grant to the committee to cover its immediate expenses in connection with a wool investigation.

During the year under review the office staff of the Council prepared a bibliography on wool, covering both wool growing and manufacture. This bibliography was issued in mimeographed form, and several hundred copies have already been distributed, on request, to interested parties in Canada and foreign countries. A beginning has also been made of the collection of the literature on wool, in order that all the published information may be readily available to the committee.

Associate Committee on Tuberculosis

Co-operating organizations:—

Dominion Department of Agriculture.
Fort Qu'Appelle Sanatorium.
Queen Alexandra Sanatorium.
Queen's University.
Sun Life Assurance Company of Canada.
University of Alberta.
University of Montreal.
University of Toronto.

Nothing could be more indicative of the marked progress which is being made in the fight against tuberculosis than the steadily decreasing mortality due to that disease. This progress, which is common to most civilized countries, has brought tuberculosis down from its unenviable position as the cause of more human deaths than any other disease to about fifth or sixth place. Professor Allen K. Krause, of Johns Hopkins University, is authority for the statement that to-day there are alive and at work no less than 1,500,000 people who would have died of tuberculosis if the death rates of the year 1900 and before had been maintained to date. That much remains to be done, however, is shown by the remarkable results of health campaigns carried out in particular districts.

Important factors in reducing the tuberculosis death rate have been, improved public health conditions, education and instruction, isolation of tuberculous patients and greatly improved methods of treatment. In the development of new and better methods of treatment research has played an important part and must be depended upon for future progress. Moreover, if some of the newer discoveries prove as valuable as their advocates claim, research may shortly accomplish much through immunization against tuberculosis.

The campaign against bovine tuberculosis must proceed hand in hand with that against the human form of the disease, for evidence is being rapidly gathered to show that bovine tuberculosis is directly responsible for tuberculosis in a very large percentage of the cases of that disease in children. As a preventive measure the pasteurization of milk has proved exceedingly effective.

Furthermore, the losses now suffered from bovine and avian tuberculosis are a serious drawback to the raising of live stock and poultry. Progress is being made by the isolation and slaughtering of infected animals, but this method of controlling the disease is so expensive and slow, as to justify an outlay on research many times in excess of the amount now being devoted to that end. The difficulty in the way of making substantial progress through additional research, however, is not so much one of securing the necessary funds as of finding trained men with sufficient skill and initiative.

During the year under review the work of the committee has progressed in all of its various branches along the lines originally laid down. The Health of Animals Branch of the Dominion Department of Agriculture, working without financial assistance from the Council, has continued its investigation of the nature and properties of tuberculin, of bovine and avian tuberculosis and of the Calmette vaccine, known as "B.C.G." The group at the Fort Qu'appelle Sanatorium, Saskatchewan, has followed up very carefully the cases of tuberculosis amongst the Indians of the Saskatchewan reserves. The Queen Alexandra Sanatorium staff at London, Ont., has studied the nature of tuberculosis antibodies and the radiography of infected lungs. The Department of Bacteriology at Queen's University has investigated the influence of iron on the growth of tubercle bacilli, the distribution of bacilli in media containing both water and oil and the dissociation of bacilli into different types. Work at the University of Alberta has been concentrated on large-scale experiments on the immunization of calves with B.C.G., and at the University of Montreal on the vaccination of children against tuberculosis. At the University of Toronto a group has investigated the incidence of tuberculosis in children and certain phases of bovine tuberculosis, with particular reference to the tuberculin test.

Tuberculosis Research of the Dominion Department of Agriculture

This work has been carried out at the well-equipped laboratory of the Health of Animals Branch, at Hull, Que.

Crude tuberculin and the various fractions or compounds of this very complex product of the tubercle bacillus have been under continuous study. The results so far obtained indicate that the active principle is present in both the protein and the carbohydrate fractions.

Much attention has been paid to the post-mortem findings of animals reacting to tuberculin, in connection with the Department's campaign against bovine tuberculosis by means of tuberculin tests and a supervised herd plan of control. In more than 90 percent of these animals gross lesions are demonstrable, and microscopic work reveals evidences of tuberculosis in many of those which to the naked eye appear to be free from the disease.

The work on avian tuberculosis has demonstrated that this disease is much more serious than generally supposed. It has been shown that both domesticated and wild birds play a considerable part as carriers of tubercle bacilli of different types.

Work with B.C.G. vaccine has been continued throughout the year, efforts being directed towards determining whether, as claimed by its originators, Calmette and Guérin, it is both innocuous to vaccinated animals and effective in preventing tuberculosis. Under the conditions of the experiments vaccination of guinea pigs with B.C.G. was found to frequently result in the development of tuberculosis in more or less pronounced forms. No such result has been observed in calves but on the other hand calves did not show an appreciably higher resistance to tuberculosis, when vaccinated and immediately exposed to infection, than did unvaccinated controls.

More complete accounts of the tuberculosis research of the Health of Animals Branch may be found in publications of the Department of Agriculture and in veterinary journals.

—(*Investigation under the direction of Dr. E. A. Watson.*)

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Tuberculosis Research among the Indians

The death rate from tuberculosis amongst the Indians in Saskatchewan is nearly twenty times that of the whites in the same province, due in large part to the very great susceptibility of the Indians to this disease. An effort has therefore been made to determine the predisposing causes and to differentiate the type of tubercle bacillus causing the disease, whether human or bovine.

Three generations of Indians at Fort Qu'Appelle have been carefully examined. Senile tuberculosis has not been found common. The studies to date show that tuberculosis amongst the Indians is largely a children's disease, although there appears to be a tendency for the maximum fatal susceptibility to shift towards the young adult group.

Most of the tuberculosis amongst the Indians appears to be of human origin, with very few if any bovine cases. In this connection the cattle on the Indian reserves will be tested to determine the prevalence of tuberculosis amongst them.

—*Investigation under the direction of Dr. R. G. Ferguson, Fort Qu'Appelle Sanatorium.*)

Tuberculosis Research at the Queen Alexandra Sanatorium

In a study of the relation of tuberculosis antibodies to tuberculous infection and immunity the antibodies have been isolated from the blood serum of tuberculous animals in as pure a state as possible. Their biological relation to clinical tuberculosis has been studied by application to tuberculous animals. Substantial progress has been made in the chemical isolation and concentration of complement fixing substances.

The primary object of the X-ray work has been to identify by this means the presence and anatomical changes in the chests of living subjects. To this end lungs are autopsied, radiographed, and areas producing X-ray shadows are removed for study under the microscope. The presence and characters of the shadows have been found to be very greatly influenced by the physical conditions under which X-ray exposures have been made. An original and very satisfactory technique has been evolved for the purpose.

—(*Investigation under the direction of Dr. F. H. Pratten.*)

Tuberculosis Research at Queen's University

It has been known for some years that a relation existed between the growth of tubercle bacilli and the presence of iron. This relation has been studied in detail, and it has been determined that a further very important influence is exerted by certain chemicals, such as sodium citrate, which cause iron to remain in solutions from which it would otherwise be precipitated due to the alkalinity prevailing. The result is that the increased rate of growth of tubercle bacilli due to the presence of iron may be greatly accentuated in the presence of sodium citrate.

The observation made by other workers that tubercle bacilli existing in two-phase systems of water and oil tend to pass into the oil has been confirmed in this investigation. It has been found, however, that this tendency to pass into the oil can be prevented by proteins, which apparently form some association with the bacteria which affects the surface of the latter.

Another line of research undertaken has been the dissociation of bacterial species into two types. Bovine tubercle bacilli were chosen for this purpose, and it was found possible to develop under certain conditions a strain of uniformly low virulence, which produces only localized lesions in experimental animals, and a strain of much higher virulence, decidedly variable in character and showing a strong tendency to revert to the more stable avirulent type.

—(*Investigation under the direction of Professor G. B. Reed.*)

Tuberculosis Research at the University of Alberta

The work of this group during the year under review has been a continuation on an enlarged scale of the experiments previously started on B.C.G., as applied in the vaccination of calves. It has become evident that the work will have to be continued for a period of years in order to definitely establish the value of this vaccine, but very interesting and instructive results have already been secured.

All the evidence obtained to date indicates that B.C.G. is entirely harmless to calves. No ill effects followed vaccination, and the whole group of animals tested developed in a perfectly normal way. When they were slaughtered they did not in a single instance show any evidence of tuberculosis. Guinea pigs were inoculated with material derived from the temporary lesions produced at the site of inoculation, but in no case did tuberculosis develop in these animals.

The evidence is not so clear as to the immunizing value of B.C.G., although it has been found to confer some additional resistance upon every group of animals vaccinated, as compared with controls. In the early experiments Calmette's technique was followed in the vaccination of animals, and their immediate exposure to infection. Only a moderate resistance was shown. Then one group was vaccinated and kept from infection for two months subsequently, when it showed a greatly increased resistance. Since then Calmette has himself recommended that such a period be allowed to elapse between vaccination and infection. This is the procedure now being adopted in a number of experiments on a larger scale.

It is worthy of note that even when vaccination has been followed by infection with virulent bacilli and the development of tuberculosis the progress of the disease has been radically different from that in unvaccinated animals. The lesions have for the most part been few in number and have shown a tendency to calcify, whereas inoculation of the unvaccinated controls usually resulted in a rapid development of generalized tuberculosis.

—(*Investigation under the direction of Professor A. C. Rankin.*)

Tuberculosis Research at the University of Montreal

As previously reported, the vaccination of children with B.C.G. was begun in Montreal to test out this method of protection against tuberculosis, following the large scale work of Calmette and others in France. In the latter country some 70,000 children have already been vaccinated, a considerable number of whom are living in contact with active cases of tuberculosis, and while in most cases the time since vaccination has been comparatively short, the results to date are decidedly encouraging.

The method of vaccination is to administer B.C.G. by mouth with milk, doses being given on the third, fifth and seventh days after birth. This method is extremely simple, causes no sickness, and is altogether preferable to subcutaneous vaccination. Because of its simplicity, physicians and parents alike are apt to regard it with favour.

In Montreal, some hundreds of babies have now been vaccinated without a single unfavourable result. The cases are being carefully followed up, and when a sufficient time has elapsed, it is hoped that it will be possible to present reliable statistics as to the degree of resistance conferred.

—(*Investigation under the direction of Dr. T. Parizeau*).

Tuberculosis Research at the University of Toronto

This investigation is believed to be the first undertaken in Canada to determine the incidence of bovine tuberculosis infection in man. For such an investigation Toronto is particularly suitable, since the city's regulations require a thorough pasteurization of milk, while those of many of the surrounding districts do not.

Through the co-operation of the Toronto hospitals, and particularly the Hospital for Sick Children, it has been possible to study the cases of a large number

of tuberculous children. Of these a considerable percentage proved to be harbouring bacilli of bovine origin, the more usual sites of involvement being the lymph glands of the neck, the mastoid process and joints. An effort is being made to determine in each case the exact source of infection. So far none have been discovered in the pasteurized area, but many cases have been traced to infected herds outside the city supplying unpasteurized milk to local consumers. No cases of bovine tuberculosis have yet been discovered in adults.

An investigation is also being made of tuberculosis in cattle, the subjects being cows obtained through co-operation with the Health of Animals Branch of the Dominion Department of Agriculture. These cattle have been kept under close observation for a period of time, during which various tuberculin tests have been carried out. An effort has been made to differentiate between the immune animal reacting to tuberculin and the clinically tuberculous animal. A large number of examinations have been made of the milk and urine of tuberculin-positive cows. Finally the cows have been slaughtered, the carcasses have been examined for gross and microscopic evidences of tuberculosis, followed by cultivation and differentiation of the strains of tubercle baccilli found.

—(*Investigation under the direction of Doctors Klotz, FitzGerald and Caulfeild.*)

Associate Committee on Cereal Rust

Co-operating organizations:

Dominion Department of Agriculture.
University of Alberta.
University of Manitoba.
University of Saskatchewan.

The losses in Canada from cereal rust vary greatly from year to year. As previously reported, the summer of 1926 was a particularly favourable season, and losses were comparatively light. In 1927, however, conditions were very different, and one of the best known authorities on agriculture in Canada estimated the losses from rust during that year to have been over one hundred million dollars. While such heavy losses are exceptional those in even a favourable year are such as to emphasize the seriousness of this problem to agriculture and the necessity of bending every effort towards its solution.

As in previous years, the work of the committee has included a number of lines of attack upon the rust problem. A large part of the effort is being expended in breeding experiments intended to produce wheat varieties resistant to rust. This is a project requiring a considerable period of years, since some of the crosses are difficult to make and the vast majority of those crosses produced do not sufficiently combine the rust-resistant properties of one parent with the equally desirable characteristics of the other. Amongst the hundreds of thousands of new varieties produced, however, are many which are considered worthy of further test.

Fundamental research is being carried out to determine the nature of rust resistance, and while this problem is a very difficult one, substantial progress is being made. Other results of very considerable scientific interest have been obtained, and it is hoped to utilize this information in a practical way.

Further tests have been made in the control of rust through sulphur dusting, and this work may now be called technically successful, though its commercial application on any considerable scale has not yet been realized.

A method of control which has already accomplished much is the destruction of the common barberry, which is a winter host of the black stem rust of wheat. The barberry has now been almost exterminated from the Canadian prairie, but in the United States the destruction of this host has not yet proceeded so far.

Research at the Dominion Rust Laboratory

At this centre work has been carried on under the Dominion Department of Agriculture without financial assistance from the National Research Council. The results obtained, however, have been made available to all those engaged in rust research.

Breeding experiments have been of three kinds. First, rust resistant wheats have been crossed with those of high quality and yield. Second, resistant varieties have been crossed to produce hybrids which might be used in crosses similar to those of the first group. Third, different species have been crossed in order to transmit the resistance of the 28-chromosome wheats to those of the 42-chromosome group, which possess other valuable characteristics. The results obtained have been decidedly encouraging.

It has been observed that varieties which in the seedling stage are quite susceptible to rust become much more resistant as they approach maturity. To determine the cause of this change a series of experiments has been carried out using one rust form on plants of various ages. It has been found that the later leaves of the varieties tested contain, as compared with the earlier leaves, a larger proportion of tissue with cell walls so thickened as to considerably restrict the development of rust.

Over forty different forms of rust are known to exist, and the question has arisen whether new forms may continue to arise. A very careful investigation of this subject has demonstrated that the phenomenon of sex exists in the rust spores, and that the hybridization of new forms of rust may occur in at least two different ways. It is believed, however, that such hybridization does not often take place in nature.

There is a possibility, also, that new forms may arise through mutations. One red form of rust has shown a mutant distinctly orange in colour, and this colour has been retained in succeeding pure cultures. There has, however, been no change in the capacity of this form of rust to infect certain varieties of wheat.

The great prevalence of rust, in 1927, afforded an excellent opportunity to make a rust survey of Canada, and surveys and collections were therefore made in all the provinces, except British Columbia. The forms in different sections of the country vary considerably, but so far it has not been found possible to find a definite relation between rust forms and wheat varieties.

Sulphur dusting experiments were carried on in 1927 on a larger scale than previously, some 650 acres being so treated. Aeroplanes have been found exceedingly useful for distributing the dust over the wheat fields. It has been learned that sulphur dusting, to be really effective, must begin before the rust appears, and must be contained thereafter at the rate of from one to three applications per week until the wheat matures. The cost is fairly high, but may in some cases be more than repaid by the additional crop secured. An immediate field for its use appears to be in small experimental plots where the crop is exceptionally valuable, and where seed are grown for registration purposes.

—(*Investigation under the direction of Dr. D. L. Bailey and Dr. C. H. Goulden.*)

Rust Research at the University of Alberta

The work carried out during the year by the Alberta group has consisted of fundamental investigations of the biochemical phases of the rust problem. Four of these main divisions have already received considerable study.

In order to investigate the physiology of the wheat plant, the seedlings of eight wheat varieties, varying in rust reaction from highly resistant to very susceptible, were analyzed for their content of leaf pigments, and were also compared in regard to their rates of respiration. The results support, in part at least, the theory that differences in the nutrients supplied by the host may account for

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some of the variation in rust resistance. All of the more susceptible varieties were found to be relatively rich in the three important physiological pigments,—chlorophyll, xanthophyll and carotin.

An investigation of the phenolic compounds of wheat plants was also undertaken since certain phenols, such as carbolic acid, have strong antiseptic properties, and compounds of a similar nature are known to exist in plants. No methods for the determination of these compounds in wheat plants previously existed, and new methods had therefore to be developed. In this the first step was to identify both the phenols and the interfering substances present. Seven compounds have already been isolated in crystalline form. It is expected that this investigation will materially contribute to present knowledge, not only the nature of rust resistance but of the chemistry of the wheat plant as well.

A closely related investigation is being conducted on the experimental creation of rust resistance by the injection of extracts of resistant varieties and of pure phenols into susceptible varieties. In this way it has been found possible to artificially create a considerable degree of resistance. This work will be continued in an effort to determine its full significance.

A fourth line of investigation which has been started is that of the physiology of the rust parasite. The difficulty of studying the rust fungus is largely due to the fact that it will not grow except upon the host. However, it has been found possible to study the effect of various chemicals upon rust by supporting wheat leaves with their cut ends in solutions of the desired character. A very promising method of direct injection has also been developed.

—(*Investigation under the direction of Dr. Robert Newton*).

Rust Research at the University of Manitoba

There were carried forward from the year 1926 some 476 hybrids and their segregates. The work in the season of 1927 reduced these to 280, which will receive further testing in future. These are of hybrid generations varying from the second to the sixth, and the amounts of seed available range from one ounce up to three pounds. Of these hybrids about 40 per cent are simple crosses of two varieties and all the rest are compound crosses of three or more varieties.

The plants have been subjected to both natural and artificial infection. The former varies greatly according to the season, but the latter can be controlled so as to expose the plants in any season to infection from those rust forms which do most of the damage.

One Marquis-Iumillo hybrid which in 1926 showed extreme resistance to rust was found to contain chromosomes corresponding to the parent Iumillo. In 1927 this hybrid segregated into a number of forms which will have to be tested separately in future, with subsequent chromosome counts.

Marquis-Khapli crosses also showed much segregation. Most of the crosses showed Marquis colour, but nearly 98 per cent of the heads were of the undesirable Khapli type or intermediate. There have been obtained 22 heads of Marquis type and colour.

—(*Investigation under the direction of Prof. H. F. Roberts*).

Experiments have been continued on the crosses of the common wheats Kota and Ruby with Kanred, and on inter-species crosses of Marquis with Emmer, Iumillo and Pentad. Work has been discontinued on the Kota-Ruby hybrids because of their susceptibility to rust and on the Kota-Marquis hybrids because this cross has been very thoroughly studied in the United States.

From the above crosses over 125,000 plants and their progenies were given individual study in the second, third and fourth hybrid generations. In addition a large number of seedlings were tested.

It has been observed that some hybrids show a high degree of resistance to stem rust in the field, yet are susceptible in the seedlings stage in the greenhouse. On the other hand, families which are resistant in the field may be susceptible in the seedling stage.

Future work will include more extensive determinations of the reaction of the hybrids to specific rust forms in the seedling stage, additional field trials, milling and baking tests, and further breeding tests by crossing and recrossing to secure the greatest possible rust resistance.

—(*Investigation under the direction of Professor W. T. G. Wiener*)

Rust Research at the University of Saskatchewan

1. *Wheat Breeding Experiments*

The first project in wheat breeding was to cross Marquis wheat with Marquillo, itself a hybrid, and one which excels Marquis in rust resistance, and earliness, but is inferior in baking quality. Of the third hybrid generation 50,000 seedlings were produced and tested for rust resistance. All but 104 of these were eliminated, but in the fourth hybrid generation a number of varieties were proved fully equal to Marquillo in rust resistance. Of these eleven possess many of the desirable characteristics of Marquis, and upon them preliminary yield tests and milling and baking tests will be made.

A second cross consisted of Marquis with Iumillo, the parents of Marquillo. The strain of Iumillo chosen in this particular case was more highly resistant to rust than the Marquillo parent. The first and second hydrid generations produced were so susceptible that the work was repeated, and in the third generation 347 plants showed moderate or high resistance. The best of these will be experimented with further.

It was also desired to cross Marquis with Khapli, which is resistant to all known forms of rust, but since this could not be done directly Khapli was first crossed with Early Emmer, and such of the hybrids as showed high resistance were crossed with Marquis. Over 500 plants of this cross are now being studied.

A fourth project was to cross Marquis with Vernal, a highly resistant emmer. This cross was successfully made, and it now appears that the hybrids in general show marked rust resistance. There appears to be a good prospect of being able to combine a number of the best qualities of both parents.

—(*Investigation under the direction of Dr. J. B. Harrington*).

2. *A Study of Chromosome Numbers*

In order to understand the genetical and cytological results of crosses of common wheats with durums and emmers it is necessary to know the chromosome constitution of the germ cells of the first hybrid generation. This cannot be determined from ordinary hybrids, since these give only the total number in the two germ cells which fuse. It can, however, be determined by a study of backcrosses, and these have therefore been carefully investigated.

Common wheats have ordinarily 21 chromosomes, and emmers only 14. This accounts for the difficulty in crossing, and also for the fact that there is great variety in the hybrids. The chromosome numbers of the hybrids for several generations have already been studied.

—(*Investigation under the direction of Dr. W. P. Thompson.*)

3. *Crown Rust of Oats*

Crown rust was very prevalent in 1927 in southern Manitoba and Saskatchewan, and susceptible varieties of oats were heavily infected. A study has been made of some of the forms of crown rust which are found in Canada, but more work is badly needed.

Inoculation experiments were continued to confirm and extend the results already reported. This with previous work has shown that the hosts of crown rust in western Canada belong to two families, buckthorn and aleaster. There

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are four distinct forms of the rust, and each of these has a different æcial host. Some of the native grasses of the prairies are very susceptible, but it is unlikely that these play any large part in the spread of the crown rust of oats.

A statistical study was made of the spore size of the æciospores, uredinio-spores and teliospores of the four forms of crown rust. A morphological study is also under way.

—(*Investigation under the direction of Prof. W. P. Fraser.*)

Associate Committee on Field Crop Diseases

Co-operating organizations:

Federal Department of Agriculture.
University of Alberta.
University of Manitoba.
University of Saskatchewan.

Field crop diseases are prevalent in the agricultural districts of both Eastern and Western Canada to such an extent as to constitute a serious limiting factor to profitable agricultural production. No particular area seems to be free from these losses although certain areas suffer more than others. The reason for this is not clearly understood at present although it is known that the time and amount of precipitation, temperature, soil type, native vegetation and cultural practices are all important factors. It is reasonably safe to say that a high percentage of the roots and basal parts of the wheat plants throughout Western Canada are more or less injured by soil-inhabiting fungi which cripple the plant's resources to produce full yield. It has been estimated that foot and root rot was responsible in 1927 for reducing the value of the wheat crop by ten million dollars in Alberta alone. The problem is also of great importance in Eastern Canada.

The National Research Council on consideration of the many applications which it has received for financial assistance to researches in this field finally came to the conclusion that the problem was so widespread and that it was of such magnitude that the only prospect of making satisfactory progress lay in close co-operation between the research workers in this field and in the co-ordination and stimulation of their activities. The Council consequently appointed, in co-operation with the Department of Agriculture toward the close of the year under review, an Associate Committee on Field Crop Diseases for the purpose of enlisting the co-operation of the persons and organizations at work in Canada in this field, in a co-operative attack on all phases of the problem. This committee was appointed toward the close of the year under review and arrangements were completed for the committee to hold its first meeting early in the new year.

Associate Committee on Fruit Storage

Co-operating organizations:

Dominion Department of Agriculture.
Nova Scotia Department of Natural Resources.

The committee's work during the first season was of a preliminary character, being confined chiefly to observations of storage practice in the Annapolis and Cornwallis valleys of Nova Scotia. It was discovered that the methods in common use left much to be desired, and that in some cases the fruit might almost as well have been stored in the open. The observations indicated, however, that it might be possible, by the careful regulation of conditions, to greatly improve the usual storage practice without much additional cost.

For the second season's work, in 1927, the committee decided to determine what could be done through scientific control, and secured the services of Dr. S. G. Lipsett to take temporary charge of one warehouse at the Kentville Experimental Station and to make further observations of the practice in other warehouses.

Since the warehouses are not artificially cooled, dependence must be placed on ventilation to keep the temperature down during warm weather. Unfortunately many of those in charge of the commercial warehouses depend upon their own judgment instead of thermometer readings to tell them when ventilation is required, and as a result doors and windows are frequently left wide open during the day, when the fruit is considerably cooler than the outside air. Much of the air circulation therefore warms the fruit materially instead of cooling it.

Moreover, it has been found that some of the warehouses are designed on the basis of statements in the literature that to cool a bushel of apples one degree there are required 50 cubic feet of air at a temperature five degrees below that of the apples. Such warehouses are greatly underventilated, since a simple calculation shows that almost ten times that volume is necessary. The calculated value has been checked by actual experiment. Ventilation during nights and in cool weather must be sufficient to balance not only the heat conducted through the walls and roof during warm periods but also that generated by the apples themselves in the process of ripening.

By careful control of one warehouse, Dr. Lipsett was able to demonstrate the great advantages of his methods. Thus at one time a warehouse room which had not been properly handled was found to be at an average temperature of 66°F, while another room in the same warehouse, under Dr. Lipsett's control, was at 46°F.

Recommendations have been made covering the choice of warehouse sites, warehouse construction and methods of control. These recommendations and other pertinent facts regarding the storage of apples have been published as report No. 23 of the National Research Council, and this report has been widely distributed amongst interested parties in Nova Scotia and elsewhere.

Since this investigation has been satisfactorily completed and the results have been made available to the public the committee has been disbanded.

Associate Committee on Coal Classification and Analysis

Co-operating organizations:

Alberta Research Council.

Dominion Department of Mines.

The lack of a really satisfactory system of coal classification has been responsible for a great deal of confusion, both in scientific literature on coal and in the coal industry itself. No single system has been generally adopted, but many more or less haphazard systems have grown up, either in individual producing districts, certain sections of the trade, or in different countries. For instance, the term "lignite" is used in Germany to describe a low-grade brown coal, while in Canada the same term is applied generally to the much better coals of Saskatchewan and Eastern Alberta. So also the anthracites of Pennsylvania are very different from a number of coals passing under the same name in Great Britain.

Most of the systems of classification which have been proposed are based upon the constituents of the coal as determined by chemical analysis. But here again there is great cause for confusion, since many different methods of analysis have been used, and the proportions of the different constituents frequently vary widely with the methods adopted. It is evident therefore that no satisfactory system of coal classification can be devised until there is general agreement upon the analytical methods to be used.

The first important step towards coal classification in the United States was taken at the First International Conference on Bituminous Coal, held in Pittsburgh in November, 1926. At that meeting, at which several representatives of Canada were present, it was decided that a committee should be organized at once to give thorough consideration to the whole question. At subsequent meetings several committees were appointed to study and report upon special phases of the subject, and representation was requested from Canada.

The National Research Council then called a Canadian conference of those especially interested in coal classification to discuss representation on the American committee and possible organization in Canada. Representation was arranged, but it was felt that Canada's interests were sufficiently different from those of the United States to render a Canadian committee highly desirable. Subsequently the Council appointed such a committee.

One preliminary meeting of this committee has already been held. A questionnaire is being distributed in order that as much information as possible may be secured at an early date, and when this information has been collected it is planned to hold a full meeting of the committee. At that meeting it is hoped that the American committee will be represented, thus keeping each committee on coal classification fully informed of the work being done in both countries.

Associate Committee on Magnesite

Co-operating organizations:

Dominion Department of Mines.
Dominion Forest Service, Department of the Interior.
North American Magnesite Company.
Scottish Canadian Magnesite Company..

This committee was formed during 1925 to investigate various technical problems connected with the utilization of the important deposits of dolomitic magnesite situated in the Grenville district of the Province of Quebec. During the first year of its activities preliminary investigations were under way, and the work here reported represents that done during the second year.

The first problem undertaken was the separation of the magnesite from the dolomite and serpentine which are associated with it in the Grenville deposits, the objects being to not only secure a product of higher grade but to considerably increase the proportion of the rock commercially utilized. This problem was first worked out on a laboratory scale, the method devised consisting of calcination of the crushed rock at a temperature sufficiently high to decompose the desired magnesium carbonate and render it soft and friable, but low enough as to leave the impurities comparatively hard. Light crushing and screening then sufficed to separate the coarse impurities from the fine magnesia.

After a satisfactory laboratory demonstration of this process, the committee's staff took charge of the calcining plant of the co-operating magnesite companies for a trial run on a commercial scale. The results obtained were similar to those secured in the laboratory, and the cost of the operations was found to check the calculations previously made. The method will be comparatively inexpensive to carry out and will not involve radical plant changes. Canadian patent has been granted covering the principal features of the process.

It then became desirable to find commercial uses for the material discarded. Since it contained considerable magnesia it was evident that if means could be discovered of calcining this without decomposing the lime constituent of the dolomite, it might be utilized as plastic magnesia for stucco and composition flooring. Carefully controlled calcination of raw rock in the commercial kilns was found to yield in one operation a fine purified product high in magnesia for use in refractories and at the same time a coarse reject requiring only to be ground to make it suitable as plastic magnesia. Any small amount of free lime present in the latter product was neutralized by suitable additions. Since this plastic magnesia differs considerably from imported magnesias now on the market, a laboratory investigation is being undertaken to determine the conditions under which it can be used to best advantage. Preliminary experiments indicate that the product can be used commercially and give fully as good satisfaction as other plastic magnesias.

An investigation of the possibility of manufacturing refractory brick from Canadian magnesite has been continued throughout the year in the ceramic laboratories of the Department of Mines. Initial troubles, due to crackling and the formation of soft spots in the brick, have been overcome, but shrinkage is still high and spalling resistance is low. Efforts will be made to improve the brick in these respects.

The principal use of Canadian magnesite in the past has been in the preparation of magnesian refractories for use in open-hearth steel furnaces. For this purpose they have been highly satisfactory, but it has been felt that still further improvement was possible, the ultimate object being to secure a refractory which could be sintered into the bottoms of open-hearth furnaces without the admixture of any slag, as found necessary at present. Such a product would make possible the construction of monolithic bottoms which should give much better service than those now in use.

In order to develop a product with these desirable properties, about 150 synthetic refractories have been prepared in a laboratory furnace. A number of these possess the property of sintering together at open-hearth furnace temperatures, while still being so refractory that their melting points are well above any temperatures attainable in these furnaces. It is hoped that out of this large number of refractories one or more may be found of special value in certain fields.

At the request of the Forest Products Laboratory the committee undertook to develop a method of making in towers magnesium bisulphite liquor for use in the preparation of wood sulphite pulp. If magnesite be used raw for this purpose, it is found to dissolve too slowly and to produce a sludge which tends to choke the towers. When calcined it is very readily dissolved, but possesses no mechanical strength and is not suitable for use in towers. It has been found, however, that when calcined and finely ground or slaked it may be fed with water into towers already filled with coarse limestone, when it will go readily into solution, producing bisulphite liquor of a composition which can be varied over a wide range, as desired. Patents have been applied for on this method of producing magnesium bisulphite liquor.

Numerous experiments have also been carried on during the year on the utilization of British Columbia hydromagnesite. It has been demonstrated that this material can be used for a number of purposes, but the commercial feasibility of the methods employed has not yet been established.

—(*Investigation under the direction of F. E. Lathe, assisted by A. F. Gill, A. C. Halferdahl, D. W. Stewart and R. T. Watkins.*)

Associate Committee on Mining and Metallurgy

The tenth annual meeting of this Committee was held in the City of Quebec on March 8th, 1928, the meeting having been arranged to coincide with the meetings of the Canadian Institute of Mining and Metallurgy.

During the year the committee had given consideration to the question of the occurrence of sulphur in Nova Scotia coal and the advisability of instituting researches having for their object the removal or a material reduction of the sulphur content of such coal. This question had been submitted to the committee for consideration by Dr. F. H. Sexton, of the Nova Scotia Technical College, who had pointed out that what he had in mind was, not so much the general question of the occurrence of sulphur in coal, in connection with which a great deal of work has already been done, but rather the investigation of the organic sulphides found in coal, which problem is not so well known. A sub-committee, which had been appointed to consider this question, dealt with the matter in a preliminary way but during the year under review, the committee learned that the Federal Department of Mines had decided to undertake a comprehensive investigation of this problem. It was consequently agreed that there was no further necessity for the committee to investigate this problem.

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The chairman reported that the list of problems in mining and metallurgy awaiting solution through research, which was part of a general list of research problems compiled by another associate committee of the Council, had been carefully reviewed and that such problems as it seemed feasible and advisable to undertake at the present time had been referred to the proper authorities.

The sub-committee on the Utilization of Low-Grade Canadian Iron Ore reported that throughout the year it had kept in close touch with developments in the iron and steel industry both in Canada and abroad and has continued its study of the possibility of the beneficiation of low-grade iron ore.

The committee gave consideration to a suggestion, which had been made, that the National Research Council maintain for distribution a supply of standard steel samples. All phases of this question were carefully discussed and the view of the committee was finally crystallized in the opinion that the National Research Council would not be rendering any material service to the steel industry by merely stocking a supply of such standards at Ottawa, but that when National Research Laboratories are in operation in Canada the question of the preparation of such standards incidental to other work, should be further considered.

The committee also gave consideration to a suggestion that action might be taken by the National Research Council on the question of silicosis but when this question had been fully discussed, it was the general consensus of opinion that silicosis is but one phase of the larger problem of health and safety in mines and that as the Ontario Department of Mines had already taken action, it was not necessary for the committee to recommend that action be taken on this question by the National Research Council.

The committee also gave careful consideration to a suggestion that the National Research Council might take some action with the object of creating a wider market for zinc, in view of the fact that Canada is producing about one-tenth of the world's supply of zinc. When the various aspects of this problem had been carefully considered, it was the opinion of the committee that it was extremely doubtful whether the National Research Council could undertake to find foreign or even domestic markets for the products of any industry and that the question under consideration was a problem of world markets rather than research.

The chairman stated for the information of the members of the committee that the Director of the Geological Survey of Great Britain had written advising of the facilities available under his organization for the training in geophysical prospecting of young Canadian physicists accredited by the National Research Council. This question was brought forward in order that any member of the committee, who knew of a promising young man who is anxious to secure such training, might recommend him to the National Research Council.

The committee also discussed fully the question of steps which might be taken to increase the general usefulness of the committee to the National Research Council, as a result of which it was agreed that each member should submit to the committee research problems particularly affecting his own district, in order that these problems might be given due consideration and if considered advisable, transmitted to the National Research Council for action. It was the consensus of opinion that in this manner the committee would be able to keep the Council constantly in touch with all pressing research problems in the field of mining and metallurgy.

Associate Committee on Nitrogen Fixation

During the year under review the work of the committee has been confined to the collection of information on nitrogen and other fertilizer constituents, and the distribution of information to inquirers. There have been no radical changes observed in the nitrogen situation, but the developments which have been in progress during recent years are continuing.

For many years Chile saltpetre dominated the nitrogen market of the world. Its price, however, was fairly high, due to the inefficiency of the processes used in its extraction and to the large export taxes imposed by the Chilean government, which relied upon this industry for the major portion of its revenue. When, therefore, commercial methods of nitrogen fixation were worked out, it was to be expected that these would have a rapid development. The growth which took place was greatly accentuated by the enormous demand for nitrogen caused by the World War. During that struggle nitrogen was fixed on a large scale by the arc and cyanamide processes, and in Germany the development of the synthetic ammonia process was such as to make it, in the after-war period, the most important factor in the world nitrogen situation.

Concurrently with the growth of the nitrogen fixation industry there has taken place a very rapid change in the method of coke manufacture. Formerly beehive ovens were used almost exclusively, but these have now been replaced in the main by by-product ovens. The by-products have consisted not only of nitrogen in the form of ammonium sulphate but also of various organic compounds which have found very important uses in a large number of industries. The production of by-product ammonium sulphate has been further increased by the expansion of the gas industry.

So rapid has been the growth of the nitrogen industry that the principal producers have been forced to devote a great deal of attention to the development of world markets, and, in particular, to the education of the agriculturists of the world to use nitrogen on a larger scale. This work has been successful in that it has resulted in the absorption of the rapidly increasing production of nitrogen, but it could scarcely have succeeded so well without marked reductions in the price of nitrogenous fertilizers. A still greater increase in production is to be expected, and the downward price trend will probably continue.

This price reduction, made possible in the main by the economies of the synthetic ammonia processes of manufacture, has not been without effect upon the production of nitrogen by other means. Thus the arc process, dependent upon cheap power, has continued to decrease in importance. In at least one plant a part of the power will be used to produce hydrogen electrolytically for the synthetic ammonia process, while the oxygen liberated at the same time will go to enrich the air used in the remaining arcs. The cyanamide process has also seen its most prosperous days, and few cyanamide plants are now being built, although most of the existing plants, including the one in Canada, are continuing in operation. The reduced price of ammonium sulphate has in some instances resulted in an advance in the price of city gas to make good the lost revenue from this by-product. In Chile a determined effort is being made to secure a higher extraction and lower operating costs by means of improved processes, while the government taxes have been lowered to permit of profitable operation.

One of the noteworthy features of recent developments is the attention being given to the fertilizer needs of various soils and the manufacture of special fertilizers to meet those needs. A number of the newer fertilizers not only contain all three essential plant foods, nitrogen, phosphoric acid and potash, but the inert material has been reduced to such a point that the freight charges per unit of plant food are greatly decreased.

Some of the larger producers of nitrogen are carrying out elaborate trials in various parts of the world to demonstrate the effectiveness of proper fertilizing of the soil. The use of fertilizers in tropical and semi-tropical countries is rapidly on the increase. One of the most interesting developments is that in England, where a new scheme for the management of grass lands involving the use of greatly increased quantities of fertilizer, has made possible the raising of several times the number of cattle which could be supported by former methods.

In Canada the situation is practically unchanged. The use of fertilizers is not appreciably increasing, although there is no doubt that in many sections greater profits could be secured by the judicious use of special fertilizers adapted

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to the needs of the soil. The use of lime as a soil amendment is on the increase, but is still less than it should be. With no great demand for nitrogenous fertilizers in this country it is not surprising that there is no immediate likelihood of the construction of additional plants for nitrogen fixation.

Associate Committee of Chemists

It has been the custom of the committee to hold its meetings where possible in conjunction with the annual conventions of scientific societies. The 1927 meeting was held at the close of the Dominion Convention of Chemists in Quebec, the last day of the convention being left open for the meeting of the committee, to which all chemists were invited.

The first item on the agenda was an address by Dr. H. M. Tory on Research in Relation to Industrial Development. Dr. Tory outlined the organization of the Council and its committees and gave a brief description of the different kinds of work undertaken. He then proceeded to analyze the investigations which had been carried out by the Council during its ten years of existence, emphasizing in particular those researches which had proved of benefit to Canadian industries. He pointed out that work had been done for all of the primary Canadian industries,—agriculture, forestry, mining, development of power, fishing and the fur industry. A number of the investigations, such as cereal rust and tuberculosis, were on a very large scale and involved the co-operation of various departments of the Dominion and Provincial Governments. The secondary, or manufacturing, industries have likewise been assisted to a very large extent. Dr. Tory hoped that the establishment of National Research Laboratories at Ottawa would enable the Council to be of still greater service to all industries.

Dr. L. F. Goodwin then presented a paper on the Possibilities of Nitrogen Fixation in Canada. Dr. Goodwin reviewed briefly the various processes of nitrogen fixation which had come into commercial use. He pointed out the great importance of the synthetic ammonia process and discussed at some length the methods of producing hydrogen, the cost of which accounts for a very large part of the total cost of nitrogen fixation. He had studied the possibilities of a larger nitrogen fixation industry in Canada and thought it was chiefly dependent upon the increased use of fertilizers throughout the country. Dr. Goodwin's paper was discussed at some length and a number of interesting points were brought out.

The Present Status of the Fireclay Situation in Ontario was the subject of a paper presented by Dr. J. B. Ferguson. Dr. Ferguson called attention to the importance of the deposits recently discovered in northern Ontario and suggested that considerable research would be necessary before their development could take place on a large scale.

Dr. J. W. Shipley presented a paper on Alternating Current Electrolysis. He pointed out that the use of high current density in alternating-current water heaters might frequently result in the generation of explosive gases through the electrolysis of water. He gave one instance of considerable damage being done by an explosion from this cause. The researches which he had carried out indicated the modifications in design which should be made to avoid such a danger and it was now possible to construct satisfactory electric water heaters using alternating current.

Mr. P. C. Armstrong referred to the great accumulation of waste asbestos rock in the Thetford district of Quebec, and outlined the steps which had been taken to discover uses for this material. He pointed out that magnesia had previously been regarded as toxic to vegetable growth, but recent work had shown that this danger did not exist. In view of the great amount of material available he believed that considerable work would be justified to determine what soils, if any, would be benefited by the application of magnesium silicate, which was the essential constituent of the waste rock.

Dr. F. W. Atack brought up the question of the importance of accurate statistics of imports into Canada, urging that as much detail as possible should be secured for the Canadian manufacturers. At present more detail was available regarding the manufactures of Canada than about the imports, with the result that the statistics published were of more value to importers than to manufacturers.

The chairman read a paper which had been submitted by Dr. E. H. Archibald on the Sodium Carbonate Deposits of British Columbia. These deposits were located rather far from points of consumptiom, but in view of the great purity of the soda, serious effort was being made to commercially utilize them.

The chairman stated that Messrs. Archibald, Fleming, MacIntosh, Thom and Whitby were retiring from the committee according to the regular scale of rotation, and asked for nominations to fill their places. The nominations made were submitted to the Council, which at a subsequent meeting appointed to the Committee Dr. H. E. Bigelow, Dr. D. A. Pritchard, Mr. W. A. P. Schorman, Mr. R. J. Walley and Mr. T. H. Wardleworth.

Associate Committee on Spray Painting

During the past decade, the spraying of surface coatings by compressed air has become extensively used in industry by contracting painters, railroads, shipyards, furniture manufacturers, enamelware manufacturers and the automobile industry. Spray coating has, in fact, almost revolutionized the process of painting. It could not be expected that this great change in the method of using paint could occur without creating certain problems affecting safety and health.

The question of the health hazard connected with the spraying of paint was referred to the National Research Council by the Federal Department of Health late in 1926. Prior to this, because of complaints from workmen affected, discussions had taken place in labour organizations with the result that the whole question was brought forward at a general Labor Assembly held in Montreal, by which it was referred to the Dominion Council of Health. This latter body referred the question to the Federal Department of Health, which in turn referred the matter to the National Research Council.

In referring the matter to the Council, it was pointed out that the use of the paint spraying machine must, in all probability, be considered to be permanently established but that there is undoubtedly a menace to the health of the operators in the functioning of these spray guns; from the pigments in a mechanical way; from the substances used, such as lead, copper, silica, etc., by absorption; and through the inhalation and local irritative action of solvents and driers used in the material sprayed.

On consideration of this question, the National Research Council appointed an Associate Committee on Spray Painting and assigned to this committee the task of considering all phases of the question and recommending the action which, in the opinion of the committee, should be taken by the National Research Council if in the judgment of the committee further work is necessary in connection with this problem.

Two main steps had been taken by the committee up to the close of the year under review. In the first place, the literature on the subject including reports and papers which have been published covering investigations already carried out on this question was collected so that it might be available for reference purposes. In addition to this, a detailed questionnaire was prepared and submitted to the Federal Department of Health and the Health Departments of Ontario and Quebec, the two largest industrial provinces in Canada, and also to organized labour. The purpose of this questionnaire was to ascertain exactly what information was available in the files of the health departments and labour organizations with respect to the health hazard connected with the use of the spray painting machine. None of the above organizations were able to answer the questionnaire but all of them replied by letter giving such information as they had available.

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At the close of the year under review, the committee was engaged in the collection of the literature on the subject, as it was felt that in the absence of statistics from official sources in Canada, it was essential that the Committee should have full information with respect to investigations on this question carried out or in progress in other countries before reaching any decision as to the next step which should be taken regarding this problem.

Associate Committee on Biology

Co-operating organizations:

Biological Board of Canada.
Dalhousie University.

For some years this committee has been investigating the distribution of pile borers along the Atlantic coast of Canada, together with the factors influencing their rate of growth and the extent of their distribution. Preliminary reports of the investigation have been published as Reports No 15 and No. 20 of the National Research Council.

Since the publication of the latter report the work has been chiefly a study of the distribution and of the life history of the ship worm (*Teredo navalis*) and of the gribble (*Limnoria lignorum*). This study has been carried out chiefly by placing at many points along the coast test boards provided with removable blocks. These test boards have been placed horizontally in the water and blocks have been removed at definite intervals and sent to Dalhousie University for examination. During the past season the ship worm has been found from Jeddore eastward on the Atlantic coast of Nova Scotia, along the east coast of New Brunswick from Shippigan south, and on the north coast of Nova Scotia to Cheticamp. It has been found on both shores of Prince Edward Island. The most extensive damage observed was in the Northumberland Strait, although the largest specimens were obtained from Jeddore, Nova Scotia. In certain sections the destruction was not nearly so rapid as has been found in previous years.

The gribble was found everywhere with the ship worm except at Escuminac and Shippigan, New Brunswick, and Grand Narrows in the Bras d'Or lakes. The most extensive damage was done at the mouth of the Bay of Fundy and on the Atlantic coast of Nova Scotia.

The ship worm has been found to be a very rapid worker, being able to completely destroy a test block in about four months, while at the end of this period the gribble will have penetrated less than one-half inch, even under favourable conditions.

Blocks will continue to be removed from the stations above mentioned and one or more additional stations will be established during the coming summer.

—(*Investigation under the direction of Dr. A. G. Huntsman, Atlantic Biological Station.*)

Associate Committee on Heating and Insulation

Co-operating organizations:

Dominion Department of the Interior.
Dominion Fuel Board.
Queen's University.
University of Saskatchewan.
University of Toronto.

During the last few years there has been an increased application of insulating material in the construction of houses, industrial plants and other buildings. This is largely due to the fact that the people of Canada are becoming increasingly aware of the exceedingly important saving which can be effected by proper insulation against the cold. Insulation is important not only from the point of

view of the individual in saving the expense of heating and in producing additional comfort, but also from a national point of view in decreasing the quantity of fuel which this country has to import.

With this growth in the use of insulating material there has been a corresponding increase in the insulation manufacturing industry in Canada. This is leading to the large-scale utilization of products which previously were wasted and the industries so created are now giving employment to a very considerable number of men.

On studying the Canadian situation with regard to research in the field of heat insulation, the committee found that only a limited amount of investigation was under way. Several of the universities did indeed possess apparatus for determining heat conductivity, but the amount of work of this kind being carried out was altogether inadequate to the needs of the situation. The committee realized that data available in other countries could not always be used without question in Canada, both on account of the unsuitability of the methods of experimentation sometimes employed, and also because of the different conditions prevailing in this country.

As a result the committee secured a grant from the National Research Council and arranged for the installation of equipment for research on heat insulation at two different centres. At the University of Saskatchewan, where a considerable amount of work had already been done, provision was made for further investigation of building materials by means of the hot box method. At Queen's University funds were advanced for the purchase of the apparatus required to determine heat conductivity by the hot plate method. These new installations will greatly expedite the task of securing data on heat insulating materials.

The committee has throughout the year kept in close touch with the National Research Council of the United States and with other organizations in that country interested in the question of heat insulation. Representatives have been sent to conventions and meetings of committees in order that full advantage might be taken of any information available and that new methods developed might be brought immediately to the attention of the committee. A proposed test code for the determination of heat transmission was considered in some detail by the committee and a number of modifications were suggested.

Other questions which have engaged the attention of the committee during the year include the effect of moisture on insulating materials, heat losses due to air infiltration, the use of peat for heat insulation, and the question of sound insulation. It is hoped that it may be possible to carry out investigations on one or more of the subjects mentioned.

Associate Committee on Engineering Standards

The value of standardization has only in recent years been recognized at anything like its true worth. The savings possible by means of its general adoption are difficult to estimate with any degree of accuracy, but all who have studied the question agree that the aggregate value is enormous, and that all classes tend to profit through the standardization of methods and materials. The producer and manufacturer profit through the reduced capital expenditure required for the manufacture of standardized products, the increased output made possible and the lower cost of operation. The middleman secures an increased turnover on a reduced quantity and variety of stock. The consumer and general public benefit through the lower cost of production and handling, better quality of product and better service in delivery and repairs.

The Canadian Engineering Standards Association has throughout the year continued to function under the National Research Council, its main committee operating as the Associate Committee on Engineering Standards of that organization. It has in addition received gratifying support from the industries, which

have contributed a total of $5,171 towards its annual expenses. Seventy-five different companies have in this very practical way expressed their appreciation of the work being done.

Organization

The work of the association is carried on under the supervision of its main committee which is composed of fifty members who represent technical associations, universities, industrial organizations, various government departments, consulting engineers, etc. At present there are seven sectional committees which cover particular fields of engineering. The actual working special committees and panels number seventy-one. The entire association and its committees come under the administration of an executive committee consisting of the chairman, two vice-chairmen and an honorary secretary. The secretary and permanent staff at Ottawa are the only paid officers of the association, and all members of committees and panels give their services gratuitously.

Publications

Three new publications and one revised specification have been issued during the year, as follows: A20-1927 "Standard Specification for Movable Bridges", C21-1927 "Standard Specification for Control Cable", C22-1927 "Canadian Electrical Code—Part I (Essential Requirements and Minimum Standards for Electrical Installations in, on or over Buildings using Potentials of from 0-50,000 volts)," and A5-1927 "Standard Specification for Portland Cement" which is a revised specification.

The second year book of the Association was issued in March, 1928, and has been widely distributed and favourably commented upon. The book contains general information on industrial standardization, the history of the Association, details of its organization, and projects of standardization on which it has been working, also a list of co-operating bodies which have appointed representatives on the several working committees.

Work in Hand

Civil Engineering and Construction

Steel Railway Bridges.—A revised draft of this specification (A1-1922) containing many important changes will be issued shortly.

Steel Highway Bridges.—Revisions to present specifications are being considered by the committee. These revisions include changes in working stresses, methods of figuring live loads, etc.

Steel Structures for Buildings.—The proposal to raise the unit working stress from 16,000 to 18,000 pounds has been unanimously agreed to by the committee. Other changes are to be discussed.

Concrete and Reinforced Concrete.—A specification covering materials, proportioning, consistency, mixing, forms and placing, water-proofing and protective treatment, surface finish, and details of construction and design, has been prepared and is now under review by the committee.

Road Materials and Construction.—Draft specifications have been prepared by several panels of this committee, but progress has been difficult, owing to the diversity of practice in the different provinces.

Brick Sizes.—Manufacture of brick in the sizes agreed upon at the conference held by the C.E.S.A., in March 1927, was started in October, 1927 in Ontario, and in February, 1928 in Quebec.

Mechanical Work

Cast Iron Pipe.—Test data for a draft specification are being collected.

Machine Screws.—A draft of a simplified list of machine screws is being considered by the committee, and when approved will be recommended to users so as to eliminate calls on manufacturers for screws of infrequent use.

Sheet Metal Gauges.—Pending the outcome of a memorial to the Government now being circulated for endorsement among manufacturers, jobbers and users of sheet metals, that official recognition be given to the gauges now predominant in the trade, no action is being taken by the committee.

Fire Hose Connections.—The various bodies and organizations concerned in standardized hose couplings in Canada have been invited to a conference under the auspices of the C.E.S.A.

Electrical Work

Distribution Type Transformers.—Final revisions to this specification are to be considered shortly.

Power Transformers.—A draft specification is to be considered soon by the committee.

Rating and Testing of Electrical Machinery.—Reports from three panels have been accepted and are now before the sectional committee for approval.

Automotive Work

Traffic Signals for Highways.—The draft specification, which had been approved by the committee, was presented at an Interprovincial Road Congress, held in Quebec in January, 1928. It was favourably considered with the exception of warning signs on the highway proper and this matter was referred to the Canadian Good Roads Association.

Ferrous Metallurgy

Steel Castings.—After considerable work by the committee and its panel, a final report is now in preparation, although it is felt by the committee that some research work might be done in connection with core drill tests.

Sampling for Check Analysis of Steel.—A final draft of specification is before the committee for comment and it is hoped that approval will follow shortly.

Forging Quality of Bar and Billet Steel.—This project has been considered along with that for check analysis of steel and approval of the final draft by the committee is soon to be expected.

Commercial Bar Steels.—The existing American specification is now obsolete and it is proposed to issue this specification in two sections dealing respectively with Commercial Quality of Hot-Rolled Bar Steels and Commercial Cold-Finished Bar Steels, and Cold-Finished Shafting, as it is being found that this division of the project is very desirable. Draft specifications are in preparation for consideration at an early meeting of the committee.

Associate Committee on Physics and Engineering Physics

The committee held its tenth annual meeting in Ottawa on March 23rd, 1927, at the time of the annual meeting of the Royal Society of Canada.

The committee discussed the question of overlapping in the technical services of the Government and made recommendations to the Council regarding action to be taken.

The chairman read a letter received from the International Research Council regarding the study of solar and terrestrial relationships and calling attention to certain recommendations affecting Canada which had been made by its commission. After a discussion of this subject it was agreed that work should be undertaken for the determination of the height and geographical distribution of the aurora throughout Canada. The committee recommended to the Council that early action be taken in this connection.

Dr. Shaw outlined the work which he had been doing on the subject of hygroscopy and emphasized the importance of hygroscopic research in relation to certain industrial problems. The committee agreed, that, if possible, the work on hygroscopy should be enlarged in scope and urged that the Council should make arrangements for other investigators to work on closely allied problems in a co-ordinated effort.

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The problems of sound insulation were discussed by the committee and a recommendation was made to the Council that the Associate Committee on Heating and Insulation should include sound insulation in its studies. This was felt to be particularly important in view of the sound insulating properties of certain Canadian products which might find a considerable use for this purpose.

The chairman read a letter from Mr. Keay reporting on the question of improvements in the design of motor car engines using alcohol as fuel. It was agreed that this was a question of some importance in view of the possibility of manufacturing alcohol on a large scale from industrial waste, and the committee recommended to the Council that a bibliography be prepared on the subject with a view to continued study and a possible investigation.

Other subjects discussed by the committee were piezo-electric methods of studying the action of internal combustion engines; the precipitation of solid particles from smoke; alloys resistant to corrosion; ultra-violet radiation from the sun, its transmissibility through window-glass and its effect upon health; the synthesis of chemical compounds by means of cathode rays; magnetic storms; and domestic oil burners.

At a previous meeting of the committee a sub-committee had been appointed to report upon the advisability of securing additional representation from the industries on the committee. Prof. Price reported for the sub-committee suggesting that the membership should be increased from fifteen to twenty-two; in order to make possible the increased industrial representation recommended. At subsequent meetings of the Council this enlargement of the committee was authorized and seven additional representatives of the industries were appointed to the committee.

Associate Committee on Aeronautical Research

Co-operating organizations:

Royal Canadian Air Force.

University of Toronto.

Research on aeronautical problems has been carried on during the year under the committee. The need for such work becomes more and more evident as the air service throughout Canada is extended.

At the meetings of the committee held during the year under review there has been emphasized the need for a high-speed water tank for experimentation with flying boat hulls and seaplane floats. Such a tank would have to be equipped with circulating pumps driven by motors of at least 500 horsepower, unless a site can be secured at some suitable point where a sufficient head of water is available. It is also possible that a second wind tunnel will be required since that at Toronto is now being used at capacity. These matters are being given careful consideration by the committee.

Several problems require to be investigated in connection with the construction of metal aircraft. Recently some novel methods of construction have been suggested and it is essential that these be given a thorough trial on an experimental scale. A grant has been secured to cover this work and the investigation will be proceeded with in the near future. Particular attention will be paid to the construction of wing spars.

Another matter which has received the attention of the committee is the elimination of interference in radio operation on aircraft. The work of Professor Vickers at the University of British Columbia has been partially successful in that it has largely eliminated interference on certain ranges of wavelength. Much additional work is required, however, on short waves.

There is appended a report covering the progress made to date on an investigation of the stability of flying boats. This work has not yet been completed and will be continued throughout the coming year.

Investigation of Stability of Flying Boats

During the past four years a number of aircraft have been designed and built in Canada for special Canadian services, such as forest patrol, aerial surveying, forest fire suppression and exploration. These machines, because of the large extent of the water areas in the country in which they are to operate have been largely of the flying boat type. This type of aircraft has received but little attention, and, in particular, practically nothing has been done in the study of the stability of such aircraft. In view of these circumstances, the Royal Canadian Air Force requested that a study be made of the stability characteristics of the "Vedette", a three-seat flying boat. This machine, the first of a series, was designed and built in Canada for forest patrol and aerial photography service, and has proved most successful. A number are now in use in different parts of Canada.

Work has been in progress on the research for some months but has largely been of a preparatory and preliminary character. Some tests have been made to determine the normal characteristics of the model, that is, lift, drag, lift/drag and pitching moments at different speeds.

The next stage of the work consists in the determination of the so-called rotary derivatives. In the determination of these, the model is oscillated in the air stream, and the apparatus for this purpose is now being designed and constructed.

The information likely to be derived from the research should prove of very great value in the design of future aircraft of the flying boat type. At present no data are available relative to the stability of such machines. Having determined the characteristics of a typical flying boat, such as the Vedette, the information may be used as a guide in designing similar boats in the future.

—(*Investigation under the direction of Prof. J. H. Parkin, University of Toronto.*)

Associate Committee on Helium

Co-operating organizations:

University of Toronto.
Federal Department of Mines.
Federal Department of National Defence.
Ontario Department of Mines.

Previous annual reports have given a full account of the circumstances which led to the establishment of the Associate Committee on Helium and the decision of the committee to explore the possibilities of the helium bearing gas of the Inglewood district in Ontario as a source of helium. So far as is known, Canada contains the only important supplies of helium in the British Empire, and it is of the utmost importance that these supplies be conserved and developed for aeronautical, military, naval and industrial purposes. It is also essential that a supply of helium should be ensured within the empire for scientific and industrial research, in which field this gas is of great importance especially in connection with researches requiring extremely low temperatures approaching absolute zero.

During the year under review it was not found necessary to modify in any important manner the cryogenic equipment installed in the Physical Laboratory of the University of Toronto for the production of liquid air, liquid hydrogen or liquid helium. Minor changes were made, however, and improvements introduced as a result of experience in operation that have increased the efficiency and lowered the cost of operating the plant.

With a view to ensuring a supply of helium for future activities, a thorough examination was made of the Inglewood gas field. In order to ascertain the amount of gas available in the field an experiment was made that involved blowing off the gas from one of the wells recently sunk. In doing this, the pressure quickly

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dropped to a low value, and the flow of gas which gradually decreased was noted from day to day for a period of over two weeks. Observations were also made on the gas pressures in this well and also on the pressures in the neighbouring wells, all of which were found to be affected. The gas well that had been opened was then closed and the pressure in it was allowed to build up. Readings of pressure were taken on all the wells during this building-up process. From the whole series of observations thus made it was found that the conclusion could be drawn that the amount of gas immediately available in the region tapped by the gas wells was about 4,000,000 cubic feet. As the helium content of the gas is about 0.8% it follows that the amount of helium immediately available from the field is therefore limited to about 32,000 cubic feet. With this limited supply it would be quite impossible and impracticable to use the helium extraction plant formerly operated at Calgary.

A new type of extraction equipment is, therefore, being developed that has very much more modest proportions than the Calgary plant, and that involves the expansion of the gas at high pressure through a fine nozzle and the use of the heat regenerative process. It is expected that it will be possible with it to treat 25,000 cubic feet of gas and obtain a daily yield of between 150 and 200 cubic feet of helium. By operating on this limited scale for periods of about three months each summer a supply of helium can probably be ensured for a number of years. Fresh gas will have time to diffuse through to the wells from distant points in the field in the interval between the periods of operating the plant and in this way furnish additions to the available supply.

Associate Committee on New Brunswick Forest Problems

Co-operating organizations:

Federal Forest Service, Department of the Interior.

Provincial Forest Service of New Brunswick.

The task assigned to this committee is to determine, if possible, the best methods and costs of reseeding recently burned over land, old burns not restocking and certain types of cut-over lands in the Province of New Brunswick. The work has been financed by the National Research Council and has been carried out by the above named departments.

The main problem under consideration is the determination of the cheapest practical method of restocking such areas with the more valuable soft woods. The planting of trees is so costly as to be prohibitive under present economic conditions and it is consequently highly important to determine the possibilities of solving the problem of reforestation by reseeding.

Both the broadcasting and the seed spot methods of reseeding have been employed in connection with this investigation. To cover one acre by the broadcasting method requires from six to eight pounds of seed as against one pound of seed required if the seed spot method is used. Consequently the latter is the cheaper method notwithstanding the fact that it requires more labour. It also has the advantage of bringing the seed into direct contact with the soil and thus increasing the probability of germination.

Under normal conditions it requires from fifty to one hundred years to grow a tree of merchantable size. Obviously therefore in an investigation of this nature even after an adequate number of areas have been mapped, seeded and marked the observations as to the growth, mortality, etc., must be continued for a number of years before any reliable conclusions can be reached. So far as it is possible to judge at the present stage of this investigation it would appear that reseeding can be successfully carried out on areas where the young tree is afforded some protection during the early stages of its growth either by a nurse crop of intolerant hardwoods or where shade is supplied by debris or standing dead trees.

Associate Committee on Accurate Plot Work

Co-operating organizations:

Dominion Department of Agriculture.
Macdonald College.
University of Alberta.

For three seasons this committee has had test plots of oats of various kinds planted at several points throughout Canada in order that accurate information might be secured regarding the yield obtainable under various conditions of planting. It was particularly desired to know what effect variation in the size of the seed and tendency to tiller might have upon the yield. The large amount of field work necessary in this investigation was completed in the summer of 1926. As previously reported, it was possible to immediately draw certain tentative conclusions, but the great mass of data secured are being given detailed study over a period of time in order to fully determine whatever generalizations may be drawn from the results obtained.

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III. ANALYSIS OF REPORTS ON ASSISTED RESEARCHES

The first section of this report contains a statistical summary of the work carried out under assisted researches during the year under review. It is, of course, not feasible to reproduce in full here the great number of reports which have been received covering work carried out during 1927-28 under these grants, nor is this necessary since most of these papers have already been printed in technical periodicals or in the transactions of technical societies. In order, however, to provide at least a general conception of the nature, scope, volume and importance of the researches carried out under these grants, a short summary has been prepared of the principal researches conducted during the year, together with a brief explanation of the main problems involved.

A list of researches to which financial assistance has been granted by the Council will be found beginning at page 10 of this report.

The Factors Governing the Milling and Baking Quality of Wheat

Co-operating organization:

University of Alberta.

The great economic importance of Canada's wheat crop merits every attention and study looking to the improvement of Canadian wheat and the protection of its high reputation on the export market. One of the best ways of accomplishing this is by the use of more suitable varieties and better cultural methods. The comparative merits of different varieties and practices, however, must first be established by experiments. Studies on grading wheat on its protein content or any other promising method of estimating quality are also important.

The factors governing quality are very complex but they may be grouped under three heads,—soil, climate, and the inherent quality and suitability of the variety grown. By growing six different standard varieties of wheat in seven widely separated places for several seasons, it has been found that variations in quality due to environment are greater than those due to variety although the latter differences are important.

Irrigation usually results in depreciation of quality, but if alfalfa is used in rotation with the wheat, the quality is protected in a very striking manner. Both time and amount of irrigation have also been shown to have an important relation to the quality of the wheat.

The effect on quality of stage of maturity at cutting is being studied.

It has been necessary to develop improved laboratory methods for investigating the quality of wheat flour. These have comprised:

(*a*) Application of the "bound-water" method to the study of the hydration capacity of wheat gluten.
(*b*) A routine method for the determination of the resistance of wheat starch to diastatic action.
(*c*) Modification of the method for determining diastatic activity.
(*d*) A method of standardizing yeast for experimental baking.
(*e*) A device for determining the correct absorption of flour.
(*f*) Standardization of the procedure for milling and baking tests.

—(*Investigation under the direction of Professor R. Newton, University of Alberta.*)

Nature of Winter Hardiness in Crop Plants

Co-operating organization:

University of Alberta.

It is well known that in crop plants such as winter wheat, sugar accumulates with the onset of cold weather in the fall. In this investigation it has been shown that the amount of cell sugar is roughly proportional to the winter hardiness of

the plant. The sugar stabilizes the protein in the cells and in some way hinders precipitation of protein during exposure to cold. That is, sugar is an important agent in the protection of wheat plants from winter-killing. The cell sugar, however, disappears gradually from winter wheat plants during the winter months, and experiments have therefore been made on the respiration of winter wheat plants at low temperatures, in order to explain if possible the disappearance of the sugars. It is hoped eventually to be able to predict winter hardiness from chemical and other tests without recourse to lengthy field trials of new plants or varieties.

Data on catalase activity were previously correlated with winter hardiness. It is hoped that the present investigation of the rates of respiration of winter wheats, in conjunction with the data on catalase activity, may help to clear up some of the disputed points.

The program of the present investigation included the determination of the rates of respiration of a series of wheats of graded resistance to frost to be measured at zero centigrade and at temperatures below and above this with a view to determining not only the actual rates but also the speed at which varieties reacted to changes in temperature.

Preliminary results have shown that the rate of respiration at temperatures above zero centigrade is slightly greater in hardy than in non-hardy varieties. As the temperature is lowered, however, the rate of respiration becomes less in the hardy varieties, which thus exhibit a greater economy in the use of sugar during the cold weather.

The past season's experiments suggest that there are characteristic differences in the low-temperature respiration of wheat varieties, which are definitely related to winter hardiness.

—(*Investigation under the direction of Prof. R. Newton, University of Alberta.*)

The Wireworms of the Canadian Prairie

Co-operating organization:

University of Alberta.

Annual losses to grain growers on the prairies arising from the destruction of seed and young plants by wireworms are very heavy. Individual fields under observation in several districts have suffered losses of up to 70 per cent of the total seed. Few fields are entirely free from wireworms, and, when losses are slight, the damage done usually passes unnoticed. Fields that have been under the plough for many years are more heavily infested than are those in the same districts that have been more recently broken. This indicates that unless some modification can be introduced in our cultural methods, wireworm damage will become increasingly severe on the prairies. Intensity of infestation by wireworms in any given field is no index of the amount of damage that will be sustained since the amount of feeding is absolutely dependent upon the conditions of soil temperature and moisture during May and June.

The chief damage in nearly every district has been found to be due to *Ludius æripennis*. A study of the normal life cycle of this insect is being made. This cycle certainly may exceed four years. Larvæ were hatched in numbers in 1925. These have been kept in a condition to induce continual development throughout the winter and only two have matured to date (April 1928). It is nearly twelve months since the last individual to do so matured which confirms the contention that this wireworm does not universally develop in a specific number of years.

Most attention is being confined to an attempt to ascertain the reason for the increase in the wireworm population in cultivated land. Present indications are that predatory parasites and birds are of minor importance in checking wireworm increase and any real check is more readily attributable to the destruction

of the eggs by variations in soil temperature and moisture. Mortality from this cause appears to be decreased in cultivated soil as compared with unbroken sod. The real immediate problem is to prove whether the undoubted increase in the wireworm population under cultural conditions is due to this factor and to ascertain whether this increase can be checked by a modification of cultural methods.

By keeping eggs under controlled conditions of soil temperature and moisture and noting the effect upon their viability and then making comparison with records of these factors in the field, it has been found that unless the eggs be laid at a greater depth than about two inches from the surface of the soil, the pupæ will be exposed to fatal conditions in all normal seasons. It has been shown that, provided the soil has been recently worked, the female beetles burrow to a depth of between five and six inches before oviposition and that in soil of a fairly firm consistency they will lay their eggs much nearer to the surface. A possible practical method of control of the beetle population would appear to lie in so cultivating the soil that, during the oviposition period in June, the females are unable to burrow to a greater average depth than two inches.

Seed treatment for deterring wireworms from feeding on grain has yielded negative results. No particular varieties of wheat have properties which render them less susceptible to damage than other varieties as has been contended by some observers. Field rotation with flax does not reduce the numbers of the beetles.

The eggs do not develop at and above temperatures of 95°F. This temperature was reached once during 1928 at a depth of two inches at Edmonton.

—(*Investigation under the direction of Prof. E. H. Strickland, University of Alberta.*)

Prairie Mammals

Co-operating organization:

University of Manitoba.

Certain small mammals of the prairies such as gophers, mice and voles are very destructive of crops and grain. It is desirable to acquire as full knowledge as possible of the habits, life histories, geographical distribution and general ecology of these smaller mammals of the prairie region of Western Canada, in order to intelligently plan methods of control.

Five economically important species were selected for a study of their life history. This work included observations in the field and in captivity, the excavation of burrows and the collecting of embryonic material.

About 600 specimens of mice, gophers and other small mammals have been collected and carefully measured. The best of these have been preserved as museum specimens, and in every case full details of the individual have been recorded. This collection will be of value for reference and also in determining the economic status of predatory birds and mammals.

A list is in preparation which includes the available records for the last thirty years, with the known data concerning abundance and distribution of mammals during this period. A main object of this work is to ascertain the effect which the killing off of many game animals and most of the fur-bearing animals has had on those species which are harmful to agriculture.

—(*Investigation under the direction of Mr. F. Neave, University of Manitoba.*)

Bacillary White Diarrhœa in Poultry

Co-operating organization:

University of British Columbia.

Bacillary white diarrhœa is probably the most serious contagious disease of baby chicks. It is apparently widespread and is responsible for most of the losses among chicks. Adult birds often have the disease in chronic and acute forms and

their eggs, while frequently fertile, have low hatchability and are the cause of heavy losses in the chicks. The disease is caused by an organism, *Salmonella pullorum*, which in adult fowls inhabits the ovaries and egg yolks. It may be readily appreciated that one infected flock can easily be the means for spreading the disease through the country. Its control and eradication are therefore of great importance.

There are two fairly definite methods of testing fowls for the disease. In one of these, the agglutination or blood test, clear blood serum obtained from the wing veins of the birds, is mixed with a suspension of *Salmonella* organism. After incubation of the mixture at body temperature for a time, the serum from infected fowls will agglutinate the bacterial suspension. When properly carried out the results are about 97 per cent. accurate. The other test is the pullorin or wattle test and is made by injecting test fluid (an extract of *Salmonella pullorum*) into the skin at the edge of the wattle. An infected fowl will show an inflammation and swelling at the point of injection while no reaction occurs in healthy birds.

Results of egg production from hens which react to the agglutination test have been compared with the production from non-reactors. A large number of birds were tested, including reactors and non-reactors of six different breeds. It was found that the average production of eggs from hens which did not react to the agglutination test was more than four dozen eggs per year above those which reacted. In all of the six breeds, the non-reactors produced more eggs than reactors.

Since the disease is very prevalent in British Columbia, it may be estimated that the loss from lowered egg production alone amounts to several hundred thousand dollars annually. This loss may in large measure be prevented by the regular testing of flocks and the elimination of reactors.

—(*Investigation under the direction of Professors E. A. Lloyd and H. W. Hill, University of British Columbia.*)

Investigation of the Mistletoe Parasitic on Jack Pine

Co-operating organization:

University of Alberta.

In order to utilize the natural vegetation of any area to the best advantage, it is necessary to know in some detail just what plants and trees grow there and their relationships one to another. The vicinity of Brule Lake in Alberta offers an interesting study of flora among the sand dunes on its shores. The influence of certain plants in starting dunes and of other plants in arresting the movement of sand dunes is important. There are stationary sand hills to the east of Brule Lake and the flora of these stationary hills was found to be completely different even in its earlier stages from that of the dunes to the west.

In those exposed situations among the eastern sand hills that favour retention of the pioneer associations the land is at present of no agricultural importance, except for occasional hay meadows in the basins of old sloughs. Yet it is worthy of note that the natural flora is remarkably rich in berries, which are favoured by the acid soil. In the drier parts splendid crops of raspberries, strawberries, and blueberries are found, and in the wetter parts an abundance of gooseberries, dewberries and cranberries occur. This suggests that the experiment of growing small fruits in these areas would be worth trying in the future, probably as a side-line by those farming in areas adjacent to sand hills.

The pine mistletoe (*Arceuthobium americanum*) grows on the jack pine as a parasite in this region. This pine is not of economic importance locally except for such uses as railway ties, therefore the control of the pine mistletoe parasite is here not significant. But the knowledge of the distribution of the pine mistletoe, its mode of growing and spreading might be applied in areas where control of the parasite would be more important.

The fruit-bodies of the pine mistletoe explode and the seeds are thrown with considerable force for some distance. As each seed is covered with a sticky sheath, the seeds upon striking the bark of the host frequently adhere to it. Here they begin to grow, sending out aerial shoots, and in time seriously affect the growth of the tree host.

—(*Investigation under the direction of Miss E. S. Dowding, University of Alberta.*)

Flora in the Gulf of St. Lawrence Region

Co-operating organization:

University of Montreal.

The flora of the region of the Gulf of St. Lawrence has never been sufficiently well studied to permit of an appraisal of its full economic value. During the past year and the year previous several fields and laboratory studies have been made of several different localities in the above region. The estuary of the Natashquan River was again studied. Supplementary information and material in the Mingan Islands and along the north shore from Esquimaux Point to Natashquan have also been gathered.

Studies of the peculiarities of the flora of the Island of Anticosti have been completed and many new systematic entities have been secured. A series of all of the important material secured has been deposited in the National Herbarium in Ottawa. Three papers have been published as follows: Les Equisétinées du Québec, Les Gymnospermes du Québec, and Sur un Botrychium nouveau de la flore américaine et ses rapports avec le B. Lunaria et le B. simplex.

A hitherto unknown Tertiary relic-flora on the southern side of Anticosti Island has been discovered and will be reported on later.

—(*Investigation under the direction of Prof. Fr. Marie-Victorin, University of Montreal.*)

Collection and Classification of Marine Algae of the Maritime Provinces

Co-operating organization:

Dalhousie University.

No preserved collection of the marine algæ of the Canadian Atlantic coast exists and no reasonably complete list of these forms is extant.

But one season has been occupied in this work so far and nearly 100 species have been mounted. Five or six years will be required to complete the work which in addition to collecting, identifying and mounting the species found, also entails chemical analysis of the more common forms of marine algæ in this region. The work is being continued.

—(*Investigation under the direction of Prof. H. P. Bell, Dalhousie University.*)

The Glucosides of Plants in Western Canada

Co-operating organization:

University of Manitoba.

A systematic effort is being made to determine which plants in Western Canada contain glucosides. Attempts are also being made to isolate the various glucosides found and to study their properties. Whether any such glucosides prove to be of economic value can be determined only by detailed study. In case several of these glucosides should possess valuable therapeutic properties, the cultivation of the plants containing them may become important.

The biochemical procedure of Bourquelot has been used throughout this study for detecting glucosides. Of 13 plants studied, 12 contained glucosides among which a number were probably new. Numerous difficulties were met and overcome in the progress of this work.

An intensive study of the fluorescent glucoside of the wolf-berry has been practically completed. It has not been obtained in pure form, but is has been identified as æsculin, and a pure crystalline preparation of its split product has been obtained and identified as æsculetin. Aesculin is a glucoside previously reported as present in horse-chestnut bark, in *Euphorbia lathyris* and other plants.

In addition the fluorescent glucoside of bush honeysuckle has been isolated in crystalline form and identified as the related coumarin glucoside, fraxin, previously reported present in horse-chestnut bark, and in the bark of several ornamental shrubs.

—(*Investigation under the direction of Professor A. T. Cameron, University of Manitoba.*)

Sex in the Higher Fungi

Co-operating organization:
University of Manitoba.

The object of this research has been to throw light on the problem of sex and reproduction in the higher fungi, more particularly in respect to mushrooms and toadstools. An effort has been made to clear up the behaviour of the nuclei of the cells of the fungi which were reproducing themselves. Certain other problems connected with the structure and functions of the reproductive bodies have also been investigated.

The spores of *Coprinus sterquilinus*, a toadstool which may be readily grown in the laboratory, were germinated, and the mycelium (fungus plant) resulting was stained with iron-alum-hæmatoxylin, and a number of beautiful preparations were obtained. It was found that the young mycelium consists of a large branched single cell which may contain upwards of 150 separate nuclei. Later on in development, the mycelium becomes divided by crosswalls and the nuclei are then more scattered. The transition of the mycelium from the haploid to the diploid condition is still under investigation.

A few years ago Kluyver and van Neil discovered a peculiar genus of yeast cells which they called *Sporobolomyces* because the yeast cells making up each species produce spores which shoot out into the air. A nuclear study of the yeast cells has been made during the past year, and it has been found that each cell normally contains a single nucleus and that when a spore is produced, the nucleus divides, one daughter nucleus passing into the spore and the other nucleus remaining in the mother cell. No evidence was found of any nuclear fusion at any stage in the life history.

The social behaviour of the *mycelia* of a green mould which grows on wood, namely *Trichoderma lignorum*, was investigated. The union of several mycelia, each of which had sprung from a separate spore, was observed, and it was found that one only of the mycelia making up the compound mycelium produced spores, the other mycelia remaining sterile and being used up in the process.

Omphalia flavida produces a serious spot disease on the leaves of coffee bushes where coffee is grown commercially. The fungus reproduces itself normally by means of very peculiar gemmæ which are produced on tiny stocks known as gemmaphores. This mode of reproduction, which is unique among mushrooms and toadstools, has been thoroughly investigated. The fungus has been grown on living leaves of bryophyllum and oleander in the laboratory. The mycelium in the leaf was observed to be luminous, so that the leaf-spots could be seen in the dark. The mode of abcission of the gemmæ from the gemmaphores is influenced by reactions of the gemmaphore to the stimulus of gravity. The structure of a gemma is very like that of a cap or pileus of the perfect fruitbody, but it produces no spores whatsoever. When a gemma is placed on a living leaf, it germinates and is able to infect the leaf by means of mycelial hyphæ which grow out from the edges.

—(*Investigation under the direction of Professor A. H. R. Buller, University of Manitoba.*)

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The Nature of Chromosomes

Co-operating organization:

Queen's University.

Chromosomes are the minute protoplasmic constituents of all living and dividing plant and animal cells. Their number is constant for each individual and in general for all individuals throughout any species. The importance of their study is apparent when it is realized that all work on plant and animal breeding and particularly hybridization is concerned with these minute bodies.

The visible part of chromosomes and of the nuclei of cells, except for the nucleoli which may be of the same or nearly the same nature, is called chromatin and is generally believed to be the physical basis of heredity. Chemical evidence recently obtained indicates that chromatin is a fairly uniform substance and cannot therefore be the basis of Mendelian heredity. If it can be proved truly homogeneous and not heterogeneous as previously held, it may greatly alter existing theories and lead to results of importance. In this investigation root tip sections treated on the slide with tri-sodium phosphate apparently lost all the chromatin from their chromosomes and nuclei. Further work, in which the action of various strengths of sodium phosphate solutions has been observed for varying lengths of time, has confirmed earlier findings and showed as well evidence of the existence in the chromosomes of a spiral thread or chromonema.

Work was carried out on *Trillium grandiflorum* and *Tradescantia virginiana* because of their large chromosomes and because of previous work done on these forms of a descriptive nature, particularly in relation to the chromonema. More attention was given to the spiderwort, *Tradescantia virginiana* because it has a longer active period than *Trillium grandiflorum*.

Root tips were fixed in Carnoy's fluid, washed in absolute alcohol, changed by four stages to xylol and infiltrated with paraffin. Sections seven microns thick were made by the standard procedure, fastened to microscope slides and brought to water in the usual way. They were then treated with tri-sodium phosphate in concentrations ranging from 0.25 percent to 10 percent and for periods from an instant to 112 hours. In some cases they were stained first with safranin and observed under the microscope during treatment with phosphate. Pepsin hydrochloric acid was used for various lengths of time, as also was trypsin.

In general the results of this work confirm the investigator's previous findings. Further experiments are necessary, however, before definite conclusions can be reached.

—(*Investigation under the direction of Professor R. O. Earl, Queen's University.*)

Fish Muscle

Co-operating organization:

McGill University.

The work which has previously been done on the characterization of the proteins in muscle has not extended far enough and as a consequence the study of methods of fish preservation has been hampered. A knowledge of these proteins is essential both for the exact study of methods of meat preservation and for the examination of the mechanism of muscular movement.

A detailed study was made of the proteins of the muscle plasma of haddock. Two proteins or groups of proteins were isolated, one of which is soluble in distilled water and has an isoelectric-point at pH 6.0, and the other soluble in approximately molar salt solution with the isoelectric point pH 5.0-4.8. The sharpness of the isoelectric points indicates the probability of their chemical individuality. The solubility curve of the two proteins in buffered salt solutions after the method of Howe is smooth which is not to be expected in two proteins, one of which resembles an albumin and the other a globulin. Partial animo acid analyses showed that the two proteins are not identical.

Further work is proposed to determine the proportions of the two protein fractions, to make further attempts at separation and characterization, and to follow the early postmortem changes in the muscle proteins.

—(*Investigation under the direction of Prof. A. B. Macallum, McGill University.*)

The Effect of Monochromatic Light on Protoplasm

Co-operating organization:

University of British Columbia.

The stimulating effect of sunlight on the growth of most plant and animal life has long been known. In the last few years, sunlight and the light of the mercury-vapour arc lamp have been extensively used for therapeutic purposes, and considerable success has been attained in the treatment of certain diseases, including surgical tuberculosis and rickets. That there is a truly scientific basis for such treatment has been demonstrated by the production of vitamin D from ergosterol by means of ultra-violet light. This vitamin is very effective in the prevention and cure of rickets, and it is doubtless to its production that radiation owes a part of its success as a therapeutic agent.

In spite of the increasing application of ultra-violet light, however, very little is known regarding the effectiveness of any particular rays in the spectrum. Both the sun's rays and the light from the mercury vapour arc lamp contain rays ranging in length from the infra-red down to the ultra-violet. Some of these rays may be beneficial and others detrimental, and it is therefore of considerable importance to determine definitely the effect upon living organisms of each of these radiations and to learn which wave-lengths are bactericidal, anti-rachitic, growth stimulators and growth inhibitors. It is to clear up some of these points that this investigation has been undertaken.

Work has been done on a strain of yeast derived from a well-known preparation. The source of ultra-violet light was a Cooper-Hewitt mercury vapour arc. By means of a monochromatic illuminator fitted with a quartz prism and lenses, exposures of yeast to the radiation of any one of the several mercury lines became possible.

It has been found that exposure of this strain of yeast to the total mercury-arc radiation inhibits growth and development. On exposure to monochromatic light the yeast responds quite differently to light of different wave-lengths, as follows:

(*a*) Growth is stimulated by red and particularly by yellow light.

(*b*) Growth is inhibited by green and by violet light, also by the ultra-violet from 4,000 to 3,660 Angstrom units, but in varying degrees.

(*c*) The near ultra-violet light from 3,660 to 2,900 Angstrom units stimulates growth.

(*d*) The far ultra-violet light inhibits growth most markedly.

From the above results it is evident that the effect of either visible or ultra-violet light for any considerable range may be the resultant of many effects of varying phase and intensity, or in a specific case one ray may act as the determining factor.

—(*Investigation under the direction of Prof. A. H. Hutchinson, University of British Columbia.*)

The Sun's Ultra-Violet Light and the Distribution of the Food of Fishes

Co-operating organization:
Queen's University.

There are in the sea and in fresh water myriads of small animals, known as copepods, which are allied to the lobsters, crayfish and crabs but are much simpler in structure. These inconspicuous little animals are, indirectly, of great importance to man, because they furnish the chief food of most of the commercial fishes during the early part of their life, and the food of some commercial species, such as herring, throughout their entire life.

Some of these copepods, including the larger species, keep at a depth of ninety feet or more in the sea during daylight, and even on moonlight nights, and come to the surface only on the darkest nights. Since the movements of these little animals control, to a very large extent, the distribution of several commercial fishes, it is obviously of importance to learn the reason why they avoid the light.

By means of a special apparatus, many species of copepods were exposed to "filtered" sunshine. In one compartment of this apparatus the animals were exposed to both the visible and the ultra-violet rays received from the sun; in a second compartment they received only the visible rays, while in a third compartment they were exposed only to the ultra-violet rays. In every case, those species which normally avoid the light were quickly killed by the ultra-violet of the sunlight, but lived indefinitely in the sunshine from which the ultra-violet had been removed, while those species which remain near the surface of the water at all times lived just as well in the presence of ultra-violet radiation from the sun as in its absence.

As a tentative estimate, it would seem as if the ultra-violet component of sunlight, at sea level, latitude 45° North, was about 2.5 per cent of the total radiation.

—(*Investigation under the direction of Prof. A. Brooker Klugh*
Queen's University.)

Chlorination of Methane

Co-operating organization:
University of Toronto.

The most important Canadian occurrences of natural gas are in the province of Alberta, although some gas also occurs in commercial quantity in Ontario and New Brunswick. In Alberta the gas is frequently found while drilling for oil, and the amount thus discovered to date is far in excess of the ability of the industries of the province to utilize to advantage. Moreover, in many cases it is not economically feasible to cap the gas wells and thus retain the gas in the ground, since much of the gas is "wet"—contains condensable hydrocarbons similar to the constituents of gasoline—and the only way to recover these valuable light oils is to allow the gas to flow and recover them by suitable processes. When sufficient markets for the cleaned gas are not at hand the only alternatives are to shut down the wells entirely or allow the gas to escape, and the latter alternative has been adopted in a considerable number of cases,with the result that the present volume of gas daily going to waste in Alberta is not far from one hundred million cubic feet. It is highly important, therefore, to develop methods for the utilization of this waste gas.

Natural gas consists for the most part of methane, but in some fields the amount of the higher hydrocarbon ethane is also considerable. These, then, form the raw materials to utilize which new methods must be sought. One such possible method is the chlorination of methane to methyl chloride or carbon tetrachloride. Methyl chloride is at present used principally in refrigerating machines and in the dye industry. Carbon tetrachloride is in greater demand owing to its increasing use as a solvent. It is also replacing gasoline and benzene as a cleaning fluid since it will not burn, and this property has led to its extensive use in fire extinguishers. It is also used in making chloroform.

It was found that methane and chlorine reacted so as to give methyl chloride when passed over a catalyst consisting of pumice impregnated with reduced cupric chloride. The most favourable temperature of the catalyst was found to be 450°C. The catalyst must be kept reduced by water vapour or steam. The reacting gases should consist of nitrogen, methane and chlorine in the ratio of 70 : 7 : 1. The ratio of methane to chlorine is especially important since lowering it tends to produce a larger proportion of undesirable products such as methylene chloride. The nitrogen should be saturated with water vapour at room temperature in order to maintain the catalyst in the reduced condition. Oxygen should be absent. Under these conditions yields of methyl chloride of from 85 percent to 90 percent were obtained experimentally with complete utilization of the chlorine.

Carbon tetrachloride was obtained by passing methane and chlorine in the theoretical ratio of 1 : 4 over the same catalyst that was used for obtaining methyl chloride and at the same temperature. It was found that the rate of passing the gases through the catalyst was important, a too high rate resulted in explosions. Yields of 90 percent were obtained. Nitrogen, when added to dilute the chlorine, was found to favour the production of lower chlorinated products of methane. When nitrogen was added to a 1 to 4 mixture of methane and chlorine even with a rapid passage through the catalyst, explosions stopped but the yield of carbon tetrachloride was lower.

—(*Investigagion under the direction of Professor M. C. Boswell, University of Toronto.*)

Vulcanization of Rubber

Co-operating organization:

McGill University.

Rubber which is not vulcanized has but few uses compared with vulcanized rubber. The rubber industry has expanded greatly in recent years, and seems destined to expand further. Studies of the conditions governing the most important process in rubber manufacture, that of vulcanization, are therefore of very wide interest. The knowledge of the chemistry of rubber is not as complete as is desirable and studies of the effects of some of the minor constituents of raw rubber have proved to be very valuable.

The resin naturally present in Hevea rubber has been shown to consist largely of fatty acids and it has been demonstrated by several investigators that such acids play an important part in the vulcanization of rubber with the aid of many organic accelerators. Stearic acid, oleic acid and linoleic acid have been shown to influence vulcanization and the order just given represents the order of diminishing effectiveness of the acids. It appears that in the case of accelerators which are capable of producing good cures in the absence of zinc oxide, these acids are comparatively unimportant, whereas in the case of accelerators which function only poorly in the absence of zinc oxide, the presence of fatty acids is important or essential.

The amount of fatty acids present in natural rubber varies. It has been shown to be advantageous to add stearic acid so as to make the fatty acid content uniform. With certain accelerators it is even an advantage to add stearic acid in amounts beyond that needed to secure uniformity from one rubber to another.

The results of these experiments have been published and the rubber industries have availed themselves of the information in regular commercial practice.

—(*Investigation under the direction of Prof. G. S. Whitby, McGill University.*)

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The Deterioration of Concrete in Alkali Soils

Co-operating organization:
University of Saskatchewan.

In many parts of Western Canada the surface waters contain in solution a considerable proportion of soluble salts, of which the sulphates of sodium and magnesium are the most important. These soluble salts have resulted in what are generally known as "alkali" soils, which as a rule are unsuitable for agricultural purposes. A further difficulty encountered in such areas is the more or less rapid deterioration of concrete structures, the cost of repairs and replacements to which amounts to a very large sum annually.

The present investigation is the first thorough experimental study made of the underlying causes of the deterioration and of the mode of action of the alkaline waters. It is also the first serious effort to discover means of preventing such detrimental action on concrete. The investigation of the problem was begun by Professor Thorvaldson as early as 1920, and was later continued under a committee of the Engineering Institute of Canada and with the financial support not only of the National Research Council but also of several provincial governments and private companies. Recently, however, the National Research Council has assumed the whole financial support of the investigation.

During the year under review the progress of the work has been recorded in four publications, as follows: (1) The Expansion of Portland Cement Mortar Bars during Disintegration in Sulphate Solutions. (Engineering Journal, April, 1927). (2) The Action of Sulphates on the Components of Portland Cement (Trans. Roy. Soc. Canada, 1927), (3) The Effect of Steam Treatment of Portland Cement Mortars on their Resistance to Sulphate Action (Eng. Jour., March, 1928), (4) Notes on the Relative Resistance of Various Cements to the Action of Sulphate Waters (Eng. Jour., March, 1928). These papers emphasize amongst others the following points of importance upon which new light has been thrown:

First, the degree of deterioration of cement bars under the action of sulphate waters may be accurately determined by measurement of the expansion of such bars over a period of time. It has been definitely established that in this way the progress of deterioration can be followed long before there is any visible evidence of change, the result being that valuable knowledge can now be secured in months instead of years.

Second, that the action of the salts in "alkali" waters upon cement can be scientifically explained by a study of the effect of these salts upon the constituents of the cement, and that as a consequence, the action which the waters of any district will have upon a cement of known composition may to a large extent be predicted in advance. At least one Canadian cement company is making use of this information in an attempt to increase the resistance of its product to sulphate action.

Third, that suitable steam treatment will entirely prevent the action of sodium sulphate upon even the leanest cement mortars, and greatly reduce the action of calcium and magnesium sulphates upon ordinary cements. This method has been worked out to such an extent that precast concrete products such as drain tile, conduits and sewer pipe can be made resistant to sulphate action without any very large cost.

When the investigation was in its early stages, a considerable number of specimens of concrete made from different cements and with different mixes were buried in the soil in suitable locations in the prairie provinces. These have recently been examined and the observations made have served to confirm in a practical way the conclusions reached in the chemical investigation. This work has also demonstrated the wisdom of the decision to depend chiefly upon the fundamental researches of the laboratory instead of upon field tests, since the former have yielded far more information of value and have supplied that information in a much shorter period of time.

—(*Chemical investigation under the direction of Prof. T. Thorvaldson, University of Saskatchewan.*)

Alternating-Current Electrolysis

Co-operating organization:

University of Manitoba.

The recent very rapid development of hydro-electric power in Canada has made available in many places alternating current at a price sufficiently low to justify its use in domestic water heating. Off-peak power is sometimes cheap enough to enable it to partly replace coal in central-heating plants. Surplus power, developed by the large power companies in anticipation of future demands, is at present used on a large scale in raising steam for pulp and paper plants, and is likely to be so used until it is required for purposes where it can command a higher price. In view of these applications of alternating current, it became evident that the action of electric boilers should receive thorough study.

In previous reports on this investigation it has been pointed out that there is some danger of explosions from the generation of hydrogen and oxygen in boilers where the current is passed through the water as a resistor. This has been found particularly true with low-frequency current and at high current density. All of the current above a definite critical current density produces hydrogen and oxygen, the electrolysis following Faraday's law quantitatively, as in direct-current electrolysis.

Electric boilers for steam generation operate at voltages up to 6,600 or higher, and the investigation has therefore been extended to discover what decomposition of water takes place at voltages higher than those used in domestic service. This was particularly desirable since hydrogen and oxygen have been found in radiators connected to a central heating plant.

The fact has now been established that in addition to the electrolytic decomposition of water, when the critical current density is exceeded, decomposition also takes place due to arcing on the electrodes. The quantity of hydrogen and oxygen produced by excessive arcing may be several times that which can be accounted for by electrolytic action. The critical point above which electrolytic gases are generated is also the point at which arcing commences. The conclusion has been reached that the volume of the gaseous products of decomposition of water at high voltages is directly proportional to the quantities of electric energy used up.

Pressure affects gas evolution. Experiments were carried out at voltages from 700 to 2,200, and in all cases the arcing, which was much in evidence at atmospheric pressure, disappeared entirely when the pressure was increased. A gauge pressure of 31 lb. per square inch entirely suppressed the arcing at 2,200 volts.

—(*Investigation under the direction of Prof. J. W. Shipley, University of Manitoba.*)

The Effect of Low Temperatures upon the Impact Resistance of Steel Castings

Co-operating organization:

University of Manitoba.

It appears that the percentages of broken connecting rods, car wheels, car axles, and various steel castings, are higher during the winter months than in summer. This may be due to improper design, to defective materials, to poor lubrication, or to changes in the physical properties of the metals at temperatures below the freezing point. The climate of Canada presents extremes of temperature, yet but little has been known of changes in the physical properties of metals at temperatures below normal. A study of resistance to impact promised to furnish interesting information upon the problem.

In this investigation the temperatures of test bars were confined to the range from −70°F. to 150°F. The low temperatures were obtained by immersing the test bars in a bath of carbon dioxide snow and acetone.

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A gray electric-furnace cast iron gave a resistance to impact of 10 ft. lbs. per square inch at 68° F., and at −4°F. and −40°F, the resistances to impact were 9 ft. lbs. and 7½ ft. lbs., respectively. A high silicon cupola cast iron had resistances to impact at 68°F., −4°F. and −31°F. of 15 ft. lbs., 9 ft. lbs., and 7 ft. lbs. per square inch, respectively. The resistances to impact of ordinary cupola cast iron at 68°F., 5°F., and −31° F. were 18 ft. lbs., 15 ft. lbs. and 11 ft. lbs. per square inch respectively. All three of these irons contained about 0.6 per cent of phosphorous.

Ordinary electric furnace steel castings were found to have resistances to impact at 70° F., −10°F. and −25°F. of 148 ft. lbs., 48 ft. lbs., and 43 ft. lbs. per square inch respectively, which are higher than for gray cast irons, but show a marked reduction at low temperatures. A high carbon electric furnace cast steel had a lower resistance to impact than the low carbon steel. At 68°F., 10°F., and −4°F. the resistances were 64 ft. lbs., 37 ft. lbs., and 29 ft. lbs. per square inch respectively.

An electric furnace cast steel was tested for resistance to impact both with and without heat treatment to refine the grain. With heat treatment the resistances to impact at 68°F., 23°F. and −4°F. were 182 ft. lbs., 138 ft. lbs. and 100 ft. lbs. per square inch respectively. Without heat treatment the resistances to impact at the same corresponding temperatures were 135 ft. lbs., 85 ft. lbs., and 43 ft. lbs. per square inch respectively. Heat treatment of the metal was therefore of great value in this case.

Cast steel containing 0.22 per cent. of vanadium was heat treated. The resistances to impact at 69°F. and at −58°F. were 325 ft. lbs. and 150 ft. lbs. per square inch respectively, a decrease in strength of nearly 49 per cent. A steel forging containing 0.19 per cent. vanadium was tested before and after a heat treatment to refine the grain. Before heat treatment the resistance to impact at 70°F. was 46 ft. lbs. per square inch and at −58°F. it was 20 ft. lbs. per square inch. After heat treatment the resistances to impact at 68°F. and at −58°F. were 216 ft. lbs. and 112 ft. lbs. per square inch respectively. Heat treatment again proved very beneficial.

Alloy steels containing from 1.5 to 2.7 per cent of nickel were tested at 68°F. and at −36°F. The resistance to impact at 68°F. varied from 683 to 848 ft. lbs. per square inch and at −36°F. the resistance to impact varied from 473 to 758 ft. lbs. per square inch. These metals were tough and ductile and had a fine grained structure.

In general, heat treatment improved the resistance to impact of cast steels. Nickel alloyed with steel gives the best physical result of all the metals tested for resistance to impact both at normal and at low temperatures.

—(*Investigation under the direction of Prof. R. W. Moffatt, University of Manitoba.*)

Penetration of Ultra-Violet Radiation into Natural Waters

Co-operating organization:

Queen's University.

The measurement of the penetration of the ultra-violet radiation received from the sun—that is of wave-lengths from 400 mμ to 289 mμ—into the sea and into lakes is a matter not only of scientific interest but of practical importance, because some of the organisms which constitute the food of many commercial fishes are killed by this radiation, and this has an effect upon the distribution of these fishes.

An instrument for the purpose of measuring penetration of ultra-violet rays into water has been designed and built. It consists essentially of a water-tight brass box which is lowered into the water. On the top of the box are two shutters which can be opened and closed. The method of use is to establish a standard of comparison by exposing a plate to light sources of known intensity, and then to

determine the effect of exposure under the unknown conditions beneath the surface of the water. By comparison with the standard one can then readily secure quantitative information as to the intensity of the light being measured.

It is expected to measure by means of this method the penetration of ultra-violet rays into the waters of the Bay of Fundy and Chamcook Lake.

—(*Investigation under the direction of Prof. A. B. Klugh, Queen's University.*)

Nocturnal Radiation

Co-operating organization:

McGill University.

It is a matter of common knowledge that a large amount of heat is radiated from the earth's surface at night. This loss is greater on clear nights than on cloudy nights and it is on clear nights in the spring and fall that unexpected and severe frosts so frequently occur. Such frosts often cause great damage to crops, and while it is not possible to prevent frost the work done thus far gives considerable promise that eventually predictions may be possible as to where and when unusual frost and hail will occur, in much the same way as other weather conditions are now forecast.

Areas of high night heat loss, that is high radiation, are relatively colder than other areas. Measurements of this radiation have been made and it has been shown that this loss of heat during cold winter nights directly through the atmosphere to space is responsible for the largest proportion of ice formation in our rivers and lakes. The experimental results show that the radiation for short intervals of time may exceed anything which has hitherto been recorded. This indicates that at times there exists in the atmosphere areas of low moisture content, through which a temporary increase in the earth's radiation may cause an abnormal temperature drop on the surface of the earth.

—(*Investigation under the direction of Professor H. T. Barnes, McGill University.*)

Emission and Absorption Spectra

Co-operating organization:

University of Toronto.

A vacuum grating spectrograph and two fluorite spectrographs were modified in design and construction and mounted. With these instruments several investigations have been completed and others are in progress.

The spectra emitted by electro discharges in oxygen and in a mixture of oxygen and argon were photographed with the grating spectrograph to see if any spectral lines showed enhancement similar to that of the oxygen auroral green line. The spark spectra of mercury, gold, silver, and cadmium were photographed in the spectral regions covered by the grating spectrograph. By use of one of the fluorite spectrographs, spectrograms for cadmium, selenium, tellurium, gold and mercury were obtained for the region from 2000 A.U. to 1350 A.U.

Absorption experiments were also made with the fluorite spectrographs to determine whether or not the "activity" of the so-called active nitrogen was due to an atomic state of the gas, and if so, to find at the same time if any considerable proportion of the constituent atoms were in either of the two metastable states that are possible for atoms of nitrogen. Four papers have been published descriptive of this work and others are in preparation.

—(*Investigation under the direction of Professor J. C. McLennan, University of Toronto.*)

Problems in Hygroscopy

Co-operating organizations:

McGill University.
Dominion Department of Mines.

In some industries, notably the textile industries, control of atmospheric moisture within prescribed limits is essential to the maintenance of the best operating conditions. Industrial drying operations require fuller and better knowledge of the moisture content of the air. These requirements have made necessary the development of more accurate hydrometers and hygrostats, and also of better methods for determining surface temperatures than any now in use.

In order to obtain moisture equilibrium curves for various substances, a means for keeping them at a constant relative humidity was necessary. The Dominion Department of Mines supplied a large hygrostat which has been remodelled in its circulation and humidification systems. The motor has been mounted exteriorly. The relative humidity is held fixed by the strength of a solution of calcium chloride passing down strips of wick suspended in their draught. A metal drying chamber is preferable to a wooden one if the humidities desired are greatly different from that of the surroundings.

Substances such as hair, paper, tobacco and asbestos were exposed to the varying conditions of humidity covered by the annual ranges of humidity in the atmosphere. Curves were obtained showing the variations in weight of these substances which ranged from negligible changes to amounts as high as 15 per cent between average winter and summer conditions.

Relative humidity has been found to be a very important factor in the fading of coloured materials. It is desirable to correlate known average outdoor temperatures and outdoor relative humidities in different parts of the world with average conditions of temperature and relative humidity which obtain indoors in corresponding places so that the laboratory tests by manufacturers of goods may be made under the conditions of light exposure and humidity which obtain indoors in the localities for which the goods are intended. By eliminating the temperature variable in the relative humidity curves for indoors and outdoors a correlation factor has been found. This factor gives the ratio of the indoor and outdoor absolute humidities, so that if the outdoor relative humidity and temperature are known, the approximate average indoor relative humidity at any temperature can be calculated, including the average effects of indoor influences such as free water, people, dry materials, etc.

A proper study of problems, involving evaporation from moist surfaces, such as the drying process in the paper industry, could not be made until the surface temperatures and temperature gradients in the drying material were determined with precision. An examination of methods which have been developed for measuring temperatures of metallic surfaces was made and all of these were found unsatisfactory. A new method, the severed thermocouple method, was devised. The two ends of the thermocouple are soldered to a piece of heavier wire which is embedded in the surface. Errors due to fall in temperature caused by leakage at the junctions with the surface are reduced. By taking readings with a soldered junction and then with the junctions "severed", the heat loss and resultant corrections for particular cases can be calibrated.

—(*Investigation under the direction of Prof. A. N. Shaw, McGill University.*)

Viscosity of Gases

Co-operating organization:

McGill University.

From a practical as well as a scientific point of view it is desirable to ascertain accurately the viscosity of gases in order that aberrations from the ideal gas law at high densities may be calculated. At the present time several commercial processes involve reactions in the gaseous state at high pressures and temperatures and more such processes will no doubt be used in future. In connection with such processes it is desirable to know the characteristics of the reacting gases.

The apparatus constructed for the purpose of this investigation was of the oscillating disc type and refinements were introduced so that the errors of measurement were made consideraly less than in any set of measurements heretofore recorded. This apparatus was made for measuring the viscosities of gases at temperatures not higher than room temperature and at pressures not greater than atmospheric. It was calibrated with air at room temperature and at $-78.5°$ centigrade and the calibration was checked with hydrogen at room temperature. The viscosities of methyl ether and sulphur dioxide in the gaseous state have been measured over the range $20°$ to $-70°$C.

An equation has been deduced to express the aberrations of gases from the ideal gas law $pv = RT$. If the relationship expressed by this new equation is found to hold generally it will be of great practical interest, since it will be possible from determinations of the densities of a gas under two or three conditions of pressure and temperature to calculate the density under any conditions whatever.

The measurements will be extended to at least 20 gases over a long range of temperature.

—(*Investigation under the direction of Prof. O. Maass, McGill University*).

High-Speed Electrons

Co-operating organizations:

University of Toronto.

The Carnegie Corporation.

Two investigations have been made during the year, one on the effects produced when high-speed electrons are projected into a chamber filled with ammonia at various selected pressures, and a second on the phosphorescence of nitrogen solidified with liquid hydrogen.

The Decomposition of Ammonia Gas by Means of Cathode Rays

The ultimate aim of the research was the synthesis of ammonia by causing activation of hydrogen and nitrogen, and thus their combination, by means of cathode ray bombardment. Because the stability of ammonia under this treatment is important, a study of the behaviour of this gas under electron bombardment was made.

The apparatus used consisted of a cathode-ray tube, of the type lately described by Coolidge, which was actuated by a large transformer and rectifier capable of producing 200,000 volts. The reaction chamber, to which ammonia gas could be admitted, was sealed to the cathode tube and received the rays through a thin nickel window.

To eliminate the effect of a silent discharge through the ammonia, which would thereby be quickly decomposed so that any decomposition by cathode-ray bombardment might be completely masked, the reaction chamber was covered with tin-foil and the gauge used was enclosed in a metal vessel connected to the charged end of the cathode-ray tube.

In the first experiments with ammonia the increase of pressure, and thus the decomposition, was directly proportional to the time, that is, it was independent of the concentration of ammonia. This early result appears to have been due to some catalytic effect of the glass. Such a condition was not permanent and the graphs began to curve and show a dependence on the ammonia concentra-

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tion. The gas was subjected to bombardment at each voltage until final equilibrium was attained and no further increase in pressure occurred. The voltage was increased in steps. The equilibrium percentage of ammonia decomposed increased with voltages above a minimum voltage of 82,000 volts, which was the highest voltage for zero decomposition. At voltages lower than this value it would appear that the rays do not penetrate the particular window used.

The quantity of ammonia decomposed depends on the initial pressure of the ammonia. Increase of the pressure from 0.68 mm. to 4.06 mm. caused a decrease in the amount decomposed from 29.4 per cent to zero when the electron bombardment was at a velocity given by an application of 115,000 volts to the tube. Since an equilibrium is set up, this would appear to indicate that at the later stages of the experiment the hydrogen and nitrogen produced by the decomposition of the ammonia begin to unite. Two series of experiments are therefore proposed, one with an excess of nitrogen and the other with an excess of hydrogen present, to study such conditions upon the reaction.

Phosphorescence in Solid Nitrogen

Luminescence in solid nitrogen under cathode-ray bombardment was discovered by Vegard who ascribed the well-known auroral green line to this luminescence. McLennan and others have shown, however, that this line is due to oxygen. This is an outstanding example of the phenomena of luminescence and further work with a view of photographing the spectrum more completely and obtaining if possible information on the fine structure of the bands, rates of decay, polarization, and other phenomena, is desirable in order to secure data which may define the origin of the luminescence.

For the production of the luminescence, use was made of a cathode-ray tube specially designed by Dr. Coolidge for getting high-velocity electrons outside the generating tube by passing them through a thin window of nickel foil. Nitrogen was frozen by liquid hydrogen contained in a double-walled flask of nickel silver, the solid nitrogen was subjected to vigorous electronic bombardment when a voltage of 125,000 to 150,000 was applied across the tube, and the luminescence could then be observed or photographed through a quartz window placed in the side of the outer wall of the metal flask.

The spectrum of the luminescence from solid nitrogen was photographed through the whole region from 2,000 A.U. to 10,000 A.U. by using spectrographs of very high light power but of low dispersion. About 25 bands were obtained, and their maxima were measured as accurately as possible. It was found that the bands fell into several well-defined series, the properties of which were studied in some detail.

—(*Investigation under the direction of Prof. J. C. McLennan, University of Toronto.*)

Series Spectra and Atomic Structure

Co-operating organizations:

University of Alberta.

Carnegie Institution.

The spectroscope furnishes science with its most important means of investigating the ultimate structure of matter. By its use it is possible to investigate that which lies beyond the power of the best microscope to reveal. Spectroscopic measurements have already been made with a very high degree of accuracy, yet in this investigation greater precision has been attained by use of a vacuum spectrograph with a concave grating of six-foot radius ruled 30,000 lines to the inch.

Four research papers have been published during the year under review, as follows:

(1) The Spectra of Gallium, Germanium, and Indium, by R. J. Lang, Physical Review, Vol. 30, pp. 762-769, Dec. 1927.
(2) The Spectra of Singly and Doubly Ionized Germanium, by R. J. Lang, Proceedings of the National Academy of Sciences, Vol. 14, pp. 32-36, Jan. 1928.
(3) On the Spectra of Doubly and Trebly Ionized Titanium, by H. N. Russell and R. J. Lang, Astrophysical Journal, Vol. LXVI, 1927, pp. 167-196.
(4) The Second Spark Spectrum of Zinc, by Otto Laporte and R. J. Lang, Physical Review, Vol. 30, pp. 378-386, Oct. 1927.

—(*Investigation under the direction of Prof. R. J. Lang, University of Alberta.*)

Aurora Research

Co-operating organizations:

University of Toronto.
Carnegie Corporation.

A study of aurora phenomena is of interest because of the information to be secured about the condition of the upper atmosphere. Upon a knowledge of atmospheric conditions at high elevations depends the solution of a number of very important problems in radio transmission and terrestrial magnetism. The investigations in this research were in two directions. In one direction efforts were made to obtain the magnetically resolved or Zeeman components of the oxygen auroral green line, which has previously been shown to be indentical with the green auroral spectral line found by Babcock of Mt. Wilson Observatory, and in the other direction, endeavours were made to obtain observations in various localities on the intensity of the green line radiation from the night sky.

The Zeeman Effect

It was desirable to find under what conditions the oxygen green line could be obtained with the greatest possible intensity. Various discharge tubes were made and tried out, with different types of electrical excitation. The best results were obtained with oxygen mixed with an excess of argon, when a current of 150—200 milliamperes was passed through the gaseous mixtures from a high tension 2,000 volt D.C. generator. It was found possible to obtain the green line radiation with a discharge tube sealed off from the pumping system when the electrodes had been properly outgassed and all impurities had been extracted from the argon and oxygen used, by use of auxiliary magnesium electrodes.

For investigating the Zeeman effect, a specially designed oil-cooled magnetizing coil was constructed into which the discharge tube could be inserted. Some photographs were taken with a powerful 45-plate echelon spectropraph that showed a boublet structure of the green line under longitudinal observation. A second water-cooled coil has been designed and constructed with which it is expected to find the magnitude of the separation of the two Zeeman components and to fit the oxygen green line into its proper place in the term scheme assignable by modern theory to the spectrum of atomic oxygen.

Green Line Radiation from the Night Sky

The first consideration in this investigation was to construct a spectrograph that would be suitable for giving spectrograms of feeble light sources in the shortest possible time. Four different instruments were successively constructed in which either direct vision constant deviation, or 60-degree prisms were used. The instrument that proved the most powerful and gave the best results was one in which a 60-degree dense flint prism was used in conjunction with special lenses. With this instrument it was found that observable records of the spectral line corresponding to the auroral green radiation could be obtained with the

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light from the night sky on moonless nights, both in Saskatchewan, near Esterhazy, and at Toronto and Aurora in Ontario. The object has been to see if the intensity of the green line radiation from the night sky varied during the night, and the plan followed was to take a spectrogram with an exposure of about 2½ hours immediately after sunset, one of the same duration in the middle of the night and one of the same length of time just before sunrise. Whether or not solar radiation had anything to do with putting the oxygen in a state in the upper atmosphere to emit the green line radiation would probably be revealed by this procedure. So far only fair results have been obtained, due to unfavourable weather conditions.

A photographically recording photometer with a green light filter which limits the light passing through it to a spectral band extending about 100 A.U. on either side of the green line has been constructed. It is thought that the time of exposure can be reduced so as to obtain spectrograms in less than an hour. Indications have been obtained that the intensity is a minimum about the middle of the night, but many more observations over a long period will be necessary to establish the reality of this minimum beyond dispute.

—(*Investigation under the direction of Prof. J. C. McLennan, University of Toronto.*)

Zeeman and Stark Effects on the Helium Spectrum

Co-operating organization:

McGill University.

Simple spectral lines and bands produced in a magnetic field are resolved by the field, a phenomenon known as the Zeeman effect. Resolution of such spectral lines in an electric field is called the Stark effect. This research presents results of a study of the observed effect of the simultaneous electric and magnetic fields on certain of the more intense helium lines, and is further limited to the case where the fields are uniform and parallel.

The parhelium combination line near the diffuse line at wave-length 4388 was studied satisfactorily. The initial purpose of the experiments was to split this line with a superimposed and parallel magnetic field. One effect of the superimposed magnetic field is to somewhat constrict the discharge near the cathode. In consequence of this action, the maximum electric field established was in each case nearly twice that which might have been expected in the absence of the magnetic field. In a typical experiment, a potential of 8000 volts was applied to a tube 2.5 mm. in diameter with a concurrently imposed magnetic field of 2700 gauss. Under these conditions a maximum electric field of 96,000 volts per cm. was developed. The current through the tube was three milli-amperes.

The expected combined effect has been found for all principal and sharp series lines which appeared on the plates—4713, 5015, 4438— and for a few of the stronger components of the new line groups which appear in the presence of electric fields.

The parallel as well as the perpendicular components of the orthohelium group at wave-length 4471 were studied when fields of 95,000 volts per cm. and 2,500 gauss respectively were applied to the source.

—(*Investigation under the direction of Prof. J. S. Foster, McGill University.*)

Low Temperature Research

Co-operating organizations:

University of Toronto.

The Carnegie Corporation.

Scientific investigations in the field of low temperatures have in many instances in the past been followed by commercial developments. In the physical laboratory at the University of Toronto, cryogenic apparatus has been installed for producing liquified gases such as air, hydrogen and even helium which is liquid at a temperature of −272°C. Several investigations were conducted during the year under review. No important modifications were made in the cryogenic equipment during this period.

(1) Electrical Conductivity of a Number of Elements at Low Temperatures

The electrical conductivity of a number of elements has been investigated at low temperatures with a view to obtaining critical data for the construction of a theory of low temperature electrical conduction in metals.

Of the alkali metals cæsium has been studied in particular this year. The work of last year on chromium has been extended and preliminary observations have been made on cobalt that promise to give results that will be of use in discussing the properties of the group containing iron, nickel, and cobalt.

Single crystals of arsenic were prepared by the distillation of the metal, and by the use of a furnace somewhat similar to that used by Bridgman. It was found that these crystals could be made sufficiently large to measure the change in their electrical conductivity with temperature. The resistance of arsenic became very small at temperatures below that of liquid hydrogen, but super-conductivity was not observed down to 2.5° above absolute zero.

Measurements on single crystals of antimony show that the conductivity of this element follows a law markedly different from that of arsenic but more nearly like that of bismuth.

(2) Effect of Impurities on the Super-Conductivity of Lead.

Temperature resistance curves were taken and specific resistances determined for lead-cadmium alloys, the latter metal varying from 0 to 5 per cent. The results of the experiments enable the construction of a series of curves which show the effect of the presence of cadmium in the lead on the resistance of the latter at low temperatures, particularly on the conditions of occurrence of the super-conducting state.

(3) The Crystal Structure of Calcium

A distillation method was developed with which it became possible to grow crystals of calcium with facets so bright and regularly formed as to be readily shown by the optical method to belong to the rhombo-dodecahedron class. The electrical conductivity of calcium crystallized in this way is now being studied at various low temperatures.

(4) Crystal Structure of Solid Acetylene

X-ray powder photographs of solid acetylene show that this substance crystallizes in two forms, one of which is definitely cubic, and the other probably hexagonal. These facts are in agreement with the optical data obtained by Wahl. A detailed examination of the intensities of "reflection" from the various planes is being made in order to determine the respective structures and the energy change involved in the transition from one modification to the other.

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(5) The Photo-electric Effect at very Low Temperatures

The photo-electric effect has already been investigated with several of the alkali metals down to the temperature of liquid air. To investigate the effect at still lower temperatures a high vacuum potassium photo-electric cell was constructed and the electron emission under excitation by light was measured at room temperature (300°K), liquid air temperature (80°K), and liquid hydrogen temperature (21°K). Spectral bands isolated by filters were used as light sources. It was found that the decrease in the photo-electric current for any wave-length still continued as the temperature was lowered from 80°K to 21°K. The longer wave-lengths are affected most. An explanation of the phenomena is being sought in a change with temperature of the work function for the metallic surface or in a change with temperature in the light absorption coefficient for the potassium.

(6) Magnetic Properties of Single Crystals of Zinc and Cadmium

The specific susceptibilities obtained for zinc crystals were -0.183×10^{-6} in a direction parallel to the principal axis of the crystal, and -0.147×10^{-6} in a direction perpendicular to this axis. For cadmium these values were -0.276×10^{-6} and -0.169×10^{-6}. The values given by Owen, obtained from coarse-grained crystals, were, for zinc -0.155×10^{-6} and for cadmium, -0.18×10^{-6}. Still larger differences are expected for mercury. At the present time an attempt is being made to grow single crystals of this metal.

It is intended to study a larger number of crystals with respect to the influence of low temperatures upon magnetic susceptibility.

—(*Investigation under the direction of Prof. J. C. McLennan, University of Toronto.*)

Abnormal Colour Vision

Co-operating organization:

University of Manitoba:

It has been known for over a century that many people have abnormal colour vision, to which the name colour blindness has been given. Many types of this defect of vision have been found and, because of its great importance in transportation by rail and water where colour signals are employed, tests have been devised for its detection.

A more recently detected type of abnormal colour vision has been given the name of "anomalous" colour vision. In this type the eyes are by nature supersensitive to colours. There are thus two classes of abnormal vision, one involving a subsensitive and the other a supersensitive visual apparatus.

The relationship of these abnormal types to normal vision has never before been found. A comparable group of measurements was obtained on three subjects, one colour blind, one normal and a third of anomalous vision and it is now clear that one basic theory is sufficient to include all types of vision and so greatly simplify the theoretical treatment of the subject.

It has been found that the sensitivity of every sense organ is under control of that part of the nervous system which carries nervous impulses outward from the brain to the organ. These outgoing impulses are of two kinds, one of which enhances and the other depresses the sensitivity of the organ. When a sense organ such as the eye is stimulated by light or colours, the equilibrium of sensitivity is disturbed, and recovery is made by swinging alternately to enhanced and depressed states of sensitivity. This condition the investigators term the "oscillatory effect." It has now been tested by experiments upon the eye and the principle has been completely verified. As a result of this discovery a very large number of phenomena which depend upon the action of the nervous system have become clear, as for example the matter of proper rest periods in industry

and school work. It is obvious that if the nerves which control all movements and operations of the body are in a period of inhibition, only the poorest response of any kind is possible and a greater degree of fatigue results. But if at such times a few minutes of rest are given, the inhibition passes off, the enhancing actions become dominant and work may be resumed with advantage.

—(*Investigation under the direction of Professor F. Allen, University of Manitoba.*)

Power Losses in Dielectrics

Co-operating organization:

University of Alberta.

The study of dielectrics in the electrical industries is of growing importance. Power losses in dielectrics are considerable, and our knowledge of the factors involved in such losses are not by any means complete. The increasing hydro-electric development in Canada, which is second only to that of the United States, serves to give emphasis to such studies.

This investigation is a study of the variation of power losses with frequency in condensers. In earlier experiments such losses were measured on a special type of bridge, but on extending the range of the bridge, difficulty was found in obtaining a method of detecting a balance in the bridge with frequencies above those which are audible in the telephone receiver.

Last year the heterodyne method was tried without results, but mechanical interruption of the supply current by a vibrator at about 1,000 times a second gave promise of being a good method. During the past year, however, this latter method was abandoned on account of some doubt being raised with regard to its effect on the slope of the voltage wave and the introduction of transients. It is well known that the shape of the voltage wave is important in measuring dielectric loss and that the sine wave form should be used.

The heterodyne method was then again tried and with more success. The arrangement was as follows:

The leads from the telephone transformer of the bridge were joined to the input of an ordinary two-stage amplifier. The output of the amplifier was connected by a transformer to the telephones. The leads from the heterodyne oscillator also fed into this transformer. The heterodyne oscillator was completely enclosed in a metal shield and the amplifier was also shielded. The introduction of the amplifier prevented the heterodyne oscillator from feeding back into the bridge. When the bridge was unbalanced the beat note between the bridge oscillator and the heterodyne could be distinctly heard, but when the bridge was balanced the note disappeared. A sharp balance could be obtained to frequencies of over 30,000 cycles. In previous work at Harvard, the bridge method was used for frequencies up to 3000 only. The new apparatus will be used in continuing the investigation.

—(*Investigation under the direction of Professor H. J. MacLeod, University of Alberta.*)

The Generation of Electricity by Windmills

Co-operating organization:

University of Saskatchewan.

The use of windmills to generate electricity for farms has received some attention in most countries. By employing storage batteries the power developed can be made available throughout the 24 hours for either light or power. The prairie provinces of Canada constitute a particularly favourable location for such small individual plants because of the amount of wind prevailing.

Measurements of the power developed by an installation of a windmill with a 10-foot propeller geared to a one-k.w. direct current generator have been made

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for a year. The power output over a month's time has varied from 40 to 217 k.w. hr., and for a period of a year the total output of power was 1,480 k.w. hr., an amount of power amply sufficient for the ordinary farm. The chief items of cost for the power depend upon the initial cost of the installation, its period of life and usefulness, and a full utilization of the capacity of the plant.

The work already done has yielded much information which will be of value in continuing the research. Changes in design of the equipment are needed to eliminate present mechanical defects so as to give it longer life. Over 50 per cent. of the power capacity of the generator should be utilized directly, without the use of storage batteries. The large storage battery capacity at present required should be materially reduced, or storage methods should be improved.

In order to overcome the necessity of a large storage battery, and thereby reduce the cost of electricity, a windmill is required which will produce energy at the lowest practical wind velocity so as to shorten materially the present long periods of calm, or low production. Long periods of calm make necessary a large storage capacity. Furthermore, storage batteries are responsible for a large part of the cost of installation and replacement, and their life is limited.

The high-speed propeller type of windmill, while efficient, light and simple, presents a serious problem when ice accumulates on it, as it may wreck itself or other parts of the mill if even moderate winds occur before the ice is completely removed from the blades. The problem of governing a high-speed wheel is more difficult than that of a low-speed wheel.

The generation of electricity for farm use by means of windmills offers a great number of advantages, and the progress made in the present investigation indicates that by the use of special equipment it may be possible to secure these advantages at a cost which will not be prohibitive. Cheap electricity from windmills, however, can not be made available unless the cost of the necessary installation can be radically reduced.

—(*Investigation under the direction of Prof. A. R. Greig, University of Saskatchewan.*)

Structural Welding

Co-operating organization:

University of Toronto.

Welding is coming to occupy an important place in the fabrication of structural steel. A very comprehensive programme for the experimental investigation of this new art has been evolved by the American Bureau of Welding in co-operation with various bodies. The object of the study is to secure dependable data for the guidance of the designing engineer and of those responsible for the compiling of building codes and specifications in which steel is employed. A portion of the programme is being carried out at the University of Toronto and this involves a series of 342 individual tests, two thirds of which are now finished. The completion of the series and the analysis of the data obtained therefrom are at present under way.

Welding will not wholly supersede riveting in the fabrication of structural steel, but it will be doubtless replace riveting in many situations with considerable advantage to the construction industry.

—(*Investigation under the direction of Prof. P. Gillespie, University of Toronto.*)

Relation of Silver Deposits to Diabases

Co-operating organization:

University of Toronto.

The relationship between silver deposits and Keweenawan diabases in Ontario appears to be very close. Several types of diabase occur and it has been the object of this study to relate the silver deposits to some specific one of these diabases. Carefully collected specimens from Cobalt, Gowganda and South

Lorrain were studied in detail and certain phases of the diabase have been recognized which show relations to the silver deposits. The diabase phases examined in detail were quartz diabase, chill phase of quartz diabase, quartz norite, hybride type, and coarse type or quartz gabbro, all occurring in the Nipissing diabase sill.

"Barren" quartz diabase and its various phases carry silver in very small quantities, namely 0.02 oz. per ton.

The Nipissing diabase sill may be considered to consist, from bottom to top, of quartz diabase, quartz norite, and quartz gabbro. These grade imperceptibly into one another. Field relationships indicate that the typical quartz norite is a barren zone and does not contain silver ore.

The depth to which ore shoots will extend in the upper portion of the sill is controlled by the thickness of the quartz gabbro phase. Where it is poorly developed the ore will be shallow, and where it reaches its maximum thickness shoots may be found in the sill as much as 500 feet from the upper contact.

It is probable that the post-Nipissing diabase dikes, Nipissing diabase, and Matchewan diabase, all come from the same magma.

The quartz-norite found in these areas represents the beginning of the development of this phase which reaches its culmination as norite to the southwest in the Sudbury field, where it is associated with the important nickel-copper deposits.

The silver came from the Nipissing diabase magma and not from any other igneous intrusion.

—(*Investigation under the direction of Professor E. S. Moore, University of Toronto.*)

Structure and Growth of Anchor Ice

Co-operating organization:
McGill University.

The question of the formation of anchor ice on the bottoms of our navigable rivers and lakes and its influence on water transportation and power development is becoming of increasing importance with the continued growth of these industries. One locality of immediate interest is the St. Lawrence River, where the proposal has been made to construct a deep waterway. If any method can be discovered for the control of anchor ice formation for even a part of the winter it will be of considerable practical importance in that the season for navigation may thereby be lengthened.

Studies and observations on the structure and growth of anchor ice show that on nights of high nocturnal radiation, such ice forms rapidly. During periods of sunshine the light-giving rays of the sun are effective in preventing growth of anchor ice even in water at the freezing point. That this is not entirely caused by heat is shown by the fact that the heat rays, that is the infra-red rays, are unable to penetrate through more than 15 feet of St. Lawrence river water, while the visible light rays penetrate to approximately 100 fathoms and effect anchor ice up to depths of 40 feet.

Experiments with artificial radiation have been made over the international section of the St. Lawrence river at Morrisburg, where anchor ice forms very readily. A high-power mercury lamp and powerful incandescent lamps were tried. The general result obtained was that wherever light from the lamps penetrated through the water to the bed of the river, which was here three feet deep, no anchor ice grew. There was no possible chance for the direct heat of the lamp to penetrate to the bottom through the three feet of running water, nor was it possible for the temperature of the running water to be appreciably influenced by the rays of the light. It was solely a case of the direct influence of the visible radiation of the lamp, which penetrated through the water and was absorbed on the surface of immersed objects, and thereby supplied sufficient energy to prevent the formation of anchor ice.

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It is evident that very little energy in the form of radiation is required to prevent the ice from separating out as a solid precipitate. The exact nature of the radiation which is most efficient in destroying the ice-forming power of the water has not yet been determined.

—(*Investigation under the direction of Professor H. T. Barnes, McGill University.*)

The Solution, Transportation and Precipitation of Iron and Silica in Nature

Co-operating organization:

University of Toronto.

It is desirable from both scientific and economic points of view to study the puzzling problem of the origin of the large iron formations, and in particular the siliceous banded types of pre-Cambrian age. All investigators recognize that tremendous quantities of iron and silica are being carried in solution by the streams of the world to-day, but no deposits similar to those formed in pre-Cambrian time are now being laid down. Gruner has calculated that the Amazon, assuming the iron content to be 3 parts per million, could carry sufficient iron in 176,000 years to form the Biwabik formation. The amount of silica is correspondingly large. Such evidences of the importance of a study of the behaviour of iron and silica in solution suggested a laboratory and field investigation of this problem.

A series of experiments was carried out to determine the relative amounts of iron and silica dissolved from norite and diabase by distilled water, oxygenated water, carbonated water and solutions of organic matter. The results showed that:—(1) Carbonated water is the most effective solvent of iron and silica from norite and diabase. (2) Peat solution is the next most effective solvent of iron and silica. (3) Distilled water is a very poor solvent of iron, but it is a fairly active solvent of silica. (4) Oxygenated water is a very poor solvent of iron and only a fair solvent of silica.

Time and finer grinding increase the solvent action. Carbonated water is able to dissolve sufficient iron and silica from a basic terrain to form a large sedimentary iron deposit. Organic matter, if present, assists in dissolving much iron and silica. Contrary to former belief, iron is not carried as bicarbonate in cold, natural surface water high in organic matter, but in all probability it is transported as a ferric oxide hydrosol stabilized by organic colloids. A relatively small amount may be carried as salts of organic acids or adsorbed by organic colloids.

As much as 36 parts per million of ferric oxide, formed by the oxidation and hydrolysis of ferrous bicarbonate, can be held in colloidal solution by 16 parts per million of organic matter. Under exceptional conditions, iron may be in solution in surface waters as salts of inorganic acids or as a ferrous silicate hydrosol.

Silica in solution in cold natural waters is transported as a colloid provided the concentration does not exceed 25 parts per million, but if the concentration is higher it is possible for a small percentage to be transported as alkaline silicate.

The general conclusions are, that the iron going to make up most of the large sedimentary iron formations was transported principally as a ferric oxide hydrosol, stabilized by organic matter, and that the greater portion of the silica was transported as silica hydrosol.

The precipitation of ferric oxide hydrosols by electrolytes depends upon the kind of electrolyte and upon the preparation of the hydrosol. Ferric oxide hydrosols were formed experimentally: (1) by hydrolyzing a solution of ferric chloride, (2) by dispersing freshly precipitated ferric hydroxide in a solution of ferric chloride, and (3) by oxidizing a solution of ferrous bicarbonate in the presence of a small amount of peat solution.

With a concentration of 10 parts per million of ferric oxide of the first two types of ferric oxide hydrosols, complete, almost immediate precipitation was obtained with sodium chloride, potassium sulphate, magnesium sulphate, potassium chloride, potassium nitrate and sodium hydroxide in concentrations of 34,400 parts per million.

Sea salt, obtained by evaporation of sea water, in a concentration of 34,400 parts per million, also caused, almost immediately, complete precipitation of the first two types of ferric oxide hydrosols, but with the third type, complete coagulation occurred only after three days.

Solutions of ferric ammonium tartrate, ferric malate, ferric formate, and ferric tartrate were inoculated with bacteria such as exist in muck, soil and natural waters. It was found that iron was precipitated as ferric hydroxide by such bacteria, but that light had no appreciable effect on the rate of precipitation, nor did carbon dioxide or oxygen materially affect the precipitation. Such soil bacteria capable of precipitating organic iron solutions are very widely distributed in nature.

Electrolytes such as sodium chloride, potassium sulphate, carbon dioxide, calcium bicarbonate or sea water do not immediately precipitate silica from dilute sodium silicate solutions, but, excepting in the case of carbon dioxide, precipitation does occur in time. Of these electrolytes, sea water and calcium bicarbonate are the most efficient precipitants.

Magnesium sulphate immediately gives a precipitate of magnesium silicate plus silica when more than 25 parts per million of silica as sodium silicate are present, but with less sodium silicate, no precipitate forms. Carbon dioxide and magnesium sulphate stabilize solutions of sodium silicate containing 25 parts of silica per million. The conclusion is that at a dilution of 25 parts per million of silica, sodium silicate solutions are completely hydrolyzed, the silica being all in the colloidal form.

Silica hydrosols, prepared either by dialyzing a solution of sodium silicate or by precipitation with hydrochloric acid, are precipitated in time by sea water. Saturated solutions of magnesium or calcium bicarbonate are very inefficient precipitants of the silica hydrosol. Magnesium sulphate tends to stabilize the solution. Complete precipitation was not obtained in any case in 75 days. Concentration was found to affect precipitation, that is, raising the concentration of silica hydrosol, hastened the precipitation.

Mixing of ferric oxide and silica hydrosols so that the reaction mixture contained 10 parts of ferric oxide and 30 parts of silica per million, resulted in mutual precipitation. Practically all of the iron together with a little silica was precipitated while the greater portion of the silica remained in solution. However, addition of peat solution prevented mutual precipitation and delayed precipitation by sea salts, that is, the iron was precipitated in a few days while silica was precipitated only after several months by sea water electrolytes from solutions stabilized by organic matter.

The banded pre-Cambrian iron formations are well known, yet very few suggestions have been made regarding the cause of the banding. Banded iron and silica can be produced in the laboratory by Liesegang's method, but this seems inadequate to explain the large banded iron formations. The banding can also be produced by differential settling in sea water of freshly precipitated and well agitated ferric hydroxide and silica. The greater portion of the iron with considerable silica settles first, followed by the deposition of a layer of almost pure silica. New supplies of the material cause a repetition of the banding. These experimental results suggest an explanation for the occurrence of banding in the pre-Cambrian iron formations.

—(*Investigation under the direction of Professor E. S. Moore, University of Toronto.*)

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Ultrasonics

Co-operating organization:

University of Alberta.

Waves of the same type as waves of sound, but at pitches too high for audibility, are ultrasonic. Just as physicists, since Ritter's discovery of ultra-violet light in 1801, have had the interest to investigate a span of light-waves beyond the visible, so they now may investigate an easily producible range of sound-waves beyond the audible. The frequency at the threshold of audibility, at this higher end of the scale, is about 20,000 vibrations per second; above this the frequencies are, for human ears, ultrasonic.

The sources of such vibrations, hitherto, such as high-pitched short pipes, Galton's whistle, short metal rods vibrating longitudinally or transversely when hit, high-pitched tuning-forks, bird-calls, and electric arcs, were unable to supply acoustic energy in appreciable amounts. The broad physical principle involved in the modern production of ultrasonic beams is that of diffraction.

Following the Titanic disaster in 1912, proposals were made to use the echoes of high-pitched acoustic waves for preventing such disasters. This idea has since been developed. In order to direct a radiated beam, the transmitters and receivers must have linear dimensions of about the same length or larger than a wave-length. Ordinary sound waves in water are nearly 10 feet long which practically precludes their use in compact instruments. In ultrasonics, frequencies from 20,000 to over 1,000,000 per second have come to be employed.

Calculations, supported by experiment, show that if ultrasonic beams are employed in sea-water the surfaces of submerged objects such as rocks, ice-bergs or ships, act as nearly perfect reflectors, and in consequence their proximity may be disclosed by the "echo" produced by their reflections of the waves. The proximity of icebergs, shores or submerged wrecks may, under certain conditions, be detected in the same way, and their distances may be estimated.

The only successful ultrasonic generators so far developed depends upon the phenomenon of piezo-electricity. A crystal displaying the phenomenon when subjected to pressure along a certain axis called the electric axis, develops opposite electrification at its ends. On being subjected to equal tension the same quantity of electricity is liberated but the polarity is reversed. This is the underlying principle of ultrasonic receivers. Reversibly, if a quantity of electricity is applied to the faces of a plate of the crystal, cut perpendicularly to the electric axis, thereby establishing a difference of potential, there will be a dilation of the plate in the direction of the axis; if the electric field is reversed there will be equal contraction in the same direction. This is the principle of ultrasonic generators. Quartz is the most suitable crystal for practical ultrasonic instruments.

The instruments used for both transmission and reception are made alike, and the same instrument may be used for both purposes. In general, a trans-mitter or receiver consists of an electric condenser, in which a quartz mosaic is the dielectric and metal plates the electrodes. The piezo-electric condenser, when excited by an oscillating voltage, constitutes a mechanical vibrating system of appreciable thickness, possessing a fundamental resonant frequency of longitudinal vibration and many overtones.

The characteristics of the beams are shown by measurements with a torsion pendulum. If small, light, dust particles are sprinkled in front of a generator in water, the radiating face of the generator being vertical, the particles as they sink are driven forward by the pressure of the radiation and are jostled from regions of maximum to the regions of minimum energy intensities. After the particles have settled, a representation of the energy distribution is obtained in the form assumed by these sand particles.

Audible beats may be obtained from ultrasonic sources when two vibrations of different ultrasonic frequencies are produced together. The difference in tone, if within the audible range, is usually detected with ease.

By reflecting the waves emitted from a transmitter, either in a vertical or horizontal liquid column, it has been found possible to measure the velocities of ultrasound, and consequent adiabatic compressibilities, in certain liquids at various frequencies and temperatures. In this work both listening tube detectors and dust figures have been used to mark the nodal planes by which the half wave-lengths have been measured.

When ordinary sound waves pass through a wall or partition, the latter usually is thin in comparison with a wave-length. The exact laws of reflection and of transmission are difficult to investigate with ordinary sound, but by treating the problem as one analogous to the passage of light waves through transparent plates there have been worked out mathematically certain results applicable to ultrasonics.

The phenomenon of cavitation has also been studied. Cavitation in a liquid is marked by the continuous formation of bubbles near the ultrasonic generator, if driven at sufficient power. With care, curtains of bubbles can be produced so regular and well defined that measurements of wave-length and velocity can be taken from them.

—(*Investigation under the direction of Dean R. W. Boyle, University of Alberta.*)

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IV. POST-GRADUATE RESEARCH SCHOLARSHIPS

Three classes of scholarship are awarded by the National Research 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 eleven years ending March 31st, 1928, the National Research Council awarded one hundred and seventy-nine Bursaries, one hundred and fifty-two Studentships and sixty Fellowships. These three hundred and ninety-one awards were held by two hundred and twenty-five persons in fifteen departments of science at twelve Canadian universities. Each grantee carried on his work under the direction of a 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 thirteen grantees have secured the degree of M.A., or M.Sc. and eighty-five the degree of Ph.D. According to the latest returns which it has been possible for the Council to secure, five hundred and eighty-four scientific papers have been published by these grantees.

At the end of the year under review, one hundred and seventy-eight persons had completed their training in science under these awards. The Council has therefore during the past eleven 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, ninety-five persons held a Bursary, Studentship, or Fellowship for one year, fifty-one persons held awards for two years and only thirty-two 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 eighty persons who have completed their training under these awards. Of these, twenty-two 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 department of science; sixty-five persons are engaged in the teaching profession, forty-three of these having received appointments to the staffs of Canadian universities, where the majority of them will have an opportunity of continuing their scientific training and engaging in research work. Twenty-five persons are employed in the industries and twenty-five have accepted positions in the technical branches of the Federal and Provincial Governments. Seven grantees are employed in various capacities on the staffs of universities, sanatoria, etc., and fourteen persons, for various reasons, are not at present actively engaged in research work. One grantee has died and nineteen have failed to furnish the Council with information regarding their present occupation.

It is especially gratifying to note that of the one hundred and eighty grantees, only thirty-seven have accepted positions in foreign countries, of whom thirty-one are in the United States, four in South Africa, two in England and one in Newfoundland. All of the others, so far as it has been possible to ascertain, are at work in Canada, with the exception of sixteen persons who are continuing their post-graduate studies in the United States or in England.

During the year under review five Fellowships, sixteen Studentships and twenty-seven Bursaries were awarded and held under the auspices of the Council. These forty-eight awards were won by graduates of eleven Canadian universities as follows: University of British Columbia, two awards; University of Alberta, three awards; University of Saskatchewan, two awards; University of Manitoba, three awards; University of Toronto, eight awards; University of Western Ontario, four awards; Queen's University, five awards; McGill University, sixteen awards; and Dalhousie University, five awards.

The National Research Council clearly recognizes that it is essential to build up in Canada a corps of thoroughly trained research workers capable of undertaking and directing scientific research. The Council consequently regrets exceedingly that there are so few scholarships available in Canada to promising university graduates. Until the existing situation in this respect has been greatly improved, it is inevitable that many of our most brilliant graduates will accept awards available abroad and complete their training in foreign countries with the obvious result that their services are generally lost to Canada.

In view of these facts the National Research Council would urge that all business organizations, societies and individuals who believe that scientific research is an essential factor in the development of Canadian industries and natural resources, give serious consideration to the possibility of establishing in Canada an increased number of graduate scholarships for scientific research tenable at Canadian universities. Such scholarships would unquestionably keep in Canada many promising university graduates who at present are forced to go abroad for their post-graduate training and who in most cases remain abroad and use their specialized training and ability to assist in the development of foreign industries.

48 Scholarships held during the Year 1927-28

RAMSAY MEMORIAL FELLOWSHIP

Grantee	Graduated	Where held	Subject of Research
W. H. Barnes.....	B.Sc., M.Sc., Ph.D., McGill.	Royal Inst. of Physical Chemistry, London, England.	The crystal structure of ice.

FELLOWSHIPS

K. H. Butler.....	B.A., Dalhousie, M.A., McGill.	Department of Physical Chemistry, McGill University.	The preparation and properties of the hydrogen persulphides.
J. H. McLeod.....	B.Sc., Sask., M.A., Toronto.	Department of Physics, University of Toronto.	A further study of the oxygen spectral line at λ5577 A.
C. D. Niven.....	B.Sc., Aber., M.A., Ph.D., Toronto.	Department of Physics, University of Toronto.	Conductivity of metals at low temperatures.
A. L. Patterson.....	B.Sc., M.Sc., McGill.....	Department of Physics, McGill University.	The application of X-rays to the study of organic substances.

STUDENTSHIPS

C. H. Bayley.....	B.A.Sc., M.A.Sc., M.A., Toronto.	Department of Organic Chemistry, University of Toronto	Some reactions of colloidal solutions of platinum.
L. V. Bell.....	B.Sc., Alberta.....	Department of Geology, University of Toronto.	The Temiskaming sediments of the Kirkland Lake area.
G. B. Carpenter.....	B.A., British Columbia, M.A., McGill.	Department of Physical Chemistry, McGill University.	Aberrations from the ideal gas laws in systems of one and two components.
Miss M. L. Chalk.....	B.A., M.Sc., McGill.....	Department of Physics, McGill University.	Further investigations in the Stark effect.
Miss E. Cohen.....	B.A., M.A., Toronto.....	Department of Physics, University of Toronto.	Magnetic properties of single crystals of certain elements.
C. C. Coffin.....	B.A., Dalhousie.....	Department of Physical Chemistry, McGill University.	Molecular structure and molecular attraction.
A. M. I. A. W. Durnford.	B.A., M.A., W. Ontario..	Department of Physics, University of Toronto.	The Zeeman effect for platinum
H. Greenberg.....	B.Sc., McGill.....	Department of Organic Chemistry, McGill University.	A study of the constituents of the serum of Hevea Latex.
J. L. Hart.....	B.A., M.A., Toronto.....	Department of Limnobiology, University of Toronto.	A study of the spawning of the whitefish.
H. W. Johnston.....	B.Sc., M.Sc., McGill.....	Department of Cellulose Chemistry, McGill University.	The fundamental laws underlying the penetration of solids by liquids.
Miss M. E. MacKay...	B.A., M.A., Dalhousie...	Department of Physiology, University of Toronto.	The production of energy, in living tissues.
Leo Marion.....	B.Sc., Queen's.....	Department of Organic Chemistry, McGill University.	Isolation and constitution of lignin substance present in spruce wood.
L. M. Pidgeon.....	B.A.,Man., M.Sc.,McGill.	Department of Cellulose Chemistry. McGill University.	Penetration of liquids into fibrous materials.
E. W. G. Samson.....	B.Sc., M.Sc., Manitoba..	Department of Physics, University of Toronto.	The fluorescence of solid nitrogen.
Miss M. Spence.....	B.A., M.A., Queen's.....	Department of Bacteriology, Queen's University.	The toxin and antitoxin reactions of Bacillus Welchii in connection with pernicious anæmia.
B. P. Sutherland.....	B.Sc., British Columbia, M.Sc., McGill.	Department of Physical Chemistry, McGill University.	The viscosity of gases.

BURSARIES

Miss E. J. Allin.....	B.A., Toronto.....	Department of Physics, University of Toronto.	The fine structure of some lines in the spectra of certain elements.
Miss M. A. Borden.....	B.A., Dalhousie.....	Department of Zoology, Dalhousie University.	The biology of the Scallop Pecten magellanicus.
W. G. Brown.....	B.Sc., Sask.....	Department of Physical Chemistry, University of Saskatchewan	The thermochemistry of compounds of the system CaO-Al_2O_3, SiO_2, as they occur in the clinker of Portland cement.

BURSARIES—*Continued*

Grantee	Graduated	Where held	Subject of Research
Wm. Chalmers.....	B.A., British Columbia ..	Department of Organic Chemistry, McGill University.	Influence of structure on the ability of organic compounds to undergo polymerisation.
D. LeB. Cooper.....	B.Sc., Dalhousie-Kings...	Department of Physical Chemistry, Dalhousie University.	Physico-chemical properties of acetaldehyde and paraldehyde.
M. F. Crawford.....	B.A., W. Ontario.....	Department of Physics, University of Toronto.	An investigation of spectra in the extreme ultraviolet.
B. W. Currie.....	B.Sc., Sask., M.Sc., McGill.	Department of Physics, McGill University.	The flocculation of colloids under the influence of X-radiation.
A. C. Cuthbertson.....	B.Sc., McGill.....	Department of Physical Chemistry, McGill University.	Preparation and properties of pure hydrogen peroxide.
J. H. Findlay.....	B.A., B.Sc., Queen's.....	Department of Physics, Queen's University.	A spectroscopic study of the effect of mixing active nitrogen with certain vapours.
D. K. Froman.....	B.Sc., Alberta.....	Department of Physics, University of Alberta.	Transmission of high frequency acoustic vibrations in tubes.
A. R. Graham.....	B.S.A., McGill, M.Sc., Toronto.	Department of Entomology, University of Toronto.	The morphology, bionomics and control of members of the Genus Chermes.
A. C. Hill.....	B.Sc., Dalhousie, M.Sc., McGill.	Department of Cellulose Chemistry, McGill University.	Oxidation of organic compounds with special reference to hydrogen peroxide.
W. A. Jones.....	B.A.Sc., British Columbia.	Department of Mineralogy, University of Toronto.	The geology and ore deposit of the Slocan District, B.C.
C. T. Lane.....	B.Sc., M.Sc., McGill.....	Department of Physics, McGill University.	The magneto susceptibility of the alkali metals.
P. A. Macdonald.....	B.Sc., M.Sc., Manitoba..	Department of Physics, McGill University.	Colour vision and an attempt to obtain fundamental colour sensation curves.
M. D. MacLeod.....	B.Sc., McGill.....	Department of Physics, McGill University.	An investigation into the nature of the oscillations in a discharge tube containing different rarified gases.
L. A. Matheson.....	B.A., W. Ontario.....	Department of Physics, University of Toronto.	A study of the photo-electric effect in superconducting metals both above and below superconducting temperatures.
G. C. McCartney.....	B.A., B.Sc., Manitoba...	Department of Geology, University of Manitoba.	The erosion of sand grains along with a determination of the heavy mineral content of the various sands.
O. M. Morgan.....	B.A., W. Ontario.....	Department of Chemistry, University of Western Ontario.	The electrical conductivity of concentrated salt solutions.
A. H. W. Needler.....	B.A., Toronto.....	Department of Marine Biology, University of Toronto.	The life history of the haddock.
J. L. Nickerson.....	B.A., Dalhousie.....	Department of Physics, Dalhousie University.	A determination of the range of alpha particles from thorium.
D. A. Pasternack.....	B.Sc., Queen's, M.Sc., McGill.	Department of Organic Chemistry, McGill University.	The action of sulphur and sulphur halides on certain unsaturated substances especially on fatty oils.
D. S. Rawson.....	B.A., Toronto.....	Department of Biology, University of Toronto.	The fish food supply in Lake Simcoe.
B. W. Sargent.....	B.A., M.A., Queen's.....	Department of Physics, Queen's University.	The transmission of β-rays through matter (a) the actual range of β-rays of this range with voltage. (b) the production of X-rays by β-rays. The spectra of the gases absorbed by Palladium Black.
Wm. R. Sawyer.....	B.Sc., Queen's.....	Department of Physical Chemistry, McGill University.	The Effect of radiations on reactions in silicic acid gels.
M. G. Sturrock.....	B.Sc., Alberta.....	Department of Cellulose Chemistry, McGill University.	Chlorination of wood meal, and its bearing on the constitution of lignin.
M. S. Whelen.....	B.Sc., M.Sc., Sask.....	Department of Cellulose Chemistry, McGill University.	Cellulose ethers.

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178 Scholarship Graduates—1917-1927

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., Ph.D.	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., M.A.	Acadia	Graduate Student, University of Toronto, Toronto, Ont.
N. J. Atkinson, B.Sc., M.Sc.	Saskatchewan	Graduate Student, Department of Zoology, University of Illinois, Urbana, Ill.
W. F. Baker, B.A., B.Sc., M.Sc.	Manitoba	With Anglo-American Company, South Africa.
H. C. Bates, B.A., M.A.	Toronto	Research Physicist, Corning Glass Works, Corning, N.Y.
R. W. Beattie, B.Sc., M.Sc.	Queen's	Research Fellow, Northwestern University, Evanston, Ill.
A. H. Bell, B.A., Ph.D.	Toronto	Associate Geologist, with Illinois State Geological Survey, Urbana, Ill.
H. P. Bell, B.Sc., M.Sc., M.A., Ph.D.	Dalhousie	Associate Professor of Botany, Dalhousie University, Halifax, N.S.
L. V. Bell, B.Sc., M.A.	Alberta	In charge of geological survey party for Ontario Department of Mines.
P. A. Berard, B.A., L. es. Ch. Sc.	Montreal	No information.
G. H. Berkeley, B.A., M.A., Ph.D.	Queen's	Senior Plant Pathologist, Field Laboratory of Plant Pathology, London, Ont.
E. G. Bishop, B.Sc., M.Sc., Ph.D.	McGill	Geological Staff, Anglo-American Corporation of South Africa, Broken Hill, Northern Rhodesia.
Miss E. L. Bishop, B.A., M.A.	Toronto	Teacher of Mathematics, Georgetown High School, Georgetown, Ont.
L. L. Bolton, B.A., M.A.	British Columbia	Assistant in Histology and Embryology, Cornell University Medical College, Ithaca, N.Y.
E. H. Boomer, B.Sc., M.Sc., Ph.D.	British Columbia	Professor of Chemistry, University of Alberta, Edmonton, Alta.
H. A. Braendle, B.A., M.A.	Toronto	In Technical Department, Binney & Smith Company, New York, N.Y.
O. C. Brigeman, B.A., M.A., Ph.D.	Saskatchewan	Research Associate, Bureau of Standards, Washington, D.C.
B. S. W. Buffam, B.Sc., M.Sc., Ph.D.	McGill	With Anglo-American Co., Northern Rhodesia, Africa.
J. W. Burns, B.Sc., M.Sc.	New Brunswick	Assistant Professor of Chemistry, University of Western Ontario, London, Ont.
Miss F. M. Cale, B.A., M.A.	Toronto	Married.
P. Cartier, B.Sc., L. es Sc.	Montreal	Assistant Professor, Dept. of Chemistry, University of Montreal, Montreal, P.Q.
H. M. Cave, B.A., M.A.	Queen's	Graduate Student, Cavendish Laboratory, Cambridge, England.
G. C. Chamberlain, B.S.A.	Ontario Agricultural College	Assistant Plant Pathologist, Dominion Experimental Farms, St. Catharines, Ont.
Miss H. D. Chataway, B.A., B.Sc., M.Sc., Ph.D.	Manitoba	Graduate Student, University of Manitoba, Winnipeg, Man.
E. Chauret, I. Ch. L. es Sc.	Montreal	Chemical Engineer, Laboratory for Testing Materials, Montreal, P.Q.
H. R. Chipman, B.A., M.A., Ph.D.	Dalhousie	Chemist, Atlantic Experimental Station for Fisheries, Halifax, N.S.
N. D. Clare, B.Sc., M.Sc.	Manitoba	Demonstrator in Chemistry, University of Toronto, Toronto, Ont.
Miss M. L. Clark, B.A., M.A.	Toronto	Teacher of Mathematics, Collingwood Collegiate Institute, Collingwood, Ont.
R. J. Clark, B.A.	McGill	Graduate Student, Physical Laboratory, The University, Edinburgh.
Miss L. Corbett, B.A., M.A.	Queen's	Married.
R. G. Cornell, B.Sc.	Queen's	Consulting Chemical Engineer, Quinte Milk Products Ltd., Wellington, Ont.
R. N. Crozier, B.A., M.A.	British Columbia	Demonstrator in Chemistry, McGill University, Montreal, P.Q.
Miss A. E. Dempsey, B.A., M.A.	McMaster	Married. Research on Tuberculosis at the Henry Phipps Institute, Philadelphia, Pa.
A. B. de Passillé, B.Sc.A., I.C., I.Ch.	Montreal	Professor of Chemistry, Ecole Polytechnique, University of Montreal, Montreal, P.Q.
E. P. Dolan, B.Sc., M.A.	St. Francis Xavier	Deceased.
V. H. Emory, B.A.Sc.	Toronto	Research Engineer, Abitibi Power & Paper Company, Iroquois Falls, Ont.
A. B. A. Evans, B.Sc., M.Sc.	Birmingham	Publisher, Agard & Co., Ltd., Birmingham, England.
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 Biologist in charge of Pacific Salmon Research Station, Cultus Lake, B.C.
J. C. Forbes, B.A., M.A., Ph.D.	Saskatchewan	Assistant Professor of Chemistry, Medical College of Virginia, Richmond, Va.

Grantee	University where undergraduate training received	Present Occupation
H. R. Foreman, B.A., M.A.	Toronto	President and Sales Manager, H. R. Foreman & Co., Ltd., Heating and Refrigerating Engineers, 75 King St. W., Toronto, Ont.
J. H. Fox, B.A., M.A.	Western Ontario	Teacher of Physics, Collegiate Institute, Windsor, Ont.
Miss C. W. Fritz, B.A., M.Sc., Ph.D.	McGill	Timber Pathologist, Forest Products Laboratory, Ottawa, Ont.
Miss M. A. Fritz, B.A., M.A., Ph.D.	McGill	Assistant in Palæontology at Royal Ontario Museum and Instructor in Palæontology at University of Toronto, Toronto, Ont.
W. A. Gale, B.A.Sc., M.A.Sc.	British Columbia	Assistant Director of Research with American Potash and Chemical Corporation, Trona, Cal.
J. F. L. Germain, B.A., A.R.C.Sc.	Montreal	No information.
B. E. Gilbert, B.A., M.A., Ph.D.	McMaster	Head of Chemical Department, Rhode Island Agricultural Experiment Station, Kingston, R.I.
Miss K. F. Godwin, B.A., M.Sc.	McGill	Married. Graduate Student, Cambridge University, Cambridge, England.
W. L. Gordon, B.S.A., M.Sc.	McGill	Assistant Pathologist at Dominion Rust Research Laboratory, Winnipeg, Man.
W. E. Graham, B.A.Sc., M.A.Sc., M.A., Ph.D.	British Columbia	Demonstrator in Electro-chemistry, University of Toronto, Toronto, Ont.
C. Greaves, B.Sc., M.Sc., Ph.D.	McGill	Junior Chemist, Forest Products Laboratories, Ottawa, Ont.
H. B. Hachey, B.Sc., M.Sc.	St. Francis Xavier	Professor of Physics, University of New Brunswick, Fredericton, N.B.
R. S. Jane, B.A.Sc., M.Sc., Ph.D.	British Columbia	No information.
C. M. Jephcott, B.A., M.A., Ph.D.	Toronto	No information.
I. W. Jones, B.A., B.Sc., Ph.D.	Alberta	Class Assistant, Department of Geology, University of Toronto, Toronto, Ont.
Miss M. B. Kearney, B.A., M.A.	Toronto	Registrar and Instructor in Physics, Converse College, Spartanburg, S.C.
E. J. King, B.A., M.A., Ph.D.	McMaster	Biochemist in the Department of the Banting Medical Research, University of Toronto, Toronto, Ont.
K. H. Kingdon, B.A., M.A., Ph.D.	McMaster	Physicist, Research Laboratory, General Electric Co., Schenectady, N.Y.
A. L. Kuehner, B.A., M.A.	Queen's	Lecturer in Chemistry, University of Lennoxville, Lennoxville, P.Q.
P. Larose, B.Sc., M.Sc., Ph.D.	McGill	Professor of Physics and Physical Chemistry, Ecole Superieure de Chimie, Laval University, Quebec, Que.
G. C. Laurence, B.Sc., M.Sc.	Dalhousie	Research Student, Cavendish Laboratory, Cambridge, England.
W. A. Lawrence, B.A., M.A., Ph.D.	McMaster	Stanley Professor of Chemistry, Bates College, Lewiston, Maine.
J. F. Lehmann, B.Sc., M.Sc., Ph.D.	Alberta	Physicist, Synthetic Ammonia and Nitrate Ltd., Billingham, Stockton-on-Tees, England.
S. Lehrmann, B.A., M.A.	Toronto	No information.
A. H. Leim, B.A., Ph.D.	Toronto	Assistant Director, Fisheries Experimental Station, Halifax, N.S.
Miss M. Levi, B.A., M.A., Ph.D.	Toronto	Married.
S. G. Lipsett, B.Sc., M.Sc., Ph.D.	Manitoba	Research Chemist, J. T. Donald & Co., Montreal, Que.
F. R. Lorriman, B.A., M.A., Ph.D.	Toronto	Lecturer in Chemistry, University of Toronto, Toronto, Ont.
G. H. W. Lucas, B.A., M.A., Ph.D.	Toronto	Assistant Professor in Pharmacology, University of Toronto, Toronto, Ont.
A. D. Macallum, B.A., M.Sc., Ph.D.	Toronto	Research Chemist, Roessler & Hasslacher, Chemical Company, Perth Amboy, N.J.
Miss A. P. MacDougall, B.A., M.A.	McMaster	Married.
D. G. MacGregor, B.A.	Dalhousie	Professor of Physics, Mount Allison University, Sackville, N.B.
J. E. Machacek, B.S.A., M.S.A., Ph.D.	Saskatchewan	Teaching Assistant in Mycology and Plant Pathology, 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	Research Student, Yale University, New Haven, Conn.
W. M. Martin, B.S.A., M.Sc.	Alberta	Assistant in Biochemistry, Division of Agricultural Biochemistry, University Farm Campus, St. Paul, Minn.
G. L. Matheson, B.Sc., M.Sc.	McGill	No information.
J. E. Maynard, B.A., B.Sc., M.Sc., Ph.D.	Manitoba	Graduate Student, University of Toronto, Toronto, Ont.
A. W. McCallum, B.Sc.F., M.A.	Toronto	Forest Pathologist, Division of Botany, Department of Agriculture, Ottawa, Ont.
Miss M. K. O'Brien, B.A., M.A.	Toronto	Sister M. Emerentia, St. Joseph's Convent, Toronto, Ont.
H. G. Oddy, B.A., M.A., Ph.D.	McMaster	Assistant Professor of Chemistry, Oregon State Agricultural College, Cowallis, Ore.

Grantee	University where undergraduate training received	Present Occupation
H. B. O'Heir, B.A., B.Sc., M.Sc.	McGill	Geologist, employed by J. Mackintosh Bell, Keeley Mines, Ont.
Miss M. Olding, B.A.	McGill	Married.
Miss I. J. Patton, B.A., M.Sc.	McGill	No information.
Miss L. E. Paynter, B.Sc., M.Sc.	Saskatchewan	Laboratorian, Fort Qu'Appelle Sanatorium, Fort San, Sask.
C. R. Peaker, B.Sc., M.Sc.	Saskatchewan	Graduate Student, Stanford University, California.
R. A. Pelletier, B.Sc., M.Sc., Ph.D.	McGill	Employed by the Anglo-American Corporation of South Africa, Broken Hill, Northern Rhodesia, Central Africa.
J. F. Phillips, B.A.Sc., M.A.	Toronto	Teacher, Riverdale Technical School, Toronto, Ont.
R. A. Prosser, B.Sc., M.A.	Acadia	Plant Recorder, American Potash & Chemical Corporation, Trona, Calif.
H. N. Racicot, B.A.	McMaster	Pathologist-in-charge, Laboratory of Plant Pathology, Ste. Anne de la Pocatiere, P.Q.
C. D. Reid, B.Sc., M.Sc., A.M.	Alberta	Instructor in the Department of Physics, Harvard University, Cambridge, Mass.
Miss C. E. Robertson, B.Sc.,M.Sc.,Ph.D.	McGill	Married.
A. D. Robinson, B.A., M.A.	Saskatchewan	Graduate student in Agricultural Biochemistry at the University of Minnesota, St. Paul, Minn.
H. L. Robson, B.Sc., Ph.D.	Saskatchewan	Chief Chemist, Burnham Chemical Co., Westend, San Bernardino Co., Calif.
D. C. Rose, B.Sc., M.Sc., Ph.D.	Queen's	Research student at Cavendish Laboratory, Cambridge, England.
P. V. Rosewarne, B.A., M.A.	McMaster	Engineer 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.
W. Rowles, B.Sc., M.Sc., Ph.D.	Saskatchewan	Lecturer in Physics, Macdonald College, P.Q.
John Russell, B.A., M.Sc., Ph.D.	British Columbia	Assistant Professor of Chemistry, University of Western Ontario, London, Ont.
J. O. G. Sanderson, B.Sc., M.Sc.	Alberta	Class Assistant to Prof. W. A. Parks, Department of Geology, University of Toronto, Toronto, Ont.
J. E. Saunders, B.A.Sc., M.Sc.	McGill	Surveyor with the South American Gold Areas, Ltd., Sao Bento, E.F.C.B., Minas Gereas, Brazil.
D. A. Scott, B.A., M.A., Ph.D.	Toronto	Assistant Director, Connaught Laboratories, University of Toronto, Toronto, Ont.
O. J. Walker, B.A., M.A., Ph.D.	Saskatchewan	Associate Professor of Chemistry, University of Alberta, Edmonton, Alta.
E. E. Watson, B.Sc., M.Sc.	McGill	Research student at Cambridge University, Cambridge, England.
Miss M. Weinberg, B.A., M.A., M.Sc.	Manitoba	Married.
E. F. Whyte, B.A., M.A., Ph.D.	Dalhousie	Dominion Analyst, Dominion Department of Health, Halifax, N.S.
J. O. Wilhelm, B.Sc., M.A.	Saskatchewan	Technical Assistant, Department of Physics, University of Toronto, Toronto, Ont.
D. Wolochow, B.A., M.A., B.Sc.	Saskatchewan	Research Chemist, University of Saskatchewan, Saskatoon, Sask.
C. A. H. Wright, B.Sc., M.Sc., Ph.D.	British Columbia	The Consolidated Mining & Smelting Co. of Canada, Ltd., Trail, B.C.
K. S. Wyatt, B.A., B.Sc.	Mount Allison	No information.
W. S. Yarwood, B.Sc., M.Sc.	Manitoba	Assistant Professor in Geology, Macalester College, St. Paul, Minn.
F. H. Yorston, B.Sc., M.Sc	McGill	Graduate Student, Battersea Polytechnic, University of London, London, England
E. G. Young, B.A., M.Sc., Ph.D.	McGill	Professor of Biochemistry, Dalhousie University, Halifax, N S.
J. G. T. Young, B.A., M.A., Ph.D.	Toronto	Assistant Professor of Physics, University of Manitoba, Winnipeg, Man.

V. FINANCIAL STATEMENT FOR THE FISCAL YEAR ENDING MARCH 31st, 1928.

RECEIPTS

Appropriation from Parliament		$170,000.00
Grant from Sun Life Assurance Company		10,000.00
Miscellaneous revenue, including refunds		21,485.08
		$201,485.08

EXPENDITURES

Grants in aid of research		107,926.68	
Fellowships	$ 6,430.00		
Studentships	15,700.00		
Bursaries	19,725.00	41,855.00	
Laboratory equipment and operation		2,869.06	
Publication of reports and bulletins		1,479.37	
Administrative expenses of Associate Committees		770.80	
General administration		6,362.73	
Travelling expenses of members of National Research Council and staff		7,920.04	
Travelling expenses of Associate Committees		4,038.81	
Salaries and honoraria		26,889.16	
Library		1,371.84	201,483.49
Refund to Receiver General			1.59
			$201,485.08

APPENDIX "A"

List of Papers covering Researches carried out with Assistance from the National Research Council

Title of Paper	Author	Where Published	Date Published
ANATOMY			
The Rate of Growth of the Sea Mussel (*Mytilus edulis L.*) at St. Andrews, N.B., Digby, N.S., and in Hudson Bay.	Mossop, Miss B. K. E.	Trans. of the Royal. Can. Institute.	1922
A Study of the Sea Mussel (*Mytilus edulis Linn.*).	Mossop, Miss B. K. E.	Cont. to Can. Biology.....	1921
ANIMAL HUSBANDRY			
A Statistical Study of the Head Length Variability of Bovine Spermatozoa and its Application to the Determination of Fertility.	Savage, A., Williams, W. W., and Fowler, N. M.	Trans. of Roy. Soc. of Can., Sec. V.	1927
Methods of Determining the Reproductive Health and Fertility of Bulls: A Review with additional notes.	Williams, W. W. and Savage, A.	Ithica, N.Y., Cornell Veterinarian.	Oct., 1927
BACTERIOLOGY			
Red Discolouration of Cured Codfish.....	Harrison, F. C. and Kennedy, Miss M.	Ottawa, National Research Council Report No. 11.	1922
Red Discolouration of Cured Codfish (Scientific Data).	Harrison, F. C. and Kennedy, Miss M.	Roy. Soc. of Can., Sec. V.	
Discolouration, Smut or Blackening of Canned Lobster.	Harrison, F. C. and Hood, E. G.	Ottawa National Research Council Report No. 12.	1923
Discolouration, Smut or Blackening of Canned Lobster. (Scientific Data).	Harrison, F. C. and Hood, E. G.	Roy. Soc. of Can., Sec. V.	
Bacteriology of Certain Sea Fish.....	Harrison, F. C., Perry, Miss H. M. and Smith, P. W. P.	Ottawa, National Research Council Report No. 19.	1926
Motility of Bacteria as Effected by Hydrogen-Ion Concentration.	Reed, G. B., and MacLeod, D. J.	Journal of Bacteriology.....	March, 1924
Pigments of Pseudomonas Pyocyaneus.....	MacLeod, D. J.....	Thesis for M.A. degree, Queen's University, Kingston, Ont.	April, 1923
Effects of Hydrogen-ion and Salt Concentration upon the Morphological Structure and upon Formation of Certain Bacteria.	MacLeod, D. J.....	Thesis for M.A. degree, Queen's University, Kingston, Ont.	April, 1923
Discolouration in Canned Lobsters.....	Reed, G. B. and MacLeod, D. J..	Report of Biological Board of Canada.	1924
The Bacterial Content of Graded Butter.....	Sadler, W. and Vollum, R. L.	Trans. Roy. Soc. of Canada, Sec. V, pp. 105-110.	1923
An Attenuated Streptococcus Lacticus Strain (Kruse).	Sadler, W. and Vollum, R. L.	Trans. Roy. Soc. of Canada, Sec. V, pp. 111–113.	1923
The Relation of Bacteria to the Quality of Graded Butter.	Sadler, W. and Vollum, R. L.	National Research Council Report No. 16, Ottawa.	1926
The Duration of B. Welchii Antitoxin Immunity in Rabbits.	Reed, G. B. and Spence, Miss C. M.	Journ. of Infectious Diseases.	1927
The in vino Action of B. Welchii Toxin in Erythrocytes in Comparison with other Hæmotoxins.	Reed, G. B. Orr, J. H. and Spence, Miss C. M.	Journ. of Infectious Diseases.	1927
BIOCHEMISTRY			
The Parathyroid Gland.....	Collip, J. B.....	Harvey Lectures for 1925-26.	1927
The Purification of Pepsin, its Properties and Physical Characters.	Forbes, J. C.....	Jour. of Biol. Chemistry....	Feb., 1927
Some Problems of the Fox-Raising Industry..	Hunter, Andrew.....	National Research Council, Bulletin No. 8.	1920
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On the Critical Frequency of Pulsation of Tones.	Weinberg, Miss M. and Allen, Frank	Phil. Mag. Series 6, Vol. XLVII, No. 277.	Jan., 1924
On the Effect of Aural Fatigue upon the Critical Frequency of Pulsation of Tones.	Weinberg, Miss M. and Allen, Frank	Phil. Mag. Series 6, Vol. XLVII, No. 277.	Jan., 1924

Title of Paper	Author	Where Published	Date Published
PHYSICS—*Con.*			
On the Effect of Fatiguing the Ear with a Combination of Two or more Tones.	Weinberg, Miss M....	Phil. Mag. Series 6, Vol. XLVII, No. 277.	Jan., 1924
The Spark Spectra of Indium and Galtium in the Extreme Ultra-Violet Region.	Weinberg, Miss M....	Proc. Roy. Soc. Canada, Sec. A. Vol. 107.	1925
The Crystal Structure of Solid Oxygen.....	Wilhelm, J. O.....	Phil. Mag.....	Feb., 1927
An Extension of the Graphical Method of Determining Crystal Structures to the Orthorhombic System.	Wilhelm, J. O.....	Trans. Roy. Soc. Canada, Vol. 21, Sec. 3, p. 1–3.	1927
Application of the Theory of Magnetism to the Calculation of Atomic Diameters.	Young, J. F. T.....	Proc. Roy. Soc. Canada, Vol. XVI.	1922
A Method of Increasing the Dispersion of a Constant Deviation Spectroscope.	Young, J. F. T.....	Jour. Op. Soc. Am. Vol. 7...	1923
The Crystal Structure of Various Hensler Alloys by the use of X-Ray.	Young, J. F. T.....	Phil. Mag. XLVI.....	1923
PHYSIOLOGY			
Survey of General Conditions of Industrial Hygiene in Toronto.	Assoc. Committee on Ind. Fatigue.	Ottawa, National Research Council Report No. 7.	1921
Histamine and Salivary Secretion.....	MacKay, Miss M. E..	Am. Jour. of Physiology....	1927
The Vascular Reaction of the Pilocarpinized Submaxillary Gland to Histamine.	MacKay, Miss M. E..	Jour. of Pharmacology and Exper. Therapeutics.	1927
The Relationship between Rigor Mortis and the Glycogen, Lactic Acid and Free Phosphorus of Fish Muscle.	Leim, A. H., Macleod, J. J. R and Simpson, W. W.	Contr. to Can. Biology.....	1927
The Immediate Post Mortem Changes in Fish Muscle.	Macleod, J. J. R. and Simpson, W. W.	Contr. to Can. Biology	1927
Changes Occurring in Mammalian Muscle Immediately After Death.	Macleod, J. J. R. and Simpson, W. W.	Proc. Soc. Expt. Biol. and Med.	1926
The Effects of Asphyxia and Isletectomy on the Blood Sugar of Myoxocephalus and Ameiurus.	Simpson, W. W.....	Am. Jour. Physiol.	July, 1926
Immediate Post Mortem Changes in Mammalian Muscle.	Simpson, W. W. and Macleod, J. J. R.	Trans. Roy. Soc. Canada, S.5.	1926
ZOOLOGY			
Bionomics of the Tabanidæ of the Canadian Prairie.	Cameron, A. E.....	Bulletin of Entomological Research, V. 17, pt. 1.	July, 1926
A Local Outbreak of the Winter or Moose Tick (*Dermacentor albipictus*) in Saskatchewan.	Cameron, A. E.....	Bulletin of Entomological Research, V. 17, pt. 3.	Mar., 1927
The Occurrence of *Cuterelva* (Diptera, Oestridæ) in Western Canada.	Cameron, A. E.....	Pariasotology, Vol. 18, No. 4.	Dec. 14, 1926
The Hydromedusæ of the West Coast of North America, with Special Reference to those of the Vancouver Island Region.	Foerster, R. E.....	Contr. to Can. Biol., N.S. Vol. I, pp. 219–277.	1923
Studies in the Ecology of the Sockeye Salmon (Oncorhynchus Nerka).	Foerster, R. E.....	Contr. to Can. Biol., N.S., Vol. II, pt. 2.	1925
The Larva and Breeding-Place of Aedes Aldrichi.	Hearle, E.....	Can. Entomologist.....	Feb., 1921
Mosquito Control Investigations in British Columbia.	Hearle, E.....	Sc. Agriculture.....	Feb., 1921
The Importance of Mosquitoes, with Notes on B.C. Species.	Hearle, E.....	Proc. B.C. Ent. Soc. Nos. 13 and 15.	1921
Some Mosquito Problems of British Columbia .	Hearle, E.....	Ont. Ent. Soc. Report No.51.	1921
An Aerial Survey of Mosquito Breeding Places.	Hearle, E.....	Agr. Gazette, Ottawa, lx, 3..	1922
A New Mosquito from British Columbia.....	Hearle, E.....	Can. Entomoligist.....	Jan., 1923
Mosquitoes of the Lower Fraser Valley, B.C. and their Control.	Hearle, E.....	Ottawa, National Research Council Report No. 17.	1926
The Mosquito Control Act of British Columbia.	Hearle, E.....	Agr. Jour. B.C. VI.....	1921
ZYMOLOGY			
A Study of Bacterial Association. (1) The Biochemistry of the Production of Lactic Acid.	Speakman, H. B. and Phillips, J. F.....	Journal of Bacteriology.....	March, 1924

APPENDIX "B"

A Programme of Wheat Research for the Prairie Provinces

Adopted by Conference under auspices of National Research Council, at the University of Alberta, Jan. 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 dissemination, 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.

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 diatase.

C. *Lipoids.*

1. Nature and quantity.
2. Effect on colloidal properties of gluten and dough.

D. *Electrolytes.*

1. Nature and quantity of electrolytes on 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.

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.

APPENDIX "C"

Report to Board of Grain Commissioners on Investigation of Commercial Drying of Tough and Damp Wheat

Issued by Associate Committee on Grain Research, October 17th, 1927.

The work of the Associate Committee on Grain Research, following the reference to it by the Board of Grain Commissioners of the problems involved in drying tough and damp wheat, has taken four main lines:—

Completed investigations.

(1) A preliminary investigation of the methods of drying as carried out at a number of the principal elevators, from Alberta to the Head of the Lakes. This was completed and reported in February by Professor Stansfield, a member of the Committee.

(2) An investigation of the effect of drying, as now practised by commercial elevators, on the milling and baking quality of the wheat. For this purpose a series of eighty-two samples were collected for the Committee by Government Inspectors from a considerable number of elevators in the spring of 1927. These consisted of pairs of samples taken immediately before and after drying. Every sample was subdivided between the Dominion Grain Research Laboratory in Winnipeg and the laboratories of the Universities of Manitoba, Saskatchewan and Alberta, where they were tested and analysed under the direction of Dr. Birchard, Professor Geddes, Dr. Thorvaldson and Dr. Newton, respectively. Of this series of samples, sixty-nine representing a wide range of drying conditions were milled and baked by all four laboratories, and the remainder of the samples by one or more laboratories. This work is also complete and the results have been reported to and studied, by the Committee.

Investigations still in progress.

(3) An investigation of the effect of damp and tough storage on a series of 168 wheat samples of known history. These include three standard varieties of wheat, grown at the three prairie universities in the summer of 1927, under the direction of the above and Professor Harrison of the University of Manitoba. This grain was cut at different stages of maturity, and is being exposed to various amounts of rain and snowfall, and stored for various periods of time. A certain proportion of these samples are being dried with heat under accurately controlled conditions in the experimental drier constructed and operated for the Committee by Professor Stansfield at Edmonton. As this part of the work includes a study of the effect of three and six months periods of storage, it cannot be completed before the spring of 1928.

(4) An investigation of the effect of drying under a wide range of conditions, with respect to temperature of air, temperature of grain, rate of drying, amount of moisture evaporated, final moisture content of the grain, etc. The drying of the samples in these experiments is being done under accurately controlled conditions by Professor Stansfield, and the samples are being milled and baked in the co-operating laboratories. This part of the work will require some months yet to complete.

After thorough examination and discussion of the data secured in projects (1) and (2) above, which are complete, and the additional data secured in projects (3) and (4) so far as they have gone, and in view of the present urgency of the situation, the Committee are agreed that the results justify certain tentative generalizations, conclusions, and recommendations. These are the following:—

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Generalizations

(1) Commercial drying under proper conditions can be done without injury to the milling and baking quality of wheat, but under unsuitable conditions it has proved to be injurious to the baking quality.

(2) Drying at reported air temperature above 180°F. by commercial driers now in use, has caused injury somewhat proportional to the rise in temperature above this point.

(3) The maximum temperature reached by the grain depends mainly upon two factors: (a) the amount of moisture evaporated, (b) the final moisture content to which the grain is dried. The first of these affects the length of time the grain is exposed to hot air; the second governs the reduction in the cooling effect of evaporation, which at adequate moisture contents protects the grain from overheating. The evidence indicates that in most cases where the moisture was reduced below 13.5% injury took place.

(4) Batch drying, or drying where the grain is not mixed by frequent movement, has been observed to cause marked local overheating of the grain, thus leading to proportionately greater injury.

(5) Injury took place where the practice of recirculation of air from the cooler to the drier was followed.

Tentative conclusions

(1) Under suitable conditions, drying may be done without injury to the wheat.

(2) An air temperature of 180°F. should not be exceeded.

(3) Grain should not be dried to a moisture content below 13.5%. In the case of very damp grain, it may be inadvisable to dry down even to this point in a single stage. A safer practice would be to put the grain through the drier twice.

(4) Batch drying, or drying where the grain is not mixed by frequent movement, should be avoided.

(5) Recirculation of air from the cooler to the drier should be avoided.

Recommendations

(1) That a competent and experienced engineer, recommended by the Grain Research Committee, should be appointed at once to advise in regard to the installation of proper measuring devices in commercial driers, and the controlling of other mechanical features and operations connected with grain drying.

(2) That steps should be taken to secure the adoption of the precautions set forth in the above tentative conclusions, pending the completion of the investigations now under way, and of supplementary investigations of the effect of the controls now recommended.

(3) That to insure uniformity of drying methods, and the convenient application both of the present tentative precautions and of any modifications which may be found advisable as a result of the investigations still under way, the commercial drying of grain should be placed under government supervision.

(4) Since it has been suggested that the presence of sulphur in coke used as fuel in drying plants using direct heat, is detrimental to the grain, that this question should be investigated so as to fix the permissible limits of sulphur in the coke.

SIGNED
on behalf of the Committee

R. Newton, *Secretary*.

APPENDIX "D"

Regulations governing 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 seven 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, and concise statement of adequacy of general equipment of laboratory where investigation is to be carried on. If the applicant has asked for or has received 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 of 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 intendent 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 material 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.

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 acknowledgment 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.

APPENDIX "E"

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, Physics and Mathematics.

8. Application for a bursary, studentship or fellowship must be made by the candidate to the Research Council. He shall, with his first application, submit a complete record of his academic career. 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 must be submitted. All such recommendations must be forwarded to the Research Council by the professor recommending the candidate and through the head of the Department concerned. The candidate 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 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 Research Council, upon 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.

12. The holder of a bursary, studentship or fellowship shall furnish on or before February 1st, 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 31st, a complete and detailed report of the work carried on during the entire year.

13. Awards are payable as follows: 40 per cent on October 1st; 50 per cent on February 1st, or thereafter, on receipt of a satisfactory first half-yearly report; 10 per cent after the expiration of the nine months' period of tenure and the submission to the 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 Research Council the applicant be of outstanding ability.

B. Special Regulations Governing Bursaries

15. A Bursary is of the value of $750.00.

16. Application for a bursary must be made not later than March 15th.

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 the 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 $1,000.00.

21. Application for a studentship must be made not later than March 15th.

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 $1,200.00.

26. Application for a fellowship must be made not later than March 15th.

27. A fellowship will be awarded only to a candidate whose record shows that he possesses the capacity to conduct *independent* research.

23. 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.

Address all communications to:—

The Secretary,
National Research Council.
Ottawa, Ontario.

January, 1929.

APPENDIX "F"

Publications of the National Research Council

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 (Out of Print)	L. Gross, M.D.
7	Survey of General Conditions of Industrial Hygiene in Toronto	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 Lobsters	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	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, Esq., Steel Company of Canada, Hamilton, Ontario, 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 Sadler, 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	Investigations on the Treatment of Nova Scotia Oil Shales	A. E. Flynn, A.R.S.M.
19	Bacteriology of Certain Sea Fish	F. C. Harrison, D.Sc., F.R.S.C.
20	Consideration of the Relation between the Distribution of Teredo Navalis and Temperature and Salinity of its Environment	R. H. M'Gonigle, B.A.
21	The Life History of Exeristes Roborator Fab., a Parasite of the European Corn Borer	By J. Harold Fox, M.A.

BULLETINS

Bulletin Number	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 with Reference to the Testing of Fog Signal Machinery	L. 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	The Heating of Houses, Coal and Electricity Compared (Out of Print)	A. S. L. Barnes
7	The Manufacture of Ethyl-Alcohol from Wood Waste (Out of Print)	G. H. Tomlinson, B.A.
8	Some of the 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 Resumé 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.
12	Nitrogen in Industry	Nitrogen Fixation Committee, Prof. J. C. McLennan, Chairman.

APPENDIX "G"

Publications of the Canadian Engineering Standards Association.

Associate Committee on Engineering Standards, of the National Research Council

No.

A1 —1928—Standard Specification for Steel Railway Bridges (3rd edition).

A1a—1928—Material Specifications, Steel Railway Bridges (2nd reprint).

C2 —1920—Standard Requirements for Distribution Type Transformers.

C3 —1924—Standard Specification for Galvanized Telegraph and Telephone Wire (reprint).

B4 —1921—Standard Specification for Wire Rope for Mining, Dredging and Steam Shovel Purposes.

A5 —1927—Standard Specification for Portland Cement (2nd edition).

A6 —1922—Standard Specification for Steel Highway Bridges.

D7 —1922—Standard Specification for Flexible Steel Wire Rope and Flexible 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 Gates.

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.

A19—1926—Standard Classification of Items of Highway Expenditure.

A20—1927—Standard Specifications for Movable Bridges.

C21—1927—Standard Specifications for Control Cable for Electrical Power Plant Equipment.

C22—1927—Canadian Electrical Code—Part I.

APPENDIX "H"

List of Associate Committees

Associate Committee on Grain Research
Associate Committee on Wool
Associate Committee on Tuberculosis Research
Associate Committee on Cereal Rust
Associate Committee on Field Crop Diseases
Associate Committee on Fruit Storage
Associate Committee on Coal Classification and Analysis
Associate Committee on Magnesite
Associate Committee on Mining and Metallurgy
Associate Committee on Nitrogen Fixation
Associate Committee of Chemists
Associate Committee on Spray Painting
Associate Committee on Biology
Associate Committee on Heating and Insulation
Associate Committee on Engineering Standards
Associate Committee on Physics and Engineering Physics
Associate Committee on Aeronautical Research
Associate Committee on Helium
Associate Committee on New Brunswick Forest Problems
Associate Committee on Accurate Plot Work
Associate Committee on Oceanography
Associate Committee on Food Research
Associate Committee for British Columbia
Associate Committee on Library

APPENDIX "I"

LIST OF MEMBERS OF ASSOCIATE COMMITTEES

Associate Committee on Grain Research

H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S., Chairman	President, National Research Council, Ottawa, Ont.
F. J. Birchard, B.A., Ph.D.	Research Chemist, Dominion Grain Laboratory, Winnipeg, Man.
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Dominion of Canada

NATIONAL RESEARCH COUNCIL

THE HONORARY ADVISORY COUNCIL FOR
SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT of the PRESIDENT

AND

FINANCIAL STATEMENT

1928-29

OTTAWA, March 29th, 1930.

The Hon. JAMES MALCOLM,

Chairman, Sub-committee of the Privy Council on Scientific and Industrial Research,

Ottawa, Ont.

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 31st, 1929.

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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NATIONAL RESEARCH COUNCIL

I. REVIEW OF ACTIVITIES OF THE NATIONAL RESEARCH COUNCIL.

The duties and responsibilities of the National Research Council are clearly defined in the Act under which the Council operates and which will be found in Appendix "A" of this report. In brief, the Council has charge of all matters affecting scientific and industrial research in Canada and all questions of scientific and technological methods affecting the expansion of Canadian industries or the utilization of the natural resources of Canada.

The activities in which the Council has been engaged during the year under review may be broadly divided under the following main headings:

(1) The prosecution of research work through the awarding of assisted research grants to qualified research men working on individual problems in established laboratories;

(2) The training of research workers through the awarding of postgraduate scholarships in science and research;

(3) The co-ordination of research work on problems of major importance by means of national conferences between the leading Canadian authorities on such problems;

(4) The organization and prosecution of co-operative investigations in connection with major research projects through associate research committees;

(5) The establishment of National Research Laboratories.

There were in active operation during the year under review in laboratories spread from the Atlantic to the Pacific ninety-one specific investigations. These researches were carried out under grants awarded by the Council to an associate committee directing a major research or to an individual investigator specially qualified to undertake the research work entrusted to him.

These investigations were carried out in twenty-five divisions of science at eleven Canadian universities and in fourteen Government and industrial laboratories.

The departments of science in which these investigations were undertaken were as follows: Department of Physics, twenty-two investigations; Chemistry and Botany, seven investigations each; Field Husbandry and Mechanical Engineering, six investigations each; Bacteriology and Pathology, five investigations each; Plant Breeding and Biology, four investigations each; Biochemistry, Mining Engineering and Plant Biochemistry, three investigations each; Plant Pathology, Animal Pathology and Biophysics, two investigations each; Forestry, Geology, Electrical Engineering, Civil Engineering, Ceramics, Entomology, Aerodynamics, Zoology, Oceanography and Pharmacology, one investigation each.

The laboratories in which these investigations were carried out were as follows: Universities of British Columbia; Alberta; Saskatchewan; Manitoba; Western Ontario; Toronto; Queen's; McGill; Montreal; Dalhousie; Macdonald College; Connaught Laboratories; Queen Alexandra Sanatorium; Fort Qu'Appelle Sanatorium; Federal Departments of Agriculture, Mines and National Defence; Board of Grain Commissioners, Winnipeg; Steel Company of Canada; Biological Board of Canada.

In addition to the work just described, there were in operation during the year under review fifty research scholarships awarded by the National Research

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Council in order to build up in Canada a corps of research men competent to undertake independent research work on scientific and industrial problems. Each person, who is successful in winning one of these scholarships, is placed under the personal supervision of an approved member of the staff of the university where the scholarship is held. Such scholarships have been awarded by the National Research Council for the past twelve years, and Section 4 of this report, beginning at page 76, gives full information regarding these scholarships and what has been achieved through them.

With the object of co-ordinating research work in Canada, the National Research Council has consistently followed a policy of bringing together in conference outstanding persons interested in and working on related projects of major importance, with the object of avoiding unnecessary duplication of work and also of stimulating existing research activities. Such conferences are requested, first, to discuss the present state of knowledge on the subject under consideration, and then in the light of this discussion, to draft a complete and specific research programme on the problem under review. The Council invites to such conferences representatives of the Federal and Provincial Government departments, the universities, scientific institutions and societies, and outstanding individuals known to be interested in or working on the problem under consideration. A considerable number of such scientific conferences have been held and specific research programmes worked out and put into operation as co-operative enterprises under associate research committees which are then appointed by the Council to co-ordinate and direct the work.

At the close the year under review, there were organized under the Council twenty-seven associate committees with a total membership of four hundred and thirty-six persons. The summary of the activities of these committees, which is given in Section II, beginning at page 17 of this report, will afford some conception of the value and scope of the work carried out largely on a voluntary service basis under the auspices of the associate committees which have been established by the Council.

There was actively at work under the auspices of the National Research Council during the year 1928-29, a total research organization of five hundred and ninety-eight persons, and of this number four hundred and eighty-three persons served without remuneration in the direction of research work, in the supervision of persons holding scholarships, on associate research committees and on advisory committees.

It is the fixed policy of the National Research Council to utilize to the fullest possible extent both the trained man power and equipment of existing laboratories in Canada, in order to promote co-operative effort in research work and to co-ordinate and stimulate such work throughout Canada, in so far as this may be possible with the facilities and financial resources which are available to the Council. It will be seen from the foregoing facts that, in accordance with this policy, the Council has during the year under review carried out researches in every province of the Dominion where there were facilities available for such work.

The National Research Council wishes to record its appreciation of the contribution made by the four hundred and eighty-three persons who without remuneration directed researches, supervised scholarships and served on committees. It is particularly gratifying to the Council to find that the scientific men of Canada possess almost without exception a genuine willingness to co-operate in every feasible way in the co-ordination of Canadian Research work. Were it not for this fact, it would be impossible for the Council to establish a voluntary service research organization, such as now exists under its auspices.

In this connection it should be noted that many of the most important investigations now in progress under the Council can be effectively undertaken only as co-operative investigations and that in many other instances, the limiting factor in getting the work done is the finding of thoroughly trained investigators competent to undertake the work in question. Consequently, even though the appropriation of the National Research Council were greatly increased, it would still be dependent on the co-operation of the scientific men of Canada in connection with much of the research work now in progress.

Four meetings of the National Research Council were held during the year under review, each meeting lasting for two days. At the 76th meeting of the Council, held on May 30th and May 31st, 1928, eleven members were present; the 77th meeting was held on October 25th and 26th, 1928, and ten members were present; on February 1st and 2nd, 1929, the 78th meeting of the Council was held with ten members present, and the 79th meeting of the Council was held on March 26th and 27th, 1929, with eleven members in attendance.

Since early in 1921 the President of the National Research Council has served in an honorary capacity only and has given part of his time and attention to the service of the Council. From February, 1921, until the fall of 1923, Dr. R. F. Ruttan, Dr. R. A. Ross and Dr. F. D. Adams occupied the position of honorary president of the National Research Council in succession, and on October 5th, 1923, Dr. H. M. Tory was appointed to that office. An extremely important stage in the development of the work of the National Research Council was reached during the year under review, when on June 1st, 1928, Dr. H. M. Tory resigned the presidency of the University of Alberta in order to accept the presidency of the National Research Council on a full-time basis, and took up permanent residence in the city of Ottawa.

The appointment of a president who would devote his entire time to the work of the Council became essential owing to the decision of the Federal Government to establish National Research Laboratories at Ottawa under the auspices and control of the National Research Council. This is a step which has been given a great deal of attention by the National Research Council for several years and a step which the Council had repeatedly recommended. In fact, without such facilities, it is impossible for the Council to carry out many of the duties assigned to it under the Research Council Act, particularly in the fields of industrial research and standardization. Consequently, the decision of the Government to establish such laboratories in Canada marks an extremely important stage in the history of the National Research Council.

During the year under review, the Council gave a great deal of attention to the various questions connected with the expansion of its activities as a result of the decision to establish National Research Laboratories.

The site for the National Research Laboratories was definitely selected by the Governmnet on a property in Ottawa formerly known as the Edwards Lumber Mills, located on the south bank of the Ottawa River at the Rideau River Falls. This property was purchased by the Government, and the Toronto architectural firm of Sproatt and Rolph were engaged to prepare plans and specifications for an up-to-date laboratory building to be located on this site, which is approximately ten acres in extent.

As this work progressed it became evident that it would be more economical to construct the entire laboratory building immediately rather than to build it by instalments, as at first contemplated, since in modern laboratory construction many special features are built into the building, including such services as flues for chemical fumes, acid drains and sinks, direct and alternating current outlets, storage battery facilities, compressed air and gas.

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The various scientific divisions of a laboratory do not all require the same special services. The chemistry division does not require all of the special services required by the physics division, or the biological division, or the engineering division, and vice versa. Obviously, therefore, if the laboratories were built by instalments, not only would the work be seriously interfered with in the rearrangement of the space among the various scientific divisions, as new sections of the building became available for occupation, but also it would inevitably be found, in the reallocation of the laboratories, that there were frequently built-in services which were not needed, or that structural changes were necessary to provide services which had not been installed. Consequently, it was estimated that the cost of constructing the National Research Laboratories by instalments would be greater within a period of five years than if the entire building were erected immediately and certain sections designed and special services installed suitable for the type of work to be carried out in them permanently.

Moreover, it became evident from the numerous requests received by the Council from Canadian industrial organizations, for assistance in the solution of their problems, that the entire building would be required in any event within a very short period of time.

After carefully considering the requirements of the Council, and the site upon which the building is to stand, the architects recommended a rectangular building in the shape of a squared figure eight, with the lecture theatre and library located in the central part of the building immediately behind the main entrance. The plans and model prepared by the architects show that they have succeeded in designing a building possessing the structural strength and rectangular layout advantages of a factory building without in any way sacrificing architectural considerations. These plans provide for a four-storey building standing sixty feet in height, four hundred and eighteen feet in length and one hundred and seventy-six feet in depth.

In order to enable the Council to carry on its expanding activities and to organize its scientific staff and research programme in the interval pending the construction of the new laboratory building, temporary provision has been made in certain of the buildings on the former mill property adjacent to the site of the new Laboratories. The administrative offices of the Council moved to this location in December 1928, and work was immediately started on the renovation of certain of the old mill buildings to render them suitable for use temporarily as laboratories. It is proposed that when the new Laboratories are available, these temporary laboratories shall be used for semicommercial tests required in connection with promising investigations carried out in the research Laboratories.

In order that the Council might have the benefit of the latest information regarding the development of research laboratories in other countries, the President of the Council, during the year under review, visited the great research laboratories in Europe and in the United States, thus completing a survey of world research facilities which had commenced with his visit to Japan in 1926. While in Europe, he visited the main laboratories in Great Britain, Germany and France. In Great Britain he made a careful study of the National Physical Laboratory and of the research activities and laboratories associated with the Advisory Council of Scientific and Industrial Research of Great Britain, under which the Department of Scientific and Industrial Research in Great Britain operates. These laboratories included the Fuel Research Station at Greenwich, the laboratory of the British Woollen and Knit Goods Manufacturers Association at Leeds, and the laboratory of the British Cotton Manufacturers Research Association at Manchester. In Germany he visited the great laboratories

centering around Berlin and Charlottenburg, including the thirty laboratories of the Kaiser Wilhelm Institute at Dahlem. In the United States he visited both the Bureau of Standards at Washington and the Mellon Institute of Industrial Research at Pittsburg, and in addition, a number of the laboratories operated by large private corporations.

In the last few years, scientific papers resulting from the research activities of the universities, the National Research Council, and other research agencies in Canada have become so numerous as to cause difficulty in securing prompt publication. The Council was impressed with the fact that this situation had arisen largely because there has been in Canada no national periodical devoted to research. Canadians have, consequently, been largely dependent upon foreign journals, already overcrowded as a result of the activities of their own scientific men. This situation not only resulted in delaying the publication of Canadian scientific papers, but also resulted in loss of credit to Canada for the research work covered by papers published in foreign journals. During the year under review, the National Research Council, after having given all phases of this problem prolonged and very careful consideration, decided to establish under its auspices a national journal devoted exclusively to the publication of research papers.

This Journal is known as the Canadian Journal of Research, and while it is intended primarily for the publication of results of work carried out under the auspices of the Council, either in its own laboratories or under assisted research grants or scholarships, it will also be open for suitable papers from any Canadian research workers. It is planned that this Journal shall at first be issued bi-monthly, but it is expected that within a very short period of time there will be available a sufficient volume of scientific papers to require a monthly issue of the Journal. It is the intention of the National Research Council that in its future development, the Canadian Journal of Research shall keep pace with the progress of scientific and industrial research throughout Canada, and the Council hopes that it may make a material contribution toward that progress.

The National Research Council expended during the year under review a total sum of $323,112.24. It will be of interest to note the distribution of this expenditure among the various activities and services of the Council—61.2% of the total was expended in research work carried out by associate committees and under assisted research grants; 13.5% was expended on post-graduate scholarships; 1.3% was expended in the publication of scientific papers and the scientific library maintained by the Council; 4.1% was expended for travelling and other expenses in connection with meetings of associate committees; the entire adminstration of the Council including associate committees cost only 4.2% and 2.7% was expended on travelling expenses of the members and staff of the National Research Council; the balance amounting to 13% was expended on salaries of the staff of the Council.

It will be seen, therefore, that 76% of the entire expenditure of the Council was devoted directly to research work in Canada. A classified statement of the expenditures of the Council from 1916-29 inclusive, will be found on page 16 of this report.

91 Researches in Progress During 1928-29

Subject of Research	Grantee	Where Carried On
The utilization of Canadian magnesite	Associate Committee on Magnesite	National Research Laboratories, Ottawa. Federal Department of Mines, Ottawa.
Problems of the grain industry	Associate Committee on Grain Research	Four co-operating laboratory groups: Board of Grain Commissioners, Winnipeg; University of Manitoba; University of Alberta; University of Sasaktchewan.
Cereal grain rust	Associate Committee on Cereal Rust	Four co-operating laboratory groups: Dominion Rust Laboratory, Dept. of Agriculture, Winnipeg; University of Manitoba; University of Alberta; University of Saskatchewan.
Tuberculosis in man and animals	Associate Committee on Tuberculosis	Nine co-operating laboratory groups: Dept. of Bacteriology, Univ. of Alberta; Dept. of Pathology and Bacteriology, Univ. of Toronto; Connaught Laboratories, Univ. of Toronto; Dept. of Bacteriology, Queen's University; Dept. of Bacteriology, McGill University; Faculty of Medicine, Univ. of Montreal; Queen Alexandra Sanatorium, London, Ont.; Fort Qu'Appelle Sanatorium, Fort San, Sask. Federal Department of Agriculture.
Problems of the wool industry	Associate Committee on Wool	
Engineering standardization	Associate Committee on Engineering Standards	Ottawa, Ont.
Heating and insulation of buildings	Associate Committee on Heating and Insulation	Three co-operating laboratory groups: Dept. of Mechanical Engineering, Queen's University; Dept. of Mechanical Engineering, Univ. of Toronto; Dept. of Mechanical Engineering, Univ. of Saskatchewan.
Foot and root-rot diseases of crop plants	Associate Committee on Field Crop Diseases	Federal Dept. of Agriculture; Univ. of Alberta; Univ. of Manitoba; Univ. of Saskatchewan.
Reporting on nitrogen fixation	Associate Committee on Nitrogen Fixation	
Investigation of the problem of slacks in apple barrels	Associate Committee on Apple Slacks	Federal Department of Agriculture.
Reforestration experiments in cut-over and burnt-over lands of New Brunswick	Associate Committee on New Brunswick Forest Problems	Two co-operating laboratory groups: Dominion Forest Service, Dept. of the Interior, Ottawa, Ont.; Dept. of Lands & Mines, Fredericton, N.B.
Utilization of Canadian iron ores	Sub-committee on Iron Ores of the Associate Committee on Metallurgy	Hamilton, Ont.
Best methods for obtaining accurate results in testing varieties, strains and treatments of grain	Associate Committee on Accurate Plot Work	Dominion Experimental Farms.
Work on oceanography	Associate Committee on Oceanography	Univ. of British Columbia, Vancouver, B.C.
Health hazards in spray painting	Associate Committee on Spray Painting	Federal Dept. of Health; Ontario Dept. of Health; Quebec Dept. of Health.
Destruction of wood piling by marine boring animals	Associate Biological Committee	Atlantic Biological Station of the Biological Board of Canada.
Factors governing the milling and baking quality of wheat	Dr. Robert Newton	Dept. of Field Husbandry, Univ. of Alberta, Edmonton, Alta.
Pressure variations inside the cylinders of the internal combustion engine	Dr. D. A. Keyes	Dept. of Physics, McGill University, Montreal, Que.
Ultrasonics (inaudible sound waves)	Dr. R. W. Boyle	Dept. of Physics, Univ. of Alberta, Edmonton, Alta.
Wireworms and false wireworms	Prof. E. H. Strickland	Dept. of Entomology, Univ. of Alberta, Edmonton, Alta.
Investigation on concrete deterioration	Prof. T. Thorvaldson	Dept. of Chemistry, Univ. of Saskatchewan, Saskatoon, Sask.
Bacillary white diarrhœa in poultry	Prof. H. W. Hill and Prof. E. A. Lloyd	Dept. of Bacteriology, Univ. of British Columbia, Vancouver, B.C.
Use of ultra short waves for direction indicating apparatus	Major W. A. Steel	Dept. of National Defence, Ottawa, Ont.
The inheritance of sugar and starch in Indian corn	Prof. H. F. Roberts	Dept. of Botany, Univ. of Manitoba, Winnipeg, Man.
Generation of electricity using a windmill as the prime mover	Prof. A. R. Greig	Dept. of Mechanical Engineering, Univ. of Saskatchewan, Saskatoon, Sask.
Rotary derivatives of a boat type seaplane	Prof. J. H. Parkin	Aerodynamic Laboratory, Univ. of Toronto, Toronto, Ont.
Fog alarm research	Dr. L. V. King	Dominion Lighthouse, Prescott, Ont.

91 Researches in Progress During 1928-29—*Continued*

Subject of Research	Grantee	Where Carried On
The exploitation of high speed cathode rays	Dr. J. C. McLennan.....	Dept. of Physics, Univ. of Toronto, Toronto, Ont.
Radium emanation.....	Dr. G. H. Henderson and Dr. D. A. McIntosh	Dept. of Physics, Dalhousie Univ., Halifax, N.S.
Dielectric losses in different classes of porcelain	Prof. A. V. Wendling....	Ecole Polytechnique, Montreal, Que.
Emission and absorption spectra in the infra-red and extreme ultra-violet regions	Dr. J. C. McLennan.....	Dept. of Physics, Univ. of Toronto, Toronto, Ont.
Relation of silver ores to diabase.....	Dr. E. S. Moore.....	Dept. of Geology, Univ. of Toronto, Toronto, Ont.
Investigation on the glucosides of plants indigenous to western Canada	Prof. A. T. Cameron.....	Dept. of Biochemistry, Univ. of Manitoba, Toronto, Ont.
Magnetic susceptibility of the alkali metals	Dr. A. S. Eve.....	Dept. of Physics, McGill University, Toronto, Ont.
Effect of radiant energy on protoplasm....	Prof. A. H. Hutchinson..	Dept. of Botany, Univ. of British Columbia, Vancouver, B.C.
Structural welding.....	Prof. P. Gillespie.....	Mechanics of Material Laboratory, Univ. of Toronto, Ont.
Surface energy of solids.....	Prof. F. M. G. Johnson and Dr. O. Maass	Dept. of Chemistry, McGill University, Montreal, P.Q.
Vegetable resources and flora of eastern Canada	Fr. Marie-Victorin.....	Dept. of Botany, Univ. of Montreal, Montreal, P.Q.
The habit and life history of the smaller mammals of the prairies	Mr. F. Neave.....	Dept. of Zoology, Univ. of Manitoba Winnipeg, Man.
Properties of hygroscopic substances.....	Prof. A. N. Shaw.....	Dept. of Phsyics, McGill University, Montreal, Que.
Chlorination of methane.....	Prof. M. C. Boswell.....	Dept. of Organic Chemistry, Univ. of Toronto, Ont.
The effect of light on life processes.....	Prof. A. B. Klugh.....	Dept. of Biology, Queen's University, Kingston, Ont.
Effects of electric and magnetic fields. Stark effect in helium. Stark effect in molecular spectra	Prof. J. S. Foster.....	Dept. of Physics, McGill University, Montreal, Que.
Further investigation of gas laws.....	Dr. O. Maass.....	Dept. of Chemistry, McGill University, Montreal, Que.
Investigation of mistletoe, parasitic on jack pine	Miss E. S. Dowding.....	Dept. of Botany, Univ. of Alberta, Edmonton, Alta.
Effects of certain reagents upon root tip sections of Trillium grandiflora	Prof. R. O. Earl.....	Dept. of Biology, Queen's University, Kingston, Ont.
Winter hardiness in crop plants.....	Dr. Robert Newton.....	Dept. of Field Husbandry, Univ. of Alberta, Edmonton, Alta.
The chemistry of fish curing.....	Dr. A. B. Macallum.....	Dept. of Bio-chemistry, McGill University, London, Ont.
Collecting, identifying, recording and mounting of the marine algæ of the Canadian Atlantic coast	Prof. H. P. Bell.....	Dept. of Botany, Dalhousie University, Halifax, N.S.
Chemical separation: identification and possible synthesis of antipressor substance from hepatic tissue	Dr. A. A. James.....	Dept. of Biochemistry, Univ. of Western Ontario, London, Ont.
Researches in the field of low temperatures	Dr. J. C. McLennan.....	Dept. of Physics, Univ. of Toronto, Toronto, Ont.
Fungi.....	Prof. A. H. R. Buller....	Dept. of Botany, Univ. of Manitoba, Winnipeg, Man.
The effect of temperature on the strength of castings	Prof. R. W. Moffatt.....	Dept. of Civil Engineering, Univ. of Manitoba, Winnipeg, Man.
Investigation of the mechanical properties of metals at low temperatures	Profs. I. F. Morrison and A. E. Cameron	Dept. of Mining Engineering, Univ. of Alberta, Edmonton, Alta.
Ultra-violet spectroscopy with vacuum grating spectrograph	Dr. R. J. Lang and Prof. Stanley Smith	Dept. of Physics, Univ. of Alberta, Edmonton, Alta.
Colour vision.....	Dr. F. Allen.....	Dept. of Physics, Univ. of Manitoba, Winnipeg, Man.
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.....	Dept. of Physics, Univ. of Toronto, Toronto, Ont.
Power loss in dielectrics.....	Dr. H. J. MacLeod.....	Dept. of Physical and Electrical Engineering, Univ. of Alberta, Edmonton, Alta.
The deterioration of rubber in oxidation and the nature of resin present in rubber	Dr. G. S. Whitby.....	Dept. of Chemistry, McGill University, Montreal, Que.
Earth's nocturnal radiation.....	Dr. H. T. Barnes.....	Dept. of Physics, McGill University, Montreal, Que.
Structure and growth of anchor ice.....	Dr. H. T. Barnes.....	Dept. of Physics, McGill University, Montreal, Que.
Processes leading to the utilization of natural gases	Dr. E. H. Boomer.....	Dept. of Physics, Univ. of Alberta, Edmonton, Alta.
Effects of velocity on reabsorption rates..	Prof. O. S. Gibbs.....	Dept. of Pharmacology, Dalhousie University, Halifax, N.S.
Cathode rays.....	Dr. J. A. Gray.....	Dept. of Physics, Queen's University, Kingston, Ont.
Maple sugar and syrup.....	Dr. J. F. Snell.....	Dept. of Physics, Macdonald College, Que.
Development of a new method of measuring electrical conductivity and moisture	Prof. E. F. Burton.....	Dept. of Physics, University of Toronto, Toronto, Ont.
Mineral deficiency or adequacy of Quebec soils	Dr. R. R. McKibbon....	Dept. of Chemistry, Macdonald College, Que.
Effect of ultra-violet rays on eggs, chicks and laying hens	F. C. Elford.....	Dominion Experimental Farm, Ottawa, Ont.

91 Researches in Progress During 1928-29—*Continued*

Subject of Research	Grantee	Where Carried On
Study of the short radio waves, one to five meters	Prof. J. C. McLennan....	Dept. of Physics, Univ. of Toronto, Toronto, Ont.
Designing and testing of a series of windmills	Prof. J. H. Parkin.....	Dept. of Mechanical Engineering, Univ. of Toronto, Toronto, Ont.
Analysis of the hydrolysis of starch to glucose	Prof. E. C. Young.....	Dept. of Biology, Dalhousie University, Halifax, N.S.
Adhesions of ice to various surfaces of aeroplane structure	Dr. H. T. Barnes.....	Dept. of Physics, McGill University, Montreal, Que.
Sound analysis of carillon on Peace Tower	Prof. E. F. Burton.....	Ottawa, Ont.
Reactions between the halogen hydrids and unsaturated hyrdocarbons	Dr. O. Maass.....	Dept. of Chemistry, McGill University, Montreal, Que.
Bio-hydrographical investigations of the Pacific adjacent to Fraser River	Prof. A. H. Hutchinson..	Pacific Biological Station, Nanaimo, B.C.
Ultra-violet spectroscopy.....	Prof. S. Smith.....	Dept. of Physics, Univ. of Alberta, Edmonton, Alta.
Chemical constitution of bios.....	Prof. W. Lash Miller....	Dept. of Chemistry, Univ. of Toronto, Toronto, Ont.
The life cycle of fish tapeworm.....	Dr. Daniel Nicholson....	Dept. of Pathology, Univ. of Manitoba, Winnipeg, Man.

63 Additional Researches Completed in Previous Years

Subject of Research	Grantee
The inheritance of earliness and lateness in wheat	Dr. W. P. Thompson
Water requirements of crops in western soils	E. S. Hopkins
The relation of bacteria to the quality of graded butter	Prof. W. Sadler
Fungi	Dr. A. H. R. Buller
Acidity and lime requirements of soils in Quebec and New Brunswick	Dr. J. F. Snell
The influence of acid in the soil on useful (nitrogent fixing) bacteria	Dr. F. C. Harrison
Insulin-like substances in plants	Dr. J. B. Collip
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 Nutrition Problems of the Fox Industry
The resistance of plants to low temperatures	Prof. J. F. Lewis
The biological origin of false wild oats	Prof. J. R. Freyer
Life history and habits of the Tabanidae (horsefly)	Prof. A. E. Cameron
Study of the blood chemistry in animals with the super renal glands removed	Prof. J. B. Collip
Investigation of the life history of the onion maggot	Prof. E. M. DuPorte
The use of Canadian oils in ore concentration	Dr. J. B. Porer
The extraction of benzene and toluene (valuable liquids) from coal gas	Dr. H. S. Davis
De-tarring of gas by electrical precipitation	Dr. J. G. Davidson
Reduction of iron ores by gases	Dr. A. Stansfield
A method of smelting titaniferous iron ores	Dr. C. W. Drury and A. F. G. Cadenhead
The testing of oil shales in the field	Louis Simpson
The treatment of silver-lead-zinc ores	Horace Freeman
The preparation (production) of metallic barium	Prof. H. E. Bigelow
Oil from shales	Prof. A. E. Flynn
Alberta tar sands	Dr. A. Lehmann
Lake Agassiz clay deposits	Prof. R. C. Wallace
The microscopic examination of cement during hardening	F. M. Dawson
Causation of cracks in concrete protective coating on iron and steel structures	Prof. P. Gillespie
The corrosion of iron and steel in the soil	Prof. J. W. Shipley
Investigation on the utilization of the resources of helium in Canada	Associate Committee on Helium
The properties and liquefaction of helium	Dr. J. C. McLennan
Canadian waste sulphite liquor as a source of alcohol	Dr. V. K. Krieble
The discolouration of cured codfish	Dr. F. C. Harrison
The discolouration of canned lobster	Dr. F. C. Harrison
Artificial propagation of the sturgeon	Associate Biological Committee
The food relations of certain minute organism (Entomostraca) in the cultivation of fresh water fishes	Prof. A. B. Klugh
Bacteria found in frozen fish	Dr. F. C. Harrison
Nicotine from tobacco waste	Arthur D. Hone
Utilization of milkweed	Dr. A. C. Neish
Problems of industrial fatigue	Associate Committee on Industrial Fatigue
The utilization of peat	Department of Mines
Channel interference in wind channel testing	Prof. J. H. Parkin
Interference in radio broadcast reception	Prof. T. R. Rosebrugh
Fog signalling	Prof. L. V. King
Vitamines	Food Research Committee
Surface tension in liquids and emulsions	Dr. J. C. McLennan
Chemical reactions at high pressures	Dr. J. C. McLennan
Conductivity and vapour pressure of salt solutions	Dr. A. N. Shaw
Crystalline shapes of bicarbonate of soda	Prof. Paul Riou
Investigation of Röntgen rays	Dr. J. A. Gray
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. L. Hughes
The spectrum of infra-red rays	Dr. J. C. McLennan
The action of ultra-violet rays	Prof. L. Bourgoin
Intensity measurements in spectra	Prof. J. K. Robertson
The spectrum of tin	Prof. J. K. Robertson
Constitution of rubber	Dr. G. S. Whitby
Generation of explosive gases in electric water heaters and boilers	Dr. J. W. Shipley
The breeding efficiency of bulls and horses	Dr. A. Savage
Experimental study of precipitation of iron and silica	Dr. E. S. Moore
Cultivation of medicinal plants in British Columbia	Dr. R. H. Clark and Prof. J. Davidson
Laws governing the screening of crushed ores	Dr. J. B. Porter
Grinding ore in ball mills and rock crushing by rolls	Prof. H. E. T. Haultain
Determining the elimination of magneto noises from aircraft receiving sets	Prof. H. Vickers
Storage of fruit in warehouses	Associate Committee on Fruit

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Classified Statement of Expenditures 1916-29

Year	Research Activities and Grants	Scholarships	Library and Publication	Administration of Council and Committees	Travelling Expenses		Salaries	Total
					Research Council and Staff	Associate Committees		
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
1925-26	61,931.65	30,082.00	2,161.27	5,584.11	6,463.50	3,104.46	19,243.35	138,570.34
1926-27	79,233.45	41,105.00	2,278.37	6,292.91	8,690.11	2,651.70	23,074.52	163,326.06
1927-28	110,797.33	41,855.00	2,851.21	7,133.53	7,920.04	4,038.81	26,889.16	201,485.08
1928-29	196,510.31	43,720.00	3,926.69	13,333.49	9,200.14	13,496.00	42,925.61	323,112.24
	$753,141.51	$370,243.66	$27,707.51	$76,585.02	$71,701.18	$45,090.68	$273,396.86	$1,617,866.42
Averages shown in percentages....	46.53%	22.85%	1.71%	4.73%	4.43%	2.79%	16.96%	100%

II. SUMMARY OF ACTIVITIES OF ASSOCIATE COMMITTEES

Foreword

Twenty-seven associate committees were in operation under the auspices of the National Research Council at the close of the year under review, with a total membership of 436 persons who, without remuneration, gave freely of their time and experience in furthering this phase of the activities of the Council.

Nineteen of these were Associate Research Committees charged by the Council with responsibility for the organization and direction of co-operate investigations in connection with the following major research problems: grain researches; cereal rust; field crop diseases; animal diseases; aeronautics; heating and insulation of buildings; Canadian helium resources; the utilization of Canadian magnesite; the utilization and development of Canadian wool; the classification of Canadian coals; tuberculosis in man and animals; best methods for securing accurate results in plot work in agricultural research; the reseeding of certain burned over and cut over forest areas; spray painting; oceanography; slack barrels in exported apples; engineering standardization; biophysics; and electricl measuring instruments.

Eight associate committees, whose main function is to keep 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 represent, were also in existence at the close of the year under review. 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 or during the progress of work carried out under the auspices of the Council. Research work is occasionally carried on under the auspices and direction of advisory committees, but research is not their main function.

Such committees meet once a year to discuss problems relating to the work of the Council, to consider the manner in which the committee can most effectively co-operate and assist in such work, and to make such recommendations to the Council regarding new problems requiring attention as in the judgment of the committee may be advisable. Such an advisory committee has been established in each of the following fields: Chemistry; Physics and Engineering; Physics; Biology; Mining and Metallurgy; National Research Library; British Columbia Problems; Nitrogen Fixation; and Patents.

Summaries of the activities of these research and advisory committees are given in this section of this report and will indicate the scope and volume of the activities carried on under this phase of the work of the Council.

Associate Committee on Magnesite

Co-operating organizations:

Dominion Department of Mines.
North American Magnesite Company.
Scottish Canadian Magnesite Company.

The work of the Associate Committee on Magnesite is an example of how research may be used in the building up of an industry. The principal Canadian producers of magnesian refractories appealed to the Dominion Government for assistance in 1925, and as a result of the favourable consideration of that

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appeal this committee was formed by the Council to help the industry in seeking a solution of some of its technical problems.

Much of the difficulty encountered by the co-operating companies in selling their main product, which is chiefly used as a refractory in steel furnaces, was due to its lime content. This was largely prejudice on the part of the steel makers, but was partly due to the fact that the presence of lime in magnesian refractories considerably modifies their properties. The problem has been solved in two ways.

First of all, a method was developed for the separation of the magnesia in the rock from the associated impurities, lime and silica, as outlined in the previous annual report. This was worked out in the laboratory and then demonstrated by the Council's staff on a semi-commercial scale.

The second solution of the problem, however, is the one which has been commercially adopted by the producing companies, since it possesses the advantages of still further reducing the amount of waste rock and of turning out a superior product. The method consists in so proportioning the chief constituents —magnesia, lime and silica—with the iron oxide added in the form of roll scale, as to produce a refractory which is at the same time highly heat-resistant, non-slaking in ordinary moist air, and capable of readily setting at furnace temperatures into a solid, coherent mass. This last property makes this special magnesian refractory of particular value in open-hearth furnace work, since it is not only quickly burned in, thus greatly reducing the cost of this expensive operation, but forms a monolithic bottom which gives long and highly satisfactory service. The competing products, low in lime, which formerly almost monopolized the market, require admixture with considerable slag to cement their particles together, and at best form a heterogeneous mixture. The best proof of the success of this improved product is found in the fact that it has not only captured practically the whole of the Canadian market but is also being exported in large quantity.

The success of the semi-commercial tests in controlled calcination was such as to indicate a possible new use for calcined dolomitic magnesite. Fairly pure calcined magnesite, or 'plastic magnesia', has long been used on a small scale mixed with magnesium chloride solution to form a rapid setting and strong oxychloride cement, suitable for magnesite stucco, composition flooring and other purposes. In the past such material has not been uniformly satisfactory, however, due to the fact that even the purest of it contains some free or active lime, and to its slaking on being stored. Since experiments had proved it possible to calcine dolomitic magnesite without the production of appreciable active lime, it was evident that such a calcine from Canadian magnesite could be used as plastic magnesia. Further, experiments demonstrated that the small amount of active lime in it could be effectively neutralized at the time of pulverizing, and that the product could be kept in special containers without appreciable slaking, thus overcoming two of the chief difficulties encountered in the use of foreign plastic magnesias.

The plastic magnesia produced from Canadian dolomitic magnesite has now been tested out by the staff of the Council, both as stucco and flooring. The results have been such as to convince the companies of the desirability of producing such a material on a commercial scale, and steps are now under way to that end. Incidentally, they will take over for that work a member of the Council's staff who has done the greater part of the laboratory work in connection with this development. This indicates one way in which the National Research Council can be of assistance to industry—by training men who will work out new methods in the laboratory and then proceed to apply them commercially.

During the year work on the manufacture of refractory brick from dolomitic magnesite has been continued. Numerous difficulties have been encountered and overcome, and while the work has not yet reached a satisfactory conclusion it has been decided to try out in actual furnace construction a few of the brick which in laboratory tests have indicated certain unusual and valuable properties. The work will be continued in the hope of effecting further improvements.

(*Investigation under the direction of F. E. Lathe, assisted by J. W. Craig, A. F. Gill, A. C. Halferdahl and D. W. Stewart.*)

Associate Committee on Wool

Co-operating organizations:

Canadian Co-operative Wool Growers.
Canadian Woollen and Knit Goods Manufacturers Association.
Dominion Department of Agriculture.
University of Alberta.
University of Saskatchewan.

Four conferences of wool growers and manufacturers were held during the year covered by the previous annual report of the National Research Council. At these meetings a number of the more important problems were discussed, and the following recommendations were made to the Council: (1) That there be appointed an Associate Committee on Wool to investigate the problems of both wool growing and manufacture. (2) That a field survey of range flocks in Alberta and British Columbia be undertaken by a small group of experts who should make a special study of the breeding methods in use and the results obtained in both wool and mutton production. (3) That if possible a special study be made of rams' fleeces in eastern Canada. (4) That the Dominion Bureau of Statistics be requested to adopt for its estimates of wool production the principles laid down by the Council's Sub-committee on Wool Statistics. (5) That an attempt be made through the Department of National Revenue to obtain more complete information as to the quality and quantity of wool and woollen goods imported into Canada.

Following the recommendations of the conferences the Council appointed an Associate Committee on Wool. To this committee was assigned the responsibility of dealing with the various recommendations which had been made, as well as that of making a general investigation of the problems of the wool-growing and manufacturing industries. During the year two meetings of this committee have been held.

The proposed survey of western range flocks was authorized by the committee, and was carried out during the months of June and July, 1928, by six of the best qualified men in Canada. This group visited practically all of the important range flocks in southern Alberta and British Columbia and discussed with the ranchers their breeding methods and the chief problems of wool growing. The opportunity was also taken advantage of to inform the ranchers as to what the committee believed to be the best practice. As a result of this survey the following recommendations were made to the main committee: (1) That ranching areas unsuitable for general agriculture be made available for sheep grazing under regulations which will permit of possession over a considerable period of years and thus justify reasonable expenditures in providing improvements necessary for successful ranching. (2) That in the mountainous districts of Alberta and British Columbia provision be made for 'sheep walks' by which flocks may be driven to the upper levels for summer pasturage. (3) That experimental

sheep breeding be undertaken in an effort to obtain further information as to the type of sheep best suited to range conditions. (4) That additional facilities be provided by which the ranchers may be able to secure the best types of range rams.

The general committee, after considerable discussion of these recommendations, decided that in view of their importance they should be given special study by two sub-committees. These were appointed and were given instructions to investigate and report back to the main committee at a subsequent meeting.

The committee also wished to carry out the recommendation that a special study be made of rams' fleeces in eastern Canada. Upon investigation, however, no suitable man could be found in Canada to undertake this work, nor could one be obtained from England in time for the 1929 season. It was therefore decided to postpone action until the completion of an Empire wool survey being carried out by a representative of the British Government.

The committee agreed to endeavour to secure, through Departments of the Dominion Government, the fullest information possible regarding wool importations, production and consumption. It was believed that detailed statistics, if obtainable, would be of great assistance to the Canadian industry.

A small committee was asked to investigate the question of the establishment of a wool laboratory under the auspices of the National Research Council. This committee made a study of wool research done in other countries, of the tests for which provision would have to be made, of the equipment and personnel required. It was recommended to the Council that in the National Research Laboratories definite provision be made for research on wool. This recommendation was subsequently considered by the Council and the decision was made to establish a laboratory for textile research as soon as suitable accommodation could be secured.

A questionnaire was sent out to the departments of agriculture in all the provinces of Canada regarding the amount of land available for sheep grazing but unsuitable for general agriculture. When all the information had been obtained it was decided that it would be advisable to refer this question back to the provinces for action. This was accordingly done.

Considerable correspondence took place between the committee and the British Association for the Woollen and Worsted Industries with regard to the possibility of Canada participating in Empire research on wool. The matter was referred to the Council, and the president was instructed to endeavour to complete arrangements with the British organization whereby Canada might receive the benefit of their investigations. Steps to this end are being taken.

Associate Committee on Grain Research

Co-operating organizations:

Board of Grain Commissioners for Canada.
University of Alberta.
University of Manitoba.
University of Saskatchewan.

In the last annual report there were recorded the circumstances which led to the organization of the Associate Committee on Grain Research, and the programme of investigations to which it set its hand. During the year now under review, rapid progress has been made with several of these investigations, and some new projects have been undertaken. The larger projects, having to do with such important practical questions as the effect of artificial drying or of frost injury on milling and baking quality, have been carried on co-operatively by all laboratories, while a number of more fundamental researches have been prosecuted independently by the different laboratories.

Standardization of Laboratory Methods

One of the first problems to which the committee set its hand was the standardization of laboratory methods, particularly of such important empirical tests as milling and baking. A sub-committee was appointed for this purpose, including in its membership the chemists immediately responsible for the laboratory test. These have met occasionally to compare and discuss their methods, and to carry out jointly actual laboratory experiments. In co-operative projects the general plan has been to divide all samples into four parts and carry out independent tests in all four laboratories. The baking programme includes a test by a basic or 'straight' formula (no improvers added) in all laboratories, and one 'differential' test in each laboratory. The four differential tests adopted so far involve the addition to the dough of potassium bromate, malt, malt and arkady, and a blend of weak flour, respectively. Methods of scoring and recording have also been standardized, thus facilitating compilation and comparison of results from different laboratories. Very satisfactory agreement between the laboratories has been obtained in the results of all chemical tests, and good progress has been made towards achieving the same correspondence in milling and baking results.

The Drying of Wheat

The first stage of the investigation on the artificial drying of tough and damp wheat has been completed, and a report published. It was shown to be possible to dry wheat without injury in any of the commerical driers studied. In general, 180°F. appeared to be the maximum safe temperature for air used in drying. If, however, the wheat contained over 18 per cent moisture, it was advisable to use lower temperatures. Over-drying of the wheat was shown to involve grave risk of injury, even though the drying air did not exceed 180°F. Results obtained with commercial driers were confirmed by the use of an experimental drier.

Damp wheat, if dried carefully, was found equal in value to wheat threshed dry. Weathering, even to the extent of over-wintering in the stock, did not necessarily injure the quality, but if conditions were unfavourable, or such as to cause incipient sprouting, a decided lowering of value resulted. Winter storage of damp wheat in steel drums did not lead to deterioration, but corresponding data for elevator storage are not yet available. Experiments on this and other points are being continued as weather conditions and other circumstances permit.

Frost Injury to Wheat

The widespread frost injury to the wheat crop of 1928 led to requests for an investigation of its effect on milling and baking value. Preliminary information on this point is being obtained by experiments with a large number of samples collected throughout the prairie provinces, with a view to correlating visible damage to the kernels with damage to milling and baking quality. The committee has also decided to install a refrigerating plant at Edmonton and carry out experiments with wheat exposed at different stages of maturity to definite degrees of frost. In this way experimental material of known history will be produced.

Protein Content as a Factor in Grading Wheat

By resolution of the House of Commons on February 16, 1928, the National Research Council and Board of Grain Commissioners were asked to investigate

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the feasibility of utilizing the protein content of wheat as a basic factor in grading, and certain related questions. Members of the Associate Committee on Grain Research visited important grain marketing centres in the United States, and reported upon the working of protein testing in that country and its possible applicability to Canada. There are some serious difficulties, the most important of which arises out of the fact that the bulk of the Canadian wheat crop is exported, and such efforts as have been made in the United States to export wheat on a protein basis have been unsuccessful. It was recommended that the inquiry should be extended to the principal wheat-importing countries of Europe.

The report on protein testing also included a report on the proposal to establish an experimental flour mill. The purposes served by similar mills in the United States, their size, equipment, cost and problems of operation were investigated and reported.

As another phase of this investigation, the committee began the collection and study of data showing the relation between protein content and baking quality. Loaf volume is generally accepted in this country as a measure of 'strength'. The 'differential' baking tests referred to above promise to bring out more clearly than has been done previously the relation between protein content and loaf volume. Heretofore, this relation has often been obscured by deficient gas production in the dough preventing the loaves attaining the maximum volume which the protein was capable of supporting.

The Quality of Wheat Varieties Grown in Canada

The reference from the House of Commons included the question of the most suitable varieties of wheat to be grown. With the added co-operation of the Dominion branch experimental farms in the prairie provinces, the committee began an investigation of the milling and baking qualities of all the common varieties, grown under a wide range of conditions. In the course of a few seasons it is expected that this work will produce more authoritative information than has yet been available on this subject.

A New Method for Estimating Moisture in Wheat

With the support of the committee, a rather comprehensive test was made by Dr. E. F. Burton and Mr. F. E. Pitt, of the University of Toronto, of the applicability of their new electrical apparatus to the determination of moisture in wheat. The electrical conductivity of wheat varies with the moisture content of the kernels, and the amount of the variation can be measured by the effect produced when a container holding the wheat is introduced into the rapidly alternating electric field generated in a specially arranged radio circuit. The moisture content is read directly from a calibrated scale on an ammeter included in the circuit. The method is very rapid, and if the apparatus can be turned out in suitable form for general use, it should be of practical value.

Independent Researches at the Universities

In addition to participating in the co-operative investigations summarized above, the university laboratories each carried forward independently a share of the programme of researches published in the last annual report. Progress reports on these researches are, however, made at each meeting of the committee, and the results are published in a single series of numbered papers.

Grain Research at the University of Alberta

At the University of Alberta, work has been continued on the analysis of data accumulated during a study of wheat quality in relation to environment begun in 1924. Both quality and quantity of protein and baking value vary with variety, locality and season, but environment has a relatively greater influence than variety. However, both variety and conditions of growth must be right in order to get the finest wheat. Irrigation in general increases yield and decreases protein content, but the use of alfalfa in the rotation will do much to sustain protein content. Fall irrigation seems an especially good practice, increasing yield with little or no expense to quality. Superphosphate applied to irrigated plots improved the appearance and grade of the wheat, but had no effect on the protein content.

The application of the 'bound-water' method to the study of the capacity of gluten for absorbing moisture showed that when flour is mixed with water the gluten takes up water about equal to its own weight, while starch takes up about 30 per cent of its weight. When the natural salts are washed out of the flour, the gluten takes up about double its weight of water. Contrary to popular belief, there was no important difference in the water taken up by the glutens of good and poor flours, except in a very weak flour.

A method has been devised which resolves the diastatic activity of flour into its two major components: (1) the concentration and activity of the enzyme, (2) the resistance of the starch to the action of this enzyme. By the use of this method it has been found that continued grinding or extraction with ether decreases the resistance of the starch. Both diastatic activity and starch resistance are affected by the conditions under which the wheat is grown. The increase in diastatic activity when wheat is sprouted is due mainly to a change in the quantity or activity of the enzyme.

In continuation of studies on the effect of heat treatment on wheat (as in artificial drying), the gluten proteins have been prepared in pure form by very careful methods, for the study of their properties as affected by heat.

Studies of the effect of crop sequence at Edmonton showed very great differences in protein content of wheat after various crops or treatments. In general, the best quality was obtained after fallow, with the various crops coming roughly in the following order: alfalfa and sweet clover, corn, flax, red clover, cereals, grasses. Both quality and yield after brome grass were better if the sod was plowed early in the season than when it was plowed later.

(*Investigation under the direction of Dr. R. Newton and Dr. J. G. Malloch.*)

Grain Research at the University of Manitoba

At the University of Manitoba, a statistical study was made of the data obtained by 50 replicate milling tests of a single lot of No. 1 northern wheat. The humidity of the mill-room was kept at about 70 per cent, but variations in temperature were found to have an important effect on apparent flour yield, through the effect on the moisture content. However, the conclusion was that under the conditions of these experiments the flour yield in a single milling is very unlikely to vary more than 30 grams from the average of 50 millings, in a total yield of about 1450 grams flour from 2000 grams wheat. In view of the frequent criticisms which have been made of laboratory milling tests, it is very satisfactory to find that, with the system followed by the committee, for comparative purposes at least the flour yields are not likely to be in error more than two per cent.

Careful studies were also carried out on the effect of heat treatment of wheat and flour, with reference to time and temperature of heating, and mois-

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ture content of the wheat or flour. Moderate heat treatment brought about apparent improvement in quality, when the baking was done by the "straight" formula, but this improvement was not equal to that produced by the addition of bromate to the unheated flour. Further, the use of bromate revealed actual damage to baking quality by all heat treatments, since in no case did the heated samples baked by the bromate 'differential' formula measure up to the unheated samples baked by the same formula. Damage was shown by loss of fermentation tolerance, decreased loaf volume, and coarser texture. Damage increased with severity of heat treatment. The sensitivity to heat damage increased rapidly with increasing moisture content. These findings confirm and extend the results obtained co-operatively by the committee in the investigation of the artificial drying of wheat, and are especially significant in view of recent British patents for the improvement of flour by heat treatment.

To throw light on the nature of the injury caused by heat, investigations were begun on the effect of heat treatment on various physical properties of the flour, and on the relation to baking quality of changes in the germ caused by heat.

(Investigation under the direction of Dr. W. F. Geddes.)

Grain Research at the University of Saskatchewan

At the University of Saskatchewan, special attention has been given to the improvement and standardization of the experimental baking tests. A simple basic or 'straight' baking formula alone gives insufficient information, as it fails to show the potentialities of flours when submitted to commercial usage. The basic formula plus 0.001 per cent potassium bromate was found a very good 'differential' test, which in general causes an increase in loaf volume more or less proportional to the quantity and quality of protein present. The blending of 40 parts of White Club wheat flour (weak) with 60 parts of the test flour has also been found a very good method of measuring the reserve baking strength of the latter.

The use of a test loaf made from 50 grams of flour, as compared with the ordinary test loaf made from 100 grams, has been shown to be practicable. This is of special value when the available quantity of experimental material is small, as in early tests of new plant-breeding productions.

Experiments are being conducted with wheat stored in small containers at different moisture contents and temperatures. These are laboratory studies growing out of the 'tough' wheat investigations of the committee.

(Investigation under the direction of Dr. T. Thorvaldson and Dr. R. K. Larmour.)

Associate Committee on Tuberculosis

Co-operating organizations:

Dominion Department of Agriculture.
Fort Qu'Appelle Sanatorium.
McGill University.
Queen Alexandra Sanatorium.
Queen's University.
Sun Life Assurance Company of Canada.
University of Alberta.
University of Montreal.
University of Toronto.

During the past year tuberculosis research has been conducted at eight different centres throughout Canada, and one general meeting of the committee has been held. At that meeting progress reports were received from all groups of workers, and plans were made for a continuation of the investigation.

Without question, the chief interest at the meeting of the committee was centred in the reports covering experiments on B.C.G., a vaccine developed by Calmette and Guérin at the Pasteur Institute, France, for use on both young children and calves. The originators of this vaccine claim that it is entirely harmless, and that it produces a very high degree of immunity to tuberculosis when used according to their directions. Their results have been confirmed by numerous reputable investigators, but others, also of recognized scientific standing, question both the harmlessness of B.C.G. to laboratory animals and its efficacy in producing immunity to tuberculosis in children and bovines. Particular importance was therefore attached to the Canadian experiments, some of which have been carried out on a considerable scale. Unfortunately, the Canadian investigators themselves, using slightly different methods, have obtained varying results, both as to the harmlessness of B.C.G. to laboratory animals and its value in increasing resistance to tuberculosis. The results, as reported to the committee, are therefore inconclusive, and further work must be done before the committee can reach a unanimous decision as to the value of this vaccine.

The other work of the committee, while attracting less attention, is not to be considered less important. Fundamental researches are proving essential in establishing a foundation of knowledge upon which experiments can be based. Further, the application by tuberculosis workers of knowledge already obtained is demonstrating the possibility of greatly reducing sickness and mortality from the disease, both in the larger cities, where tuberculosis is being most actively combated, and also where special conditions exist, as amongst the Indians.

There follows a brief outline of the work of each group of investigators co-operating in tuberculosis research under the committee.

Tuberculosis Research of the Dominion Department of Agriculture

In 1905 the Department adopted the supervised-herd plan of control of tuberculosis in cattle. This developed in 1919 into the accredited-herd plan, and led in 1922 to the adoption of the restricted-area plan. These various plans have been extended over practically the whole of the Dominion on a scale which has been equalled in no other country except the United States. In its campaign against tuberculosis the Department aims to prevent infection and exposure by detecting and destroying infection itself. Detection of the disease in cattle is made by the tuberculin test. From 1915 to Oct. 15, 1928, 1,267,620 cattle were tested by this method; of these about 100,000 were found to be reactors and were destroyed. At present the incidence of bovine infection in Canada is probably not over five per cent.

In connection with this campaign research has been carried out on the various strains of tubercle bacilli, the nature and properties of tuberculin, the cause and nature of subcutaneous tuberculosis, the immune carriers of tubercle bacilli, and other related problems.

A problem on which considerable recent work has been done is that of the possible value of B.C.G. as a vaccine. From the Department's point of view it is particularly important that this vaccine should be thoroughly tested before any recommendation is made as to its general use on cattle, since vaccinated animals normally react to tuberculin, and might therefore be confused with animals actually infected with tuberculosis. Two research problems of primary importance have been involved. First, has B.C.G. been completely deprived of virulence? Second, is B.D.G. efficacious in the prevention of tuberculosis?

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Experiments on the virulence of B.C.G. have been carried out on 134 guinea pigs. Of these, 92 appeared on post-mortem examination to be entirely free from tuberculosis; 30 had early, slight or localized lesions; 12 developed typical generalized tuberculosis. No definite evidence has been obtained that B.C.G. gives rise to tuberculosis in bovines.

The efficiency of B.C.G. has been tested on 21 calves, born of tuberculosis-free mothers and vaccinated shortly after birth, then at once exposed to natural infection through the medium of milk from infected cows and cohabitation with reacting cattle. Six controls were used. All 27 animals at post-mortem examination showed involvement, slight to extensive in character. The average involvement in the vaccinated and in the unvaccinated animals was approximately equal.

(Investigation under the direction of Dr. E. A. Watson.)

Tuberculosis Research Among the Indians

In connection with this investigation a very thorough study has been made of the literature dealing with the Indians of the western plains, in order that the fullest possible information might be obtained as to their manner of living and the prevalence of tuberculosis and other diseases amongst them in the period antedating the present work. A large number of Indians have been under close medical observation, with special reference to the prevalence and severity of tuberculosis.

During the decade from 1884 to 1894 a very high proportion of the deaths of these Indians was due to tuberculosis. In one year the mortality from this cause rose to 10 per cent. Since 1894 the epidemic has greatly declined in force, but even at present, under much more sanitary conditions, the mortality from tuberculosis is still approximately 20 times that of the surrounding white population.

The present investigation discloses the fact that there has been no appreciable reduction in infection, since of 374 children, tested at an average age of 12.4 years, over 92 per cent reacted to the tuberculin test. Neither is there any apparent loss in virulence, since a number of deaths have recently occurred of individuals who not more than five months previously had no active disease.

The type of the disease found amongst the Indians falls into two classes, the severe type, running rapidly a fatal course, and the moderate type, reacting with localized lesions. The second type resembles that found amongst white children.

As far as has been determined, the type of germ causing tuberculosis amongst the Indians is human. Until recently these Indians have not consumed a great quantity of milk or milk products. The cattle on the File Hills reserve have been tested and seven per cent have been found to react to tuberculin.

Infusion of white blood by crossing has been shown to have conferred increased resistance to tuberculosis. It has not decreased morbidity, but it has considerably reduced mortality.

That the combination of good food, housing and sanitation has a noticeable effect upon morbidity has been observed in the health of children in schools of varying hygienic status. Of the third generation of the File Hills demonstration colony only 14 per cent have died from tuberculosis compared with 21 per cent on the adjacent reserve.

(Investigation under the direction of Dr. R. G. Ferguson,
Fort Qu'Appelle Sanatorium.)

Tuberculosis Research at McGill University

A visit was first made to the Pasteur Institute and to other European centres of tuberculosis research, and details were secured as to methods of manufacture and use of B.C.G. A culture of B.C.G. was obtained from Calmette, and its manufacture has been carried on over a considerable period, using Calmette's methods. Some of this vaccine was used on babies in Montreal, but the time is still too short to permit of any conclusion as to its effectiveness in producing immunity.

Since Petroff reported that he had produced from B.C.G. two distinct types of colonies, smooth and rough, of high and low virulence, respectively, an effort was made to similarly dissociate B.C.G. A smooth type of colony was produced, but no such clear dissociation of smooth and rough types as observed by Petroff could be obtained. Further, when guinea pigs were inoculated with the smooth type of colony they continued to gain in weight, and when killed at 90 to 100 days were found to be in a healthy condition. Animals similarly inoculated with bacilli of human origin died in about six weeks of generalized tuberculosis.

A series of experiments has been made in the growth of tubercle bacilli from sputum, pus, body exudates, organs, etc., in order, if possible, to save time and dispense with animal inoculation, which is ordinarily required to find out whether the type of bacillus present is bovine, avian or human. Eight different media were tried. The best results were obtained with a veal-glycerine-egg medium.

(*Investigation under the direction of Dr. F. C. Harrison.*)

Tuberculosis Research at the Queen Alexandra Sanatorium

Fundamental research has been carried out in an effort to determine the nature of tuberculosis immunity, with particular reference to tuberculosis humoral antibodies. The method planned is to chemically isolate the antibodies in as pure a state as possible and to determine their relation to the disease by applying them to tuberculous animals. In carrying out this plan there has been used serum from human and sheep blood showing the presence of tuberculo-complement fixing substances. Sheep have been given repeated intravenous inoculations of a human strain of living tubercle bacilli.

The serum was dried in a chemically inert medium and extracted with a series of selective solvents. Each fraction has then been carefully studied. This field of research is an extremely difficult one, and most of the time has been spent in overcoming the numerous difficulties which have been encountered, but recent additional expert assistance has been secured and it is hoped that more rapid progress will be made in future. Biological tests will follow the completion of certain chemical phases of the investigation.

A study has also been made of X-ray photography in relation to pulmonary pathology. There has been developed an original technique in which lungs are obtained at autopsies, radiographed, then frozen, cut into thin slices and radiographed before thawing. In this way it is possible to remove accurately defined shadow-producing areas for study under the microscope. Much valuable information has been obtained as to the technical methods, the nature of pulmonary pathology, and its identification in living subjects.

Incidentally, it has been necessary in this connection to investigate the physics of X-ray production. This study of the physical laws relating to the paths of X-rays has proved very informative. Conditions have been discovered and technique developed which will minimize distortion and the information thus derived should prove of benefit, not only in improving and standardizing X-ray technique in general, but also in pointing out possible improvements in X-ray equipment.

(*Investigation under the direction of Dr. F. H. Pratten.*)

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Tuberculosis Research at Queen's University

Previous reports have outlined experiments on the influence of iron upon the metabolism of tubercle bacilli. This work has been extended and two papers embodying the results of the experiments have been published.

Iron has been found to exert a considerable influence upon the growth of tubercle bacilli. Ordinarily, when iron is added in the form of chloride or sulphate to a synthetic medium, almost complete precipitation of the iron takes place. The addition of sodium citrate, however, inhibits the precipitation of iron. In one synthetic medium (adjusted to pH 7.4) it was found that tubercle bacilli produced about 20 per cent more growth when iron was added, but no citrate. When both iron and citrate were added growth increased over 100 per cent. In more acid or more alkaline media less conspicuous advantages resulted from the addition of iron.

Another question investigated has been the pigmentation of bacilli. Observations have shown a relation between the iron content of a culture medium and the yellow, brown or red pigment of acid-fast bacilli. No relation has been found between iron content and the pigmentation of non-acid-fast organisms.

A study of the dissociation of bacterial species into two types has been continued. Many different strains of human tubercle bacilli have been used. Most of these strains have produced colonies of one general type, of a high degree of virulence for guinea pigs. Certain stock cultures, however, which have been cultivated for a number of years, produce entirely different colony forms, of a waxy, folded type. These have produced no gross lesions in guinea pigs, although the original culture was highly virulent. Similar results have been obtained with certain bovine strains.

Experiments have also been under way for some time on the possibility of dissociating B.C.G. into two strains of different appearance and virulence. Good progress has been made, but reports are being withheld until the results of inoculation into guinea pigs are available.

A further series of experiments has been carried out on a strain of bovine tuberculosis to determine whether radiation by X-rays would vary the colony types, since several workers have observed that chromosome aberrations can be produced by this means. The colony forms produced from the untreated cultures were all of a uniform normal type, while the irradiated cultures gave a small but varying percentage of mutant forms. True breeding strains of these types were eventually secured.

(Investigation under the direction of Dr. G. B. Reed.)

Tuberculosis Research at the University of Alberta

The work by the Alberta group has been confined to experiments with B.C.G. Research has been continued over a period of four years, during which time some 200 calves have been vaccinated and over 100 have been used as controls. A number of the experiments are being carried on over a period of years, and post-mortem results are therefore not yet available; completed experiments involve about 200 animals.

Thirty calves in these experiments were vaccinated with B.C.G. to determine whether the vaccine might give rise to tuberculosis. Vaccination was not followed by any appreciable rise in temperature, nor was there any interference with normal development. Ten of the animals were killed after a lapse of seven months and the others after one year. All the animals were found to be free from gross or microscopic lesions. Material from these animals did not produce tuberculosis in guinea pigs inoculated with it. B.C.G. therefore appears to be harmless to bovines when administered under the conditions of these experiments.

Several experiments, each involving a considerable number of animals, were carried out to determine whether B.C.G. confers resistance to infection, and, if so, the extent of that resistance. In the first two experiments the animals were vaccinated and then immediately exposed to infection, through the use of milk from infected cows and association with tuberculous animals, without allowing any time to elapse for resistance to develop. Of the 25 vaccinated animals 14 were at autopsy entirely free from tuberculous lesions, and most of the infected animals had but slight lesions; of the 11 unvaccinated controls all showed tuberculosis, usually in a more pronounced form than the diseased animals which had been vaccinated.

In other experiments the animals were first vaccinated and then fed on pasteurized milk for a period of two months, in order to permit the development of resistance before infection. Some of the calves were then inoculated with virulent tubercle bacilli, others were exposed to infection under natural conditions. Each group of vaccinated animals thus made the subject of experiment showed a much higher resistance to tuberculosis than the unvaccinated controls; in four experiments the percentages of animals showing complete absence of tuberculous lesions were 66 and 16, respectively. The lesions found in the two classes again differed markedly, those of the vaccinated animals frequently being so small as to be visible only under the microscope.

(*Investigation under the direction of Dean A. C. Rankin.*)

Tuberculosis Research at the University of Montreal

The vaccination of children by mouth with B.C.G. was begun some time ago in Montreal to test this method of protection against tuberculosis. Over a period of two years 615 babies have been vaccinated. Of these children 17 were in contact with pronounced cases and 35 with suspected cases of tuberculosis. The above cases are being followed up as closely as possible, although some families have moved away and been lost sight of, at least temporarily.

These tests indicate that B.C.G. may be regarded as entirely harmless, since in no case has there been any unfavourable result.

As regards the degree of resistance conferred by B.C.G., this can obviously be determined only after a large number of vaccinations, and observations extending over a period of years. It may be observed, however, that of the 52 children living with open or suspected cases of tuberculosis only three have died, and of these only one was a doubtful case of tuberculosis. No autopsies were performed, and microscopic evidence is therefore not available.

In general, it may be said that the results of vaccinating young babies with B.C.G. are distinctly encouraging, although it is still too early to arrive at any definite conclusion.

(*Investigation under the direction of Dr. J. A. Baudouin.*)

Tuberculosis Research at the University of Toronto

One of the important problems to which much attention has been given in the past two years is that of the determination of the incidence of bovine infection in children, in the city of Toronto and vicinity.

Bovine strains of tuberculosis have been isolated from a number of children, the lymph glands of the neck being the usual sources of infection. In only one case was there any evidence of pulmonary involvement. It was demonstrated that most of the children had partaken of raw milk from an infected milk supply; all patients came from areas where unpasteurized milk was used. It thus appears that bovine tuberculosis is a factor in childhood infection, particularly in rural districts, and in other areas where there are no regulations requiring the pasteurization of milk, a procedure which is com-

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pletely effective in protecting children against this form of infection. Not a single case has been observed of infection with bovine tuberculosis in the Toronto district.

Work dealing with the bacteriological findings in cattle reacting to the tuberculin test has been continued. Frequently animals giving a positive tuberculin reaction fail at autopsy to show any evidence of a tuberculous process, and such cases are ordinarily recorded as negative for tuberculosis. Microscopic examination, however, has revealed latent foci in lymph nodes of a number of animals belonging to this class. These findings are strong evidence of the reliability of the tuberculin test.

Of the 13 cows examined 11 showed the presence of acid-fast bacilli on one or more occasions, and tubercle bacilli were isolated from the milk of four. When the udders were examined at autopsy no tuberculous lesions were discovered, but studies of human renal tuberculosis lead to the belief that tubercle bacilli in milk indicate the presence of an udder lesion, either large or small.

A study of renai human tuberculosis has been carried out upon a group of patients in which infection of the kidneys was demonstrated by pathological analysis. No evidence has been found of the excretion of tubercle bacilli; whenever these were found in the urine tuberculous lesions were discovered in the kidneys. The distribution of tubercle bacilli to the kidneys and localization in those organs are not as infrequent as sometimes stated; a considerable percentage of active pulmonary cases have renal involvement.

(Investigation under the direction of Dr. Oskar Klotz.)

In co-operation with the Health of Animals Branch of the Dominion Department of Agriculture a study was undertaken of cows which had been certified as tuberculin positive by the inspector of the department. After a period of three months the tuberculin test was repeated, specimens of milk and urine were obtained and examined for the presence of tubercle bacilli, and samples of blood were tested.

Of the 36 animals tested at autopsy 24 showed gross lesions diagnosed as tuberculosis and confirmed by microscopic or cultural methods; 10 showed no microscopic lesions, and two showed gross alteration of tissue of a suspicious nature. Of these 12 animals tuberculosis was definitely proved in three. In all the animals showing gross tuberculosis the strain was found to be bovine, with the exception of one which appeared to be avian.

Double intracutaneous tests were made on 400 children at the Hospital for Sick Children, Toronto, one series with the commercial tuberculin grown on beef glycerine broth and one with a strain grown on synthetic media. Of the 400 cases, 101 were positive to both strains, and in addition three cases were positive to the first mentioned strain but did not react to the latter. Of these three cases one gave a positive reaction with a glycerine bouillon control; the other two have not been retested.

(Investigation under the direction of Dr. A. H. W. Caulfeild.)

Associate Committee on Field Crop Diseases
(Western Section)

Co-operating organizations:

Federal Department of Agriculture.
University of Alberta.
University of Manitoba.
University of Saskatchewan.

The Associate Committee on Field Crop Diseases was appointed in the spring of 1928 to co-ordinate and promote investigations into diseases other than rusts. The cereal rusts had constituted such a serious menace to grain growing in the West that a special committee had been appointed several years earlier to deal with this problem alone. The activities of the present committee are intended to be Dominion-wide in scope. For convenience in getting together to deal with regional problems, it has been organized in two sections, eastern and western. So far only the western section has been active in promoting a definite programme of investigation, and this report is a summary of the activities which it has sponsored during the past year.

The Dominion laboratories which are located at the Universities of Alberta, Manitoba and Saskatchewan do not obtain financial assistance from the National Research Council, but nevertheless co-operate in the general programme of the committee. More detailed accounts of the activities of the Dominion laboratories will be found in the annual report of the Dominion Botanist.

Research at the Dominion Rust Research Laboratory, Winnipeg, Manitoba

In a partial survey of Manitoba, collections of root-rot infected wheat and barley, referable to the *Helminthosporium-Fusarium* complex, were made at 66 widely separated points. Wheat infected with *Ophiobolus graminis* was found at 31 points.

Studies were also made on the smut diseases of wheat, oats and barley. Bunt or stinking smut of durum wheat was particularly prevalent in 1928. Copper carbonate dust appeared to be the most satisfactory disinfectant for the control of bunt in common wheat. Formalin on the other hand proved best for the control of bunt in durum wheat, and for the covered smuts of oats and barley. Eleven varieties of oats, *Avena sativa*, proved immune or highly resistant to one strain each of loose and of covered smuts of oats. Breeding work is in progress.

(Investigation under the direction of Mr. J. H. Craigie and Dr. C. H. Goulden.)

Research at the University of Alberta

In the course of the plant disease survey in Alberta, the following fungi have been found associated with foot and root rots of wheat: *Ophiobolus graminis*, *Helminthosporium sativum*, *Fusarium* spp., *Wojnowicia graminis* and *Leptosphaeria herpotrichoides*. The heaviest damage in individual fields was caused by *Ophiobolus graminis*. The fungus tentatively determined as *Leptosphaeria herpotrichoides* was collected for the first time in Canada in the fall of 1927.

The occurrence in the soil of *Helminthosporium sativum* and *Fusarium* spp. of the types which cause foot rot of wheat was demonstrated. The results, however, did not indicate that the foot-rotting fungi are as abundant in the soil as might be expected from their prevalence on adjacent wheat stubble. The finding of these organisms in summerfallow soil late in the fall indicates that

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they may persist for considerable periods in land which is not in crop. One of the strains of *Helminthosporium sativum* obtained from the soil was very virulent, in fact considerably more virulent than one isolated directly from wheat. Rotations designed primarily to determine the persistence of foot-rotting organisms under different conditions were laid down.

Investigations on the reaction of foot-rot fungi to extremes of temperature and drying, show them to be very resistant to these adverse conditions. Four of them, namely, *Fusarium graminearum*, *Helminthosporium sativum*, *Ophiobolus graminis* and *Leptosphaeria herpotrichoides*, readily survived the winter of 1928-29 at Edmonton on the soil surface, when minimum temperatures as low as −49°F. were experienced. A comparison of single spore strains of *Helminthosporium sativum* and *Fusarium graminearum* of northern origin with those of southern origin did not indicate that the northern strains are better adapted to grow at lower temperatures than the southern strains.

Experiments on the effect of seed and soil treatment with chemicals, on the development of foot rots and other diseases as well as on growth of the cereal crops, were made. A large number of chemical dusts were used as seed disinfectants. Although some of the dusts slightly reduced the amount of foot rot in wheat, none of them gave control of practical value. Three of the dusts, however, gave complete control of barley stripe, namely K.I.C., K.I.D., and a mixed dust prepared in the laboratory. Formalin, the most commonly used cereal seed disinfectant in Alberta, caused much seed injury, especially to wheat, when used in too concentrated solutions, as is rather commonly done, when sown in dry soil or when seeding was delayed after treatment. Barley was less susceptible to injury and oats much less susceptible, but care must also be exercised if injury is to be prevented in these crops. Sulphuric acid was used as a spray on growing spring wheat to determine the effect on the development of foot rots. Concentrations as high as eight per cent by weight were used without reducing the yield, but the treatment did not reduce the amount of foot rot significantly.

(*Investigation under the direction of Dr. A. W. Henry.*)

Breeding for disease resistance cannot be carried on effectively without an accurate knowledge of the disease organisms and of their relation to the host plant. The plant breeder must therefore work in close co-operation with the plant pathologist. Again, the plant breeder must understand the principles governing the inheritance of resistance to the disease in question. This often requires him to carry his investigations into the field of pure science as a prerequisite to practical progress.

The first introductions and crosses were made in the season of 1928, at the University of Alberta, in connection with the programme of breeding for foot-rot resistance in wheat and barley. A prominent feature of the programme is the use of a disease garden, artificially inoculated with all manner of diseases, where new varieties will be required to withstand the severest and most comprehensive test before being multiplied for possible distribution. Old standard varieties will also be grown in the disease garden, to obtain better information in regard to their relative resistance and susceptibility to the more important diseases.

(*Investigation under the direction of Dr. O. S. Aamodt.*)

Research at the Dominion Laboratory of Plant Pathology, University of Alberta

The chief work carried out during 1928 was the continuation of the extensive field survey of the foot-rot situation which was begun in 1927. Nine hundred and fourteen fields were observed. While the damage from root rots was not as severe as in 1927, yet the distribution was more general than in that year, when

it was noted that the greater injury occurred in the black-soil areas. Mature perithecia of *Leptosphaeria herpotrichoides* were observed in 1928 wheat at several points in Alberta, and it was proved that this fungus causes foot rot. Two other soil-inhabiting fungi, not heretofore recognized as important, were also shown to cause foot rot.

Wheat stem rust, *Puccinia graminis tritici*, was scarce, and although fairly widely distributed, no damage occurred. Observational evidence was obtained on a case of overwintering of stripe rust, *Puccinia glumarum*, on winter wheat at Claresholm. Stripe rust was found on wild barley, *Hordeum jubatum*, throughout the province, from the international boundary on the south, as far north as Grande Prairie and Pouce Coupé in the Peace River area, and east to the Saskatchewan border. Epidemiological studies on this rust are being continued.

Field studies on the varietal resistance of wheat, barley, and rye to root-rotting organisms were continued. Tests were made with cultures of *Fusarium*, *Helminthosporium* and *Ophiobolus*. No striking results were obtained under field conditions at Edmonton and Camrose. Tests under rigidly controlled conditions in the greenhouse seem necessary.

Samples for analysis were obtained from the plots in the crop sequence and soil cultural project for the control of foot rots of wheat at the Dominion Experimental Stations in Alberta, Saskatchewan and Manitoba.

Root-rot studies of sweet clover and related hosts were continued, but definite results are not yet available.

(*Investigations under the direction of Dr. G. B. Sanford.*)

Research at the University of Saskatchewan

The plant disease survey work conducted by the University of Saskatchewan during the summer of 1928 showed that the disease known as "take-all" undoubtedly caused the most damage of any of the foot, and root-rot diseases of wheat in the area covered, namely the western, northwestern and northern wheat-growing sections of Saskatchewan. The severity of this disease appeared to be influenced by rainfall rather than by soil type. *Helminthosporium* and *Fusarium* taken together caused the next most prevalent type of foot and root rot. "Browning" root rot was widely distributed, but could not be diagnosed readily at the time when the survey was made.

The principal researches made in 1928 were those on the "browning" root rot of cereals. This is a specific disease of cereals which is widespread in Saskatchewan. It is characterized by a discolouration of the outer leaves of the young plants in early June, delayed growth and a reduction in the number of tillers and in yield. The presence of oöspores in the lesioned root tips of affected plants is diagnostic. There is some evidence that this disease is a root rot caused by *Pythium*. A hitherto undescribed fungus belonging to the *Ancylistacae* was found attacking the finer roots of wheat, barley, rye and maize seedlings, growing in the greenhouse in Regina clay (gumbo) soil from "browning" infested fields. It was shown to injure wheat seedlings, but to be incapable of attacking dead plant parts. The name *Lagena radicicola* (new genus and species) has been suggested for this fungus. A comprehensive investigation of related organisms occurring on cereal roots is proposed.

Preliminary studies on the root rot of wheat caused by *Wojnowicia graminis*, in which three single spore strains were used, demonstrated slight but consistent parasitism for this fungus under greenhouse conditions. Field tests were less consistent. *Ophiobolus graminis* under similar conditions was vigourously parasitic.

Investigations were begun on the *Septoria* diseases of cereals. Pure cultures of the following organisms were obtained: *Septoria nodorum*, *S. tritici*,

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S. avenae, *S. agropyri*, *S. secalis*, *S. passerini*, and *S. bromi*. The first four produced pycnidia in culture but not abundantly. *Leptosphaeria* perithecia were obtained on the lower leaves, leaf sheaths and stems of Marquis wheat during late summer and fall. The *Leptosphaeria* type of perithecia was also collected on oats, barley, rye and western rye grass. Single ascospore cultures were made. These consistently failed to fruit, except one culture of the wheat *Leptosphaeria* grown on celery stalks which produced pycnidia of the *nodorum* type and the culture of the oat *Leptosphaeria* which produced pycnidia of the same type as *S. avenae*.

(*Investigation under the direction of Prof. W. P. Fraser.*)

The work accomplished during the previous three years in co-operation with the Dominion Laboratory of Plant Pathology at Saskatoon demonstrated clearly that two things at least were essential before much further progress could be made. One was the obtaining of more exact information concerning the disease organisms themselves. The other was the creation of a disease garden populated thickly by both *Helminthosporium sativum* and *Fusarium culmorum*, in which new hybrid strains of wheat could receive a severe test for resistance to the attack of these organisms. The disease garden was commenced in 1928, and is being sown both spring and fall with a mixture of inoculum of the two foregoing organisms. It is intended to add inoculum of other disease organisms as the need arises, providing that this does not introduce into the seed virulent organisms not otherwise to be found there. This garden should furnish a field test of importance for new hybrid strains of wheat. In the spring of 1929, it is planned to sow in it a replicated series of the most promising rust-resistant lines from the cross Marquillo × Marquis, to obtain information in regard to their resistance to root rots.

Greenhouse investigations on the disease organisms and the resistance of new wheat hybrids in the young plant stage are to be conducted by the Dominion Laboratory of Plant Pathology, Saskatoon.

(*Investigation under the direction of Dr. J. B. Harrington.*)

Research at the Dominion Laboratory of Plant Pathology, University of Saskatchewan

Research on the following projects assigned to this laboratory at the first meeting of the Associate Committee on Field Crop Diseases has been pursued: (1) life history of *Ophiobolus graminis* throughout the prairie provinces, (2) life history of *Fusarium* species causing root rots, (3) life history of *Helminthosporium sativum* causing root rots, (4) co-operative crop sequence and cultural studies (with farmers) for the control of "take-all" disease of wheat in Saskatchewan, (5) study of the annual fungous flora of basal parts of the wheat plant.

In the plant disease work, 524 fields were examined, 447 of which were wheat. The "take-all" and "browning" diseases of wheat were found causing medium to severe damage in numerous fields. Pre-maturity blight was present in several fields of wheat and oats, causing damage estimated at from a trace to slight. Foot rots caused by *Helminthosporium* and *Fusarium* species were common but caused less damage than "take-all" and "browning".

(*Investigation under the direction of Dr. P. M. Simmonds.*)

Associate Committee on Cereal Rust

Co-operating organizations:

Dominion Department of Agriculture.
University of Alberta.
University of Manitoba.
University of Saskatchewan.

While the losses due to cereal rusts were relatively small in 1928, the memories of the destructive epidemics of the past and the ever present threats of repeated occurrences in the future are sufficient to command and maintain an interest and enthusiasm for the research work in this field, not only on the part of the farmer and the grain trade but of the general business interests. This attitude toward rust research has been extremely gratifying and encouraging to the scientifiic corps conducting the experimental work.

The work of the committee, as in previous years, consists of a varied attack upon the rust problem through all possible avenues of approach. Whenever sufficient new knowledge is made available on any phase of the rust problem which might materially assist in reducing rust losses, it is immediately put into practice. New hybrid selections are given thorough field trials and then sent to the milling and baking laboratory for quality tests. New sulphur compounds with different chemical properties are tested in the field for their usefulness in the practical control of these destructive diseases.

Owing to the intricate special problems involved, the fundamental investigations are still the most important activities of the committee. It is through such studies that a more thorough understanding of the problem as a whole is being gained and new avenues of approach are being opened up.

Research at the Dominion Rust Laboratory

At this centre work has been carried on under the Dominion Department of Agriculture without financial assistance from the National Research Council. The work, however, is done in close co-operation with the other laboratories and the results obtained are made available to all those engaged in investigations on field-crop diseases.

The past season was a decided success from the standpoint of progress in the breeding work. A group of hybrid strains and selections which had been developed at this laboratory were placed in field tests for the first time. Many of the strains proved to be desirable types with high yielding abilities. Twenty-eight lines were given a preliminary milling and baking test in the laboratory of the Dominion Cerealist at Ottawa. These tests demonstrated that distinct progress had been made toward the production of a wheat combining a high degree of rust resistance with high yielding ability and quality for bread-making purposes.

There are now thirty-six wheat crosses being studied for their possibilities in combining the desirable characteristics of both parents in a single variety, or for the information they give on the inheritance of rust resistance, or for both purposes. It is highly desirable that complete information be obtained on the varieties being used as parents, as to their genetic constitution for resistance to rust in both the seedling stage and the mature plant stage. Other characters are being studied chiefly with respect to their association in inheritance with rust resistance. An excellent example of the need for close attention to other characters, especially reaction to other diseases which might become important limiting factors in production, was brought to light. In certain crosses the black chaff disease, which is ordinarily of no great economic importance, proved to be a very decided limiting factor. Correlation studies demonstrated a significant relation between yield and infection with black chaff.

The tenth year of research on physiologic specialization of wheat stem rust has brought the total number of forms which have been isolated in Canada to thirty-four. No changes in pathogenicity have yet been discovered in the colour mutations. More new forms have been found, proportionately to the number of collections made, in those regions of Canada (eastern) in which the barberry is commonly grown. This evidence seems to suggest that at least some of the new forms must have arisen through hybridization on the barberry. In some of the earlier studies of hybridization on the barberry it was demonstrated that sex exists in the rust spores. Certain exceptions were observed in which a simple pustule of itself appeared to develop spores on the barberry. These exceptions have now been demonstrated to be due to the transfer of nectar, which carries the potencies for sex, by insects from one pustule to another. The indications are that a simple pustule of itself does not develop spores.

A large number of varieties and hybrids have been tested in the seedling stage for their reaction to twenty-two physiologic forms of stem rust. These varieties were grouped on the basis of their reaction to the different physiologic forms. Each group represents a common relation between host and parasite. A knowledge of these groups is of great importance to those engaged in developing resistant varieties or in other rust investigations.

Considerable progress is also being made in breeding for stem-rust resistance in oats. The chief difficulty is in the existence of physiologic form 6, to which no varieties are known to be resistant. The number of collections of this form, however, is still very small and there seems to be a fair possibility that it will not become widespread. Seven forms of oat stem rust have been reported to date.

Further information is reported on the distribution, prevalence and physiologic specialization of the dwarf leaf rust and yellow stripe rust of barley. A single collection of dwarf leaf rust in Victoria, B.C., resulted in the demonstration of a third form of this rust. While no conclusive evidence on the existence of physiologic specialization has yet been demonstrated for stripe rust, valuable information on the factors which influence its development is being accumulated.

In the sulphur-dusting experiments for the control of rust the results were similar to those obtained in the rate and frequency experiments of 1925 and 1927. With any given quantity of dust the control improved with the frequency of application. The addition of two per cent of potassium permanganate to sulphur dusts increased the fungicidal effectiveness of the sulphur to a significant degree. This action appears to be due to an oxidizing effect on the sulphur, and not to the toxicity of the permanganate.

(Investigation under the direction of Mr. J. H. Craigie and Dr. C. H. Goulden.)

Rust Research at the University of Alberta

Further progress has been made in the investigation of the biochemical nature of resistance and susceptibility to stem rust in wheat. A portion of the work on phenolic compounds is being carried on by a research assistant at Leeds University under the direction of Dr. A. G. Perkin, a world authority on the pigments in the form of which these compounds of wheat seem mainly to occur.

A study of the phenolic compounds of the wheat plant was begun in the spring of 1927 and a series of quantitative determinations of the phenol content of eight varieties of wheat of graded resistance to rust has already been reported. The results lent some support to the "phenol hypothesis", since the varieties differed widely in their content of phenol, and the resistant varieties contained more than the susceptible varieties. During the past year the methods have been improved, and when a second series of determinations was made the re-

sults duplicated those of the first series with remarkable accuracy, considering the empirical nature of the method. Among the technical improvements made was the development of a satisfactory method for getting rid of the substances in wheat-plant juice which interfered with the determination of phenols. These preliminary studies indicated that the most important compounds present were probably natural phenolic dyestuffs of the flavone or flavonol class. Further evidence that phenolic colouring matters exist in the leaves was afforded by dyeing trials.

Rust-inhibiting substances in wheat plants were studied by injecting the juices of resistant varieties into the leaves of susceptible varieties inoculated with rust. An excellent method of injection has been developed but the percentages of rust infection were so irregular that no satisfactory interpretation of the results could be made. More definite results have been secured by the injection of phenolic substances known to occur in plants. These caused on the average a marked reduction in the rust infection of susceptible varieties. The same phenols also inhibited the germination of rust spores. These findings are particularly significant and encouraging in relation to our hypothesis that phenolic substances are responsible for the rust reactions of wheat.

(*Investigation under the direction of Dr. Robert Newton.*)

Studies have been made on the relation between several physiologic forms of black stem rust and the genetic factors in the hosts which govern their reactions. Certain genetic relationships have been established which make it appear feasible to recombine the resistant reactions to all physiologic forms into one variety. Some factors in the host govern the reactions to groups of rust forms. The relationship has simplified the problem for the plant breeder. Instead of dealing with each single rust form as a unit he can deal with them in groups.

Recent studies have demonstrated that five out of eight new physiologic forms of rust are governed in their reaction by a factor which already has been demonstrated to govern the reaction to eleven other forms. This evidence indicates that there are now sixteen physiologic forms all governed by the same genetic factor and that as far as the plant breeder is concerned these five new forms have not added materially to the complexities of the problem.

(*Investigation under the direction of Dr. O. S. Aamodt.*)

Rust Research at the University of Manitoba

Special studies were made of beardless derivatives from crosses between Khapli emmer and common wheat. The spike characters were subjected to a detailed analysis and correlated with rust reaction. In most of the hybrid segregates the grain threshed out of the chaff easily, instead of being held firmly with the glumes as in Khapli emmer. In the past season, out of a total of thirty-one beardless segregates, four were as resistant as Khapli, thirteen were intermediate, and four were susceptible like Marquis. Chromosome counts are being made of these beardless segregates.

(*Investigation under the direction of Professor H. F. Roberts.*)

Extensive studies on species hybrids have demonstrated the possibility of obtaining the desired combination of the rust resistance of the emmer and durum parents with the other characters of the bread wheats. However, a large number of these desirable strains had to be discarded because of their susceptibility to other diseases such as foot rot and black chaff. These results again demonstrate the need of a new variety not only combining resistance to rust and desirable commercial characteristics, but possessing also resistance to other diseases which may be limiting factors in production.

(*Investigation under the direction of Professor W. T. G. Wiener.*)

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Rust Research at the University of Saskatchewan

Genetical investigations and plant-breeding activities are closely interdependent. In species crosses extremely large second-generation populations are necessary in order to increase the chances of finding the desirable recombinations. Owing to chromosomal irregularities in the sex cells the great majority of the ordinarily expected intermediate hybrids do not appear. This is also responsible for the small proportion of common wheat types among the hybrids.

A simple Mendelian segregation was found for rust reaction in a Vernal emmer × Marquis cross. Two hundred and thirty-two selections from this cross which resemble the bread-wheat parent were found to be immune to rust in the field. A detailed genetic study of sixteen characters in this cross demonstrated that it is possible to recombine the individual desirable characteristics of both parents. Field rust reaction was not strongly correlated with any of the structural characters. Promising selections have been made from several other crosses and these are now being tested further. It is planned to observe the reaction of these hybrids to foot-rot producing organisms and susceptibility to saw-fly attacks.

(*Investigation under the direction of Dr. J. B. Harrington.*)

Owing to the importance of having an understanding of the chromosomal activities in species crosses for use in genetic and plant-breeding studies, the study of chromosomal conditions in later generations of hybrids between emmer and common wheat is being continued.

The failure of many hybrid plants to appear in segregating generations is due in large part to the shrivelling of the endosperm of the seeds from which they should develop. The degree of shrivelling of the endosperm is determined by the chromosome conditions. In the breeding of wheat special attention should be paid to the shrivelled seeds. From the practical standpoint the shrivelled seeds are just those in which the combinations of characters desired by the breeder are likely to occur. Plumper seeds can be produced in crossing by using the parent with the larger chromosome number as the female.

(*Investigation under the direction of Dr. W. P. Thompson.*)

Studies on the forms and alternate hosts of crown rust of oats have been amplified in cultural work. The results confirmed those obtained in previous years.

Difficulties have been encountered in artificially germinating the resting, or winter, spores of the crown rusts. A new method has been devised which overcomes this difficulty. It was discovered that these spores germinate freely in the spring when sprayed for several days with a fine spray delivered with considerable force.

(*Investigation under the direction of Professor W. P. Fraser.*)

Associate Committee on Aeronautical Research

Co-operating organizations:

Royal Canadian Air Force.
University of Toronto.

The rapid adoption of commercial aviation in Canada and throughout the world has made great demands upon research workers everywhere. Owing to the necessity of reducing to a minimum the weight of all materials used in aeroplane construction, and the even greater necessity of providing for safety, the mechanical requirements are extremely severe.

Further, much of the experimentation involved in aeronautical research requires elaborate and expensive equipment. Up to the present the committee had made use of the wind tunnel at the University of Toronto, through the courtesy of the Department of Mechanical Engineering. This wind tunnel is the only one in Canada, and if the research work of the committee is to expand in keeping with the need for research, the time is at hand when there will be required not only a larger wind tunnel but also a water channel. The committee is at present giving consideration to these matters, and research to determine the best design of a water channel is already under way. Attention is also being paid to the subject of power plant research, including work on both engines and fuels.

Stability of Flying Boats

Aircraft of the flying-boat type, because of the large water areas present, are largely employed in Canada. This type of aircraft has, however, received but little attention and, in particular, little study has been made of the stability of such aircraft. Because of the importance of this type in Canadian aviation and the necessity of securing data on which future design may be based, an investigation of the stability of the typical Canadian flying boat was undertaken.

Difficulty was encountered in securing research assistants for the work and little experimental work was accomplished until the fall of 1928. During the winter of 1928-29, two graduate students were employed on the work. Much time was spent developing apparatus and technique during the first part of the investigation. Apparatus for driving a small propeller to obtain slip stream effects was later designed and built.

The object of the investigation was to determine the so-called resistance and rotary derivates for the flying boat. These derivatives would be of considerable value in the design of similar aircraft in the future.

Complete static measurements of the forces and moments were made, from which the resistance derivatives were calculated.

Two methods for the determination of the rotary derivatives were studied and used, namely the free oscillation method and the forced oscillation method. The theory of these two methods was very thoroughly studied and the methods compared experimentally.

(*Investigation under the direction of Prof. J. H. Parkin, University of Toronto.*)

Water Channel

Because of the great water areas present in most parts of Canada, aircraft equipped with floats or hulls are largely employed in the Dominion.

For the development of improved floats and hulls for Canadian aircraft, a testing tank for experimental investigations is indispensable. At present there is not a tank for this purpose in the Dominion. In other countries tanks of the towing type are employed. As the construction of a tank is now contemplated in Canada, it was considered advisable before deciding on the type to be built to investigate the possibilities of a tank of the circulation type.

In this investigation a one-sixth scale model was employed and velocities up to twenty feet per second were obtained. Efforts were directed toward the securing of a stream with level smooth surface and with constant velocity throughout the cross section. A fair degree of success was obtained in both attempts through the use of special devices.

(*Investigation under the direction of Prof. R. Taylor, University of Toronto.*)

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Windmills for Power Generation

With the object of developing a satisfactory windmill generator unit for supplying electric current for farm use, Prof. A. R. Greig of the University of Saskatchewan commenced in 1926 studies with a full-scale windmill unit. As a result of these tests it became apparent that before a satisfactory unit could be produced a windmill, capable of operating in winds of low velocity, would have to be developed. At the request of Prof. Greig work was undertaken in the aerodynamic laboratory of the University of Toronto in 1929 with the object of developing such a windmill.

A study was made of the wind velocity records for several points in the western provinces and Ontario for the purpose of determining a suitable velocity for which the windmill should be designed. A special dynamometer for the model windmill tests has been constructed, and preliminary tests have been made.

(*Investigation under the direction of Prof. J. H. Parkin, University of Toronto.*)

Associate Committee on Electrical Measuring Instruments

Co-operating organization:

Gas and Electricity Inspection Service,
Department of Trade and Commerce.

Under the revised act of the Electricity Inspection Service the responsibility for the ultimate standards of electrical measurement and the units of measurement rests with the National Research Council. Accordingly, when the Council was informed that certain of the electrical companies were desirous of billing their customers in kilovolt amperes as well as in kilowatt hours, the president was authorized to call a conference to discuss this and any other related questions. The conference was called in January, 1929.

At this conference the representatives of the Gas and Electricity Inspection Service pointed out that they were prepared, subject to the approval of the National Research Council, to do all in their power to suit the convenience of the various interests concerned, provided always that the units and methods of measurement proposed were such as to guarantee fair treatment to both the producing power companies and the consumers of electricity. The representatives of the power companies pointed out that in many instances the present method of payment, according to kilowatt hours consumed, compelled them to provide a service for which they received no return. This might be corrected by measuring and billing on a kilovolt ampere basis.

After considerable discussion it became evident that the question was one which could not be decided hastily, but which called for a complete study of units and methods of measurement. The conference accordingly recommended to the National Research Council that there be appointed an Associate Committee on Electrical Measuring Instruments whose duty it would be to go fully into the question in all its aspects.

Another question considered by the conference was that of the provision in Canada of an electrical laboratory for high-tension research, such as is carried on at the National Physical Laboratory in England and in similar laboratories situated at several points in the United States and Germany. The need for such a laboratory was generally recognized by those present, and it seemed desirable to reach a decision in the matter at an early date, in view of the possibility of including such a laboratory in the building about to be erected by the Government for the National Research Council. After much discussion it was agreed that before any action was taken in the matter the president should communicate with the more important power companies in Canada, in order to secure their views.

Carrying out the recommendation of the conference the Council shortly afterwards appointed an Associate Committee on Electrical Measuring Instruments. This committee has had one meeting and has allocated to different groups of its members studies on the following phases of the problem: (1) Existing methods of measuring electricity for billing purposes. (2) The various types of meter and their principles of operation. (3) Methods of billing. (4) The collection of related historical material on the above subjects.

Associate Committee on Heating and Insulation

Co-operating organizations:

Dominion Fuel Board.
McGill University.
Queen's University.
University of Saskatchewan.
University of Toronto.

The work of the committee during the year under review has consisted chiefly in a continuation of the work previously begun. In view of the limited capacity of the laboratories of the National Research Council all the experimental work on heat conductivity tests was carried out in the laboratories of the universities of McGill, Queen's, Saskatchewan and Toronto. All of these laboratories except Saskatchewan were equipped with apparatus for the determination of heat conductivity by the hot-plate method. The Saskatchewan laboratory was supplied with the hot-box equipment, which is particularly well adapted to the testing of large sections of walls of thicknesses used in actual building construction. The hot-plate method is normally used in determinations of specific conductivity of individual building materials, particularly heat-insulating boards such as are now being widely used.

The committee has during the year continued the collection of heat-insulating data. These have been useful in answering the many inquiries which have been received and which testify to the increasing appreciation by the general public of the great savings effected by the use of heat-insulating materials in building construction. It is gratifying to note that both the manufacture and use of heat insulation are rapidly increasing in Canada, although as yet the majority of builders entirely neglect this very important feature of building construction.

Some experimental work has been done during the year in the Council's laboratories on the preparation of heat insulators from peat, sawdust, magnesite and other suitable materials. Work has also been done on the fireproofing of certain combustible heat insulators, in order to combine fire protection and heat insulation in one material. The results have been sufficiently encouraging to justify additional work when adequate laboratory facilities are available.

Associate Committee on Apple Slacks

Co-operating organizations:

Dominion Department of Agriculture.
Province of Nova Scotia.

In the spring of 1928 the National Research Council was advised that serious losses were being suffered by the apple growers of Nova Scotia through the failure of shipments to arrive in England in good condition. The most serious trouble appeared to be due to settlement of apples in the barrels in transit, with the result that they were damaged and sold subsequently at a lower price. The Council therefore appointed an Associate Committee on Apple Slacks to investigate this question under the direction of the Dominion Department of Agriculture, on the understanding that the Department would bear one-half

the cost of the investigation, and the Province of Nova Scotia and the National Research Council each one-quarter.

The Committee met in Halifax in July and decided to make experimental shipments of each of the varieties, Gravenstein, Golden Russet and Blenheim Orange, using 150 barrels in each shipment of each variety, varying the method of packing, and shipping at the same time as controls 50 barrels of each variety packed by regular packing-house methods.

Arrangements were made to have all the experimental barrels carefully inspected before shipment and again after their arrival in England. The inspectors were instructed to secure information on the loss in weight of different varieties from packing until arrival in England, the percentages of slacks found, the percentages of slacks in regular shipments from the various packing houses, the satisfaction given by the different makes of barrels, and any other information likely to be of use in solving the shipping problem. Five shipments have already gone forward.

Associate Committee on Spray Painting

The spray painting machine has been in wide-spread use since 1917, in painting of all types, both interior and exterior, in the automobile industry, in the vitreous enamelling of stove parts, granite ware and similar products, in the painting of such products as metal castings, plumbers' supplies, etc., in furniture finishing, leather finishing and in many other industries. The advantages of the spray gun over the application of paint by the brush or by dipping are said to be economy of time, saving of materials, better and more uniform coverage, and the securing of more artistic effects than are possible by hand methods.

The spray painting machine is a device used for the application of various kinds of paint, blown by compressed air upon the surfaces to be covered, and its almost coincident development with that of large scale lacquer manufacture has been no small factor in the extension of mass production. It is therefore unlikely that its use will be abandoned.

Objection to the use of spray painting equipment has been raised by labour organizations on the ground that such equipment exposes the worker to the spray, with consequent increase in the health hazard from any poisonous ingredient which the paint may contain.

In 1926 at a General Labour Assembly in Montreal, this question was discussed and referred to the Dominion Council of Health, the latter body in turn referring it to the Federal Department of Health, which department passed the problem on to the National Research Council. It was pointed out in the communication referring the matter to the Council that there is undoubtedly a menace to the health of the operators in the functioning of these spray guns; from the pigments in a mechanical way; from the substances used, such as lead, copper, silica, etc., by absorption, and through the inhalation and local irritative action of solvents and driers used in the materials sprayed.

The National Research Council, on consideration of this question, appointed an Associate Committee on Spray Painting and charged this committee with the responsibility of considering all phases of this question and of recommending to the Council what action should be taken if, in the opinion of the committee, this problem requires that further research work should be undertaken.

Three main steps have been taken by the committee. In the first place, a detailed questionnaire was prepared and submitted to the Federal Department of Health and to the Health Departments of Ontario and Quebec, the two largest industrial provinces in Canada. The questionnaire was also distributed to labour organizations. The purpose of this questionnaire was to ascertain what information is at present available in the files of the health departments and labour organizations with respect to the health hazard con-

nected with the use of the spray painting machine. None of the above organizations were able to furnish the information requested, but all of them replied by letter giving such information as they had available.

The second step taken by the committee was to gather the literature on the subject covering investigations carried out and papers published on this question, and to compile this information in such manner that it would be available in one document for reference purposes.

The third step taken by the committee was to visit a number of representative industrial plants using spray painting equipment, in order that the members of the committee might have personal knowledge of the conditions under which spray painting operations are carried out in Canada. The plants visited employed from two or three to more than sixty operators each, and they were spraying lacquer, enamel, varnish and paint on such articles as automobiles, stoves and ranges, pianos, radio and gramophone cabinets, aeroplanes, ships, furniture, kitchen and household utensils, street-cars, motor buses, and machinery. It will be seen therefore that as a result of these visits to industrial plants, the committee became thoroughly familiar with the general conditions under which paint spraying operations were being carried out in Canadian industries.

Although the committee had not completed its work or reached any final conclusions by the close of the year under review, it was the general consensus of opinion of the members of the committee that insofar as the materials used in spray painting are concerned, there is a definite health hazard in the use of such materials as lead, silica, copper, and benzol, and that there is considerable lack of information as to other ingredients used in spray painting and as to whether these involve a serious health hazard. There was also lack of definite information as to the extent of the health hazard involved in the use of the above materials.

With regard to the spray painting equipment, it was the opinion of the committee that even when the most modern equipment is used, it is still necessary for the operator to wear a protective mask, and further that there is considerable need for improvement in the type of mask used. The committee was also of the opinion that there is considerable ground for improvement in the manner in which the spray painting equipment and material are handled by the workmen.

After careful consideration, the committee agreed that before making any definite recommendations to the National Research Council, it should prepare a summary of the literature on this subject, including reports covering investigations already carried out on the question of the health hazards involved in spray painting; and it should also prepare a summary of the existing legislation on spray painting; and also that it should prepare a synopsis of the action which is now being taken to eliminate undesirable conditions in connection with spray painting. At the close of the year under review, the committee was engaged in the compilation of this information for presentation to the National Research Council.

Associate Committee on Coal Classification and Analysis

Co-operating organizations:

Alberta Research Council.
American Engineering Standards Committee.
Dominion Department of Mines.

The first general meeting of the committee was held in London, Ont., in June, 1928, in connection with the Dominion Convention of Chemists. At that meeting there were present representatives of the American Engineering Standards Committee on Coal Classification, of the Dominion and several

provincial departments of mines, of the universities and of the consulting chemists.

Mr. H. J. Rose, representing the American committee, presented a memorandum outlining the form of organization adopted in the United States and the work carried out to date. His advice and experience proved of the greatest value in planning a similar work in Canada.

Dr. B. R. MacKay, of the Geological Survey, gave a brief description of the various coal fields of Canada, and discussed at some length their geological age and characteristics. He also presented maps showing the coal areas of the Dominion.

Mr. R. E. Gilmore, Superintendent of the Dominion Fuel Research Laboratory, who had acted as Canadian representative on the American committee, outlined the classification which was in use by the Geological Survey of the United States and compared the coal classification problems of the two countries. He also commented upon the methods of sampling and analysis used in the Fuel Research Laboratory and compared them with the methods of the American Society for Testing Materials.

Prof. Edgar Stansfield spoke on the situation in Alberta, with its wide variety of coals, and particularly of the fuel research work of the Alberta Research Council. He presented a paper prepared by himself and Mr. Sutherland in which all of the important systems of coal classification proposed were discussed at some length, together with the results of using these methods in classifying Alberta coals. The advantages and disadvantages of the various methods were indicated.

At this meeting the organization of the committee was not fully completed, but it was agreed to refer that question to a small executive committee. This committee met shortly afterwards, and arranged for the following sub-committees:

1. Sub-committee on the Origin, Constitution, Location and Occurrence of Coal: Chairman, Dr. B. R. MacKay.
2. Sub-committee on Sampling, Analysis, and General Uses of Coal: Chairman, Mr. R. E. Gilmore.
3. Sub-committee on the Applicability of Proposed Scientific Classification Schemes to Canadian Coals: Chairman, Prof. E. Stansfield.

Following the International Conference on Bituminous Coal, held in Pittsburg in November, 1928, those members of the committee who were present met and agreed on the membership of the various sub-committees, thus completing the work of organization. They also accepted an invitation of the American committee, which was in session at that time, to attend their meetings.

Associate Committee on New Brunswick Forest Problems

Co-operating organizations:

Dominion Forest Service, Department of the Interior.
New Brunswick Forest Service.

Repeated forest fires have destroyed completely all growth on large areas of one-time forest lands in eastern Canada. Without seed supply nature can no longer reclaim these areas and if these lands are to be restored to their former productivity, practical artificial methods of supplying tree growth must be found. A very successful but expensive method is to plant nursery trees. The alternative method is sowing seed directly on the waste lands without the intermediate nursery stage. This last method is less expensive but it not so universally successful, and therefore a study of the specific conditions of light, soil, moisture and method of seeding was made.

The object was to determine whether the burned-over areas of the Maritime Provinces can be reclaimed profitably by direct seeding. The plans provided for spring and autumn sowing of white spruce and white pine on burns of various severities and dates by broadcast and seed-spot methods. As a check on rodent damage, the seed were poisoned in some cases. In all, about 1,000 acres, in thirty plots, was seeded.

On suitable sites where some shade was offered to seedlings, white spruce germinated and survived for three years in sufficient quantities to provide a future crop. White pine was not so successful generally, but seems to be adapted to the thinner and lighter soils if some shade is afforded.

Poisoning with red lead has a greater value with white pine than with spruce, but the cost is probably not warranted in either case.

During the period of establishment the mortality varied greatly, averaging about 20 per cent with spruce and a little less with pine. The slight difference between spring and autumn sowing is in favour of the former.

North-facing aspects retain more moisture and have a lower temperature during periods of drought and hence produce slightly better results. The only noticeable beneficial effect due to the length of time elapsing between the date of burn and seeding is measured by the degree of shade afforded by weed species.

The seed-spot method is more economical of seed than the broadcast method, and insures that all seed sown come in contact with the mineral soil. The ordinary grub-hoe is the most successful tool tried for spot-making in general.

Direct seeding can be done for less than five dollars per acre including cost of seed at $3.75 per pound.

Similar investigations in Manitoba indicate direct seeding to be a complete failure in that province, while in Alberta it was fairly successful.

Associate Committee on Biology

Co-operating organizations:

Biological Board of Canada.
McGill University.

The work of the committee during the year under review has consisted of research on the proteins of the fish muscle.

Studies of changes in fish muscle shortly after catching the fish are fundamental to any rational preservative process. Four phases of this problem have been attacked, as follows:

(1) A study of the early post-mortem changes in the muscle.
(2) A study of rigor mortis in relation to equilibrium between water and proteins in solution.
(3) The isolation of protein fractions from several species of fish.
(4) A study of the source of the ammonia produced in the muscle-pressed juice during autolysis.

It was found that a very early post-mortem change occurred which resulted in the release of plasma from the fish muscle. It was hoped that this release might be slow enough to allow extraction of the proteins and their isolation before the change occurred, but the change is sudden and occurs within a few minutes after death. Both haddock and hake were used in the experiments with practically identical results. The increase in plasma is thought to be accompanied by absorption of water by the fish muscle protein.

The speed of onset and degree of rigor mortis varies with the kind of fish, being more noticeable in active vigourous fish. Previous work suggested that rigor was caused by precipitation of proteins at the isoelectric point, but that

was found not to be the case. Neither was absorption of water found to be the cause.

Investigation of the proteins of several fish was carried out on the muscle press juice. Two different proteins were isolated, one of which was water-soluble and the other soluble in 0.9 normal salt solution. In general the water soluble protein exhibited a higher pH value of the isoelectric point than did the one soluble in salt solution.

During autolysis of fish muscle, ammonia is produced, and work was done to determine the source of the ammonia. Results obtained show that the greater part, if not all, the ammonia produced by the autolysis of fish muscle plasma is derived from amide groups of the protein.

(Investigation under the direction of Dr. A. B. Macallum, McGill University.)

Associate Committee on Oceanography

Co-operating organizations:

Biological Board of Canada.
University of British Columbia.

At a meeting of the Pacific Science Congress in Japan in the fall of 1926, when the Dominion Government was represented by the President of the National Research Council, it was decided to organize an International Committee on Oceanography, and to recommend to the countries participating in the congress that they form local committees to carry on research and report to the central organization in matters of common interest. This action was taken by the congress in recognition of the exceedingly important part played by the water areas of the globe in furnishing food supplies, regulating climate, etc.

After careful consideration of the recommendation of the Pacific Science Congress by a conference called for that purpose the Council decided to appoint an Associate Committee on Oceanography, organizing it with sub-committees on the following branches:

Physical and Chemical Oceanography
Marine Biology
Fish Technology.

Research work is being undertaken by all of these sub-committees, and they will in addition keep in touch with the International Committee on Oceanography in order to take full advantage of researches carried out elsewhere.

One report of research work carried out under the auspices of the committee is already available. A summary follows.

Seasonal Variations in the Chemical and Physical Properties of the Waters of the Strait of Georgia in Relation to Phytoplankton

Good fishing grounds are found in areas providing abundant fish food. The conditions favouring the growth of phytoplankton, which is the primary food of the sea, depends upon definite chemical and physical factors. This study has for its object the determination of the conditions which favour the growth of diatoms in the Strait of Georgia, and especially the effect of the Fraser River on these factors.

The factors so far investigated seasonally in the Strait of Georgia are water temperature and salinity, both at the surface and at depth; pH values; phosphate and silica values; and fluctuations in phytoplankton quantity and genera. It has been found that the surface temperature varies from 1°C. to 22°C., while at 100 yards depth the variation is only 3.5° C. throughout the

year. The surface salinity at 30 miles from the Fraser River mouth varies from 8.5 grams halide per litre in summer to 15.0 grams in the winter. At depths the seasonal variation is considerably less. During the winter, due to higher specific gravity of the surface waters, vertical mixing occurs.

The greatest variation in pH is at the surface: in winter 8.0 and in summer 8.8. High pH and low salinity of the summer months are associated with abundant phytoplankton and the reverse holds in the winter. Seasonal fluctuations in both quantity and genera of phytoplankton occur.

The phosphate and silica values are much higher than obtain in the open sea. Diatoms decrease the amount of silica but not to the point where they limit their own growth in these waters since the greatest numbers of diatoms are associated with the lowest phosphate and silica values. The Fraser River contributes silica and phosphates which are conserved within the basin of the Strait of Georgia.

(*Investigation under the direction of Dr. A. H. Hutchinson, University of British Columbia.*)

Associate Committee on Physics and Engineering Physics

At the tenth meeting of the committee, held in the spring of 1927, it was decided to recommend to the Council the enlargement of the committee in order to make possible a greater representation of industry. In carrying out this recommendation the Council appointed seven industrial representatives, and the first meeting of the enlarged and reorganized committee was held at Ottawa on May 29, 1928.

Dr. A. S. Eve reported for the Sub-committee on Radio that a number of important radio problems had been given consideration, and presented a list of recommended researches which should be carried out in an endeavour to solve the more pressing of those problems.

Dr. E. F. Burton described an apparatus devised by himself and staff which made it possible to rapidly determine the relative electrical conductivity of a wide variety of materials, including particularly those of comparatively low conductivity. Owing to the rapidity with which tests could be carried out it appeared that the apparatus might be of value commercially for the determination of moisture in grain, wood and various other materials.

The chairman, Dr. J. C. McLennan, described his experiments in the production of very short radio waves. These waves could be so regulated as to produce artificial fevers in human beings, thus making possible a new therapy, since in certain diseases it had been found that the advent of fever sometimes resulted in the cure of other diseases.

There followed a discussion of the whole question of the relation of physics to medicine. The committee recommended to the Council that this general question be assigned for study to a special committee of both physicists and medical men.

Detailed consideration was given to several problems of the upper atmosphere, problems which are of increasing importance with the rapid development of radio. Canada, owing to the proximity of the north magnetic pole, is in a more favourable position geographically than any other country for a study of some of these problems. The committee recommended to the Council that immediate provision be made for such work.

Dr. F. Allen gave an outline of results which had been obtained at the universities of Manitoba and Alberta on the impact resistance of metals at low temperatures. Owing to the low temperatures prevailing during the winter months in western Canada this was a question of much importance, and the results obtained indicated that a satisfactory solution was in sight.

Mr. John Murphy introduced the question of the prevention of ice formation on power-plant machinery. His remarks were illustrated by slides showing

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the results of experiments in ice formation, and making clear the practical methods which have been devised of preventing the trouble.

The comparatively new but important science of geophysics was introduced by Dr. A. S. Eve, who described the various methods which are being used in the discovery and delimitation of deposits of ore and non-metallic substances. These methods were being widely applied under favourable conditions, with very great profit. Dr. W. H. Collins and Dr. J. B. Mawdsley outlined the work and plans of the Dominion Department of Mines in applying these methods to Canadian conditions.

The committee gave consideration to the need in Canada of high-voltage laboratories. It was felt that in view of the ever-increasing voltages used in long-distance electrical transmission, and the extremely rapid development of the hydro-electric industry in Canada, such a laboratory should be provided at an early date.

Ultra-violet light was the subject of a discussion introduced by Dr. R. C. Dearle. Several members of the committee described their own experiments in the measurement of ultra-violet light under widely varying conditions. The question of the use of ultra-violet light in medicine was believed to deserve much further research, since the technique was still unsatisfactory and the dosage had not been properly standardized.

In view of the large number of subjects which merited consideration by the committee, and the desirability of making recommendations regarding them to the National Research Council, it was felt that in future it would be better if the meetings of the committee could be extended to two days.

Associate Committee of Chemists

The annual meeting of the committee was held in Ottawa on Sept. 14, 1928, under the chairmanship of Dr. R. F. Ruttan. As in previous years, the committee heard progress reports of the National Research Council and discussed a number of problems on which research appeared to be required.

Dr. Tory outlined to the committee the plans for the National Research Laboratories, with a central research library, which the Government had decided to erect on the Edwards property at the mouth of the Rideau River. Before making a final decision as to the general plan of the laboratory buildings he had visited the great research laboratories of Great Britain, France, Germany and the United States, in order that advantage might be taken of the progress in laboratory design which had been made in those countries. He also outlined the type of organization which the Council intended to create to carry on scientific and industrial research in the laboratories.

Prof. J. B. Ferguson opened a discussion on the question of the relation of the industries of Canada to the National Research Laboratories. He considered it highly desirable that the industries should state the type of research which they would like to see carried out by the Council. Dr. Tory explained the methods by which it was hoped that assistance of real value could be rendered to Canadian industries.

The question of the future production of metallic zinc in Canada in relation to world markets was dealt with by Dr. J. W. Shipley, who felt that researches should be undertaken to find new uses for the metal and its compounds. He suggested that certain industrial chemical processes might under suitable conditions utilize it on a large scale.

The Agricultural Pests Control Act of 1927 was outlined by Mr. T. H. Wardleworth, who expressed the opinion that the administration of the act would involve difficulties; the committee and other chemists in Canada should be fully informed as to its provisions.

Mr. J. H. Hubel, representing Dr. D. A. Pritchard, read a paper on the utilization of off-peak power, in which he pointed out how such power could often

be used to advantage in electrochemical and electrothermal industries. The use of cheap electricity in generating steam pending a demand for power was discussed at length.

By-product ethylene and hydrogen from coke-oven gases, and the cost of hydrogen from various sources, were the subjects of a paper by Dr. L. F. Goodwin. Hydrogen was of particular importance in the synthesis of ammonia, and the establishment of large coking plants in Canada indicated a possible low-cost source of this gas.

Dr. T. Thorvaldson outlined his researches on the action of alkali salts on concrete. The problem was not fully solved, although great advances had been made. (A more complete account of Dr. T. Thorvaldson's work will be found elsewhere in this report.)

The work of the staff of the National Research Council on magnesite (described more fully under the activities of the Magnesite Committee) was dealt with by Mr. F. E. Lathe.

Dr. A. R. M. MacLean, introduced the subject of the utilization of skim milk, a large amount of which is being lost annually in Canada. Lactose and casein were already being produced in quantity from this raw material, but to only a small fraction of the total possible. Better methods for the evaporation of milk were needed, as also new uses for lactose and casein.

The retiring members of the committee were Dr. J. S. Bates, Mr. H. G. Girvin, Dr. L. F. Goodwin, Dr. A. R. M. MacLean, Dr. F. W. Skirrow and Mr. J. A. Wales. The National Research Council at its subsequent meeting appointed to replace them Prof. J. W. Bain, Dr. R. T. Elworthy, Mr. J. F. Slee, Mr. G. H. Tomlinson and Prof. Alex. Vachon.

Associate Committee on Mining and Metallurgy

The Associate Committee on Mining and Metallurgy held its eleventh annual meeting in Winnipeg on March 8, 1929, coincident with the annual meeting of the Canadian Institute of Mining and Metallurgy.

One of the questions discussed by the committee was the flotation of copper-zinc ores. During the course of the discussion of this question it was pointed out that the Mines Branch of the Federal Department of Mines is now engaged in investigation on this subject, and after full consideration it was agreed that the committee would not, therefore, be justified in recommending further investigation by the National Research Council.

The committee also had under consideration the question of the disposal of zinc concentrates, and after full discussion it was the consensus of opinion that the disposal of these concentrates would probably be facilitated by the construction of new treatment plants in eastern Canada.

The committee also gave consideration to the question of the beneficiation of iron ores, which subject has been closely followed for several years past by the Sub-committee on Iron Ore. After a full discussion it was agreed that the report of the sub-committee fully covers the present situation in Canada with respect to this question.

Another important problem which was under consideration by the committee was the discovery of a method by which elemental sulphur could be obtained by the combustion of pyrite. When all aspects of this problem had been reviewed it was the consensus of opinion that the committee should recommend that the National Research Council consider the possibility of giving assistance to a research looking to the solution of this problem.

The chairman of the Sub-committee on Iron Ore reported that considerable work on iron ores had been carried on since the last report of the sub-committee. Practically all of this work has been accomplished outside of

Canada under both private and governmental direction, but it has not as yet proved commercially successful.

In Canada there has been installed in the plant of the Steel Company of Canada, Limited, and operated for the past year, one of the latest types of sintering equipment. This equipment has been installed to convert the flue dust produced in blast furnace operation into sinter, in which form it is returnable in the furnace charge so that the iron value of the dust may be reclaimed. This piece of equipment is probably a direct step towards the use of Canadian iron ores.

Considerable information is being accumulated in connection with the operation of the blast furnace by United States Government departments. It has been realized that the reactions and conditions in the different zones of the blast furnace require investigation. The furnace stock columns are approximately 5 feet in height, and the size of the individual pieces of ore, coke and stone has a bearing on the evenness of operation as well as on the uniformity of the product produced.

Mr. Morrow called attention to the fact that this is a not unimportant factor in considering the Canadian iron ore situation, and that consequently the sub-committee was keeping in touch with it.

With reference to the question of sponge iron, the operations at Kuji, Japan, using an installation by Thornhill and Anderson, are carried out in a plant designed to make approximately 100 tons of sponge iron per day, using beach sand having an iron content in the form of magnetite and limonite of about 25 per cent recoverable iron. The resultant sponge was comparatively low in metallic iron content when compared with that which could be produced from comparable American ores. Regardless of this, the originators briquetted their iron shipping it from Kuji to Kobe, where it was used in conjunction with iron from Tata to produce steel.

The Sub-committee on Iron Ore is of the opinion that this equipment has fulfilled its original purpose and demonstrated its ability. The designer and builders have since turned this plant over to the Japanese owners who are now operating it. The sub-committee has compiled estimates covering the cost of equipment and installation of a sponge iron unit for a Canadian iron mine, which estimate was made but recently. In view of the experience and data accumulated in beneficiation work at the Mesaba Company's operations in Minnesota, the sub-committee has been able to consider this proposition with a competent, practical background.

The sub-committee also reported regarding a large-scale experiment in the reduction of iron ore to sponge iron, which is being carried on at the Lorraine Works of the United States Steel Corporation, and for which approximately $1,000,000. has been allocated.

The sub-committee reported that it had considered the possibility of opening one of the old iron ore works in Ontario, to use its ore in conjunction with the sintering equipment installed in the plant of the Steel Company of Canada, Limited, at Hamilton, for sintering flue dust, as a beginning for the use of Canadian iron ores. With this object in view a preliminary survey was made by an engineer, but the cost of crushing and handling with the limited equipment on hand was too great to be undertaken as an experiment at the time. The sub-committee, however, has not dropped the idea, but is awaiting an opportune time to further consider the matter.

With respect to the iron ore situation, the committee reported that the economic aspect, as far as the Canadian iron ores were concerned, had not changed during the past year and that in the opinion of the committee, large investments for the opening up of iron ores in Canada would not be warranted till the price of ore had considerably increased. The Sub-committee on Iron Ore is con-

sequently keeping in touch with processes and conditions so that it may be prepared to make recommendations at the proper time.

Associate Committee on Nitrogen Fixation

The committee has throughout the year continued the collection of information on nitrogen fixation and related subjects. This work of the committee appears to be more than justified by the interest which Canadian companies take in the reports prepared—an interest which indicates that an expansion of the Canadian nitrogen-fixation and fertilizer industries is not far distant.

While in connection with nitrogen fixation there has been no spectacular development of any new method to record, such as was the case when synthetic ammonia began its phenomenal progress a few years ago, there has been advancement practically all along the line. The only exception to this is in the case of the arc process of nitrogen fixation, which is now definitely losing ground.

An outstanding feature of the past year has been the recovery of the Chilean nitrate industry, which underwent a period of severe depression owing to the competition of synthetic sulphate of ammonia. The Chilean nitrate producers are now reaping the benefit of the adoption of more scientific methods of extraction, and the Chilean government has given assistance in the form of reduced taxation. This has brought about a reduction in the price of the product which has resulted in greatly increased sales.

Cyanamide also seems to be holding its own better than was anticipated. The amount of power required by the process has been reduced during the last two years by about 40 per cent, and, presumably as a result, the American Cyanamide Co. at Niagara Falls, Ont., has doubled the capacity of its plant.

In England the chief producer of ammonium sulphate maintains demonstration farms, with expert advisers in various districts, has established competitions and scholarships, and has issued much valuable literature. Research work is being carried on in England, Germany and many other countries in order to ascertain the best forms of fertilizers required for specific crops and certain climatic and soil conditions. In Canada fertilizer is being distributed free by prospective producers to demonstration farms on the prairie, in order to determine whether the widespread use of commercial fertilizers would be justified by the increased returns.

In Norway about 140,000 kilowatts of the power formerly used in the arc process of nitrogen fixation is now being applied to the synthetic ammonia process, chiefly in the production of electrolytic hydrogen. The efficiency in the use of power is thus enormously increased.

An outstanding event of the year 1928 was the holding of the second International Nitrogen Conference in Europe, at which a large number of technical papers were presented. It is proposed to hold such a conference every second year.

Associate Committee on Patents and Awards

The National Research Council has from its inception been interested in the question of patents, since many of the discoveries made under the auspices of the Council will doubtless be patentable, and may in time bring in a considerable sum which can be used in the prosecution of further researches. A number of patents have already been granted to men working on the assisted researches plan, but in these the Council has of course had only a limited right.

With regard to discoveries, inventions and improvements made in the Council's own laboratories, however, the situation is different, since by the Research Council Act the control in such cases is vested in the Council itself. The rights of the discoverer or inventor are recognized by a provision that the

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Council may, with the approval of the Governor in Council, pay to its technical officers and others working under the auspices such bonuses or royalties as may be warranted.

Since this question of patents was arising frequently at meetings of the Council a special committee was appointed to consider what action, if any, should be taken. This committee met late in 1928 and recommended to the Council the appointment of a permanent Associate Committee on Patents and Awards. This recommendation was adopted, and the committee met in February, and again in March, 1929, to consider a large number of problems which had arisen.

The committee made a study of the conditions and practices prevailing in most of the important countries in the world. It at once became evident that the problem of patents on discoveries and inventions made in government laboratories was everywhere recognized as a difficult one. Apparently no single country has yet solved the problem to the satisfaction of all concerned; in several countries the practice of different government departments varies widely.

In view of the many difficulties likely to arise in dealing with this question the committee decided to take no final action in establishing a policy with regard to patents until it had been possible to give the matter the most careful consideration. Many important questions, however, have already received attention by the committee.

Associate Committee on Engineering Standards

The advantages of simplified practice through the standardization of commercial commodities have, during recent years, become a matter of common knowledge throughout the world to all persons having to do with commercial development. In Canada the activity of the Canadian Engineering Standards Association in this field is well known in industrial centres.

The main committee of the Canadian Engineering Standards Association operates as an Associate Committee of the National Research Council, and is composed of fifty-two members representing the technical associations, universities, industrial organizations, government departments, railways and large industrial firms. The work of the Association is financed jointly by the industries and by the National Research Council.

At the close of the year under review, the Canadian Engineering Standards Association had a total membership of five hundred and four persons including members of the main committee, seven sectional committees covering the different branches of engineering, and seventy-one working committees and panels dealing with particular projects.

There are seven sectional committees, each dealing with a particular branch of engineering, and under these committees working committees are organized which carry out the necessary technical work in the preparation of a standard. These working committees are composed of representatives of interests concerned in any particular project. All members of committees give their services gratuitously.

The following brief summary will afford an indication of the nature and importance of the activities carried on by the Canadian Engineering Standards Association.

Civil Engineering and Construction

Steel Structures for Buildings.—Final consideration is now being given this specification which it is expected to issue early in 1929. This specification will recommend the raising of unit working stresses from 16,000 to 18,000 pounds per square inch.

Concrete and Reinforced Concrete.—This specification is expected to issue shortly. It will cover general conditions in connection with concrete and reinforced concrete, as well as design formulae, and will include appendices covering materials used in concrete work and also structural and reinforcing steel.

Road Materials and Construction.—It has been decided to let these specifications rest for the time being as recent developments in road construction have made it extremely difficult to agree on specifications which will meet the different conditions in the various provinces.

Brick Sizes.—It has been found impossible to secure universal adoption of standard sizes which upon agreement were officially adopted by the manufacturers in the provinces of Ontario and Quebec. Postponement of further action of this project has been decided upon until a better agreement can be reached.

Reinforcing Materials for Concrete.—It has been found desirable to bring this specification up to date and the committee is now considering suggested revisions.

Mechanical Work

Cast Iron Pipe.—Rapid developments in the manufacture of cast iron pipe, particularly the centrifugal method, have made it advisable to act slowly on this project.

Machine Screws.—Data sheets have been prepared covering twenty-one machine screws to meet all reasonable design conditions. The market list covered forty-three machine screws so that the list prepared by the committee will be a material simplification.

Sheet Metal Gauges.—A petition which was circulated and endorsed by sheet metal interests throughout Canada, was presented by a committee of the sheet metal interests themselves to the government and was sympathetically received. If possible, arrangements will be made to get official recognition for one Canadian gauge.

Fire Hose Connections.—Standardization of fire hose connections was discussed at a conference in May 1928 under the auspices of the Canadian Engineering Standards Association. Information is being gathered throughout Canada on dimensions of fire hose connections and this will be presented to the committee authorized at the above conference.

Electrical Work

Distribution Type Transformers.—A revised edition of this specification is now before the sectional committee on electrical work and when approved will be forwarded to the main committee for adoption and authority to publish.

Power Transformers.—A revised edition of this specification has been prepared by a panel of the committee and is now before the members of the committee for their comment.

Oil for Transformers and Oil Switches.—A committee is now being organized to consider specification covering this material.

Automotive Work

Traffic Signals for Highways.—Specification on this project is still in abeyance and the question of agreement on warning signs on highways is before the Canadian Good Roads Association, as there is a difference of opinion between eastern and western provinces.

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Ferrous Metallurgy

Steel Castings.—Specification for steel castings is now being considered by the main committee and will shortly be published. This specification covers carbon steel castings for general purposes and for ships, and includes a special section dealing with castings subject to heavy duty and rotors and housings, etc. It is hoped that the educational features of this specification will be valuable to those concerned.

Carbon Steel Billets and Bars of Forging Quality.—This specification is now before the main committee and it is hoped to publish it shortly.

Publications

Four new publications were issued during the year, as follows: Standard Specification for Steel Railway Bridges; Standard Specification for Steel Highway Bridges; Standard Specification for Sampling for Check Analysis of Steel Billets, Bars and Shapes and the following specifications have been issued in one volume, Standard Specification for Commercial Quality Hot-rolled Bar Steels, and Standard Specification for Commercial Cold-finished Bar Steels and Cold-finished Shafting. The year-book for 1928 will be issued shortly. The Canadian Engineering Standards Association Bulletin has been published for two years and has been very helpful in promoting the work of the Association.

III. ANALYSIS OF REPORTS ON ASSISTED RESEARCHES

A complete list of the research grants made by the National Research Council will be found beginning on page 12 of this report. Those of the grants which have been made to associate committees are dealt with under that heading (see page 17); those made to individuals, whether in the universities or government laboratories, are outlined below.

Each recipient of an assisted research grant is required to submit annually a report of the progress of the work being carried out under his direction, and such reports are placed in the files of the National Research Council. In addition, a large number of papers giving the results of the researches have been published in scientific journals, (see Appendix "B", page 89). Such reports, which are frequently of considerable length, obviously cannot be reproduced in full here, but, in order to convey some idea of the extent and character of the work being done under this plan, there have been prepared summaries of the more important researches. In drawing up these summaries an attempt has been made to indicate the scope and object of each investigation and its economic significance. There is also included a short statement of the results obtained.

Factors Governing the Milling and Baking Quality of Wheat

Co-operating organization:

University of Alberta.

The study of wheat quality in relation to environmental factors such as soil, climate, crop rotation and the inherent qualities of the variety grown, is of fundamental importance to the country.

In this investigation six standard varieties of wheat were grown in each of seven different localities, representing different soil and climatic conditions, for the three seasons, 1924-26.

The diastatic activity of the flour, a factor which greatly affects loaf volume, was found to vary both with variety and conditions of growth. The ash content was not found to be characteristically different for any variety or place. The content of glutenin, which is generally regarded as the more important of the gluten proteins, did vary to some extent; Renfrew, Marquis and Ruby were higher than Red Fife, Huron and Kubanka. Both quality and quantity of protein and baking value vary with variety, locality and season, but environment has a relatively greater influence than variety. In general, the finest wheat results from a favourable combination of both variety and conditions.

Confirmation of a previous finding, that alfalfa in a rotation will do much to offset the tendency of irrigated wheat to be low in protein content and baking quality, was obtained. "Alkali" soil tends to produce high-protein wheat, though the yield may be reduced. Fall irrigation seems an especially good practice, since in these experiments it increased the yield without injuring the quality.

The application of the "bound-water" method to the study of the capacity of gluten for absorbing water, showed that when flour is mixed with water the gluten takes up an amount of water about equal to its own weight, while the starch takes up about 30 per cent of its weight. When the natural salts are washed out of the flour, the gluten then takes up about double its own weight of water. Contrary to popular belief, however, there is no important difference in the amount of water taken up by the glutens of good and poor flours, with the exception of very weak flour. The nature of gluten quality must therefore be sought in other directions.

A method has been developed which resolves the diastatic activity of flour into its two major components, the concentration of the diastase and the resistance of the starch to the action of this enzyme.

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Tests made of miscellaneous wheat samples from various sources showed: (1) The protein content of different varieties varies widely. (2) Hard Federation is inferior to Marquis in baking quality. (3) Vermilion is very inferior to Marquis, Renfrew and Red Bobs. To secure strictly comparable results, however, it is very necessary to use a field plot technique which corrects errors due to soil variations.

Crop sequence studies at Edmonton showed, in general, that the best quality was obtained after fallow with the various crops coming roughly in the following order: alfalfa and sweet clover, corn, flax, red clover, cereals, grasses. Both quality and yield after brome grass were better if the sod was plowed early in the season than when it was plowed later.

The application of superphosphate to irrigated plots at Brooks, Alberta, caused a pronounced improvement in the visual appearance and grade of wheat, but had no effect on the protein content.

(Investigation under the direction of Dr. R. Newton, University of Alberta.)

Maple Products

Co-operating organization:

Macdonald College.

Maple products are produced on a considerable scale in the eastern provinces of Canada, and a large export business has been built up. In the interest of producing a standard maple product, uniform in quality, from widely varying syrups, an investigation of the maple-products industry has been started.

Several phases of the problem have been investigated during the past year. Tests were made to decolourize syrups by means of charcoal. Charcoals were found which secured adequate decolourizing but unfortunately the flavour was removed at the same time.

Work was done on identification of maple flavour. The maple flavour is produced in sap boiled in the usual way under atmospheric pressure. Syrups concentrated by freezing or vacuum methods from the same sap had not the characteristic maple flavour, but the flavour could be produced in these syrups by reboiling them under a reflux condenser for one hour. Extraction of the flavour was made by chloroform and analysis made of the material. Tests showed the extracted material to be largely vanillin or a vanillin-like substance.

A method for producing non-mottling maple sugar was devised which consists essentially in principle in destroying the capillary structure, so that the sugar cake has a uniform velvet appearance. The procedure consists in removing as much water from the boiling syrup as possible, then cooling the syrup to 15-20°C., with constant but easy stirring, and moulding the sugar in a cold metallic form, applying a little pressure.

To produce a desirable non-hardening maple sugar, two to three per cent of glycerol by weight is added during concentration, or it may be produced by boiling the syrup up to 110°C. and then rapidly cooling with energetic stirring of the cooling syrup. The fine soft sugar produced can be formed into cakes by moulding it in cold metallic forms. This sugar, due to the fineness of the crystals, remains soft when dried.

(Investigation under the direction of Dr. J. F. Snell, Macdonald College.)

The Nature of Winter Hardiness in Crop Plants

Co-operating organization:

University of Alberta.

It has been established that winter hardiness in a wheat plant depends upon the sugar content of the plant, and that this sugar prevents precipitation of the

proteins of the plant by freezing. Since the sugars are used up in respiration, it is important to know the rate at which this process proceeds.

Respiration rates were measured on four varietes of winter wheat and two varieties of spring wheat at −7°C., 0°C., and +7°C. These varieties were all sown in August. After the advent of weather cold enough to "harden" the plants, the rate of respiration in winter wheats decreased as the season progressed. This is taken to be an expression of increasing dormancy, an adaptation for winter resistance.

At −7°C. the rate of respiration of the winter varieties was inversely proportional to winter hardiness; at 0°C. the same tendency could be observed, though in a much less marked degree; at +7°C. this correlation practically disappeared. The spring wheats, during the preiod in which it was possible to work with them, showed at 0°C. and at +7°C. no characteristic differences from the winter wheats, but at −7°C. showed a tendency to respire more rapidly than the winter wheats. This confirms and extends the conclusion that at −7°C. the rate of respiration in wheat plants is inversely proportional to winter resistance.

The significance of this conclusion lies in the fact that in a severe climate winter plants are for long periods covered with snow at temperatures below the freezing point. Under these conditions the hardier varieties of wheat would appear to conserve more effectively their sugar reserves, which are an important protection against frost-denaturation of the cell proteins. Furthermore, the slower respiration at freezing temperatures is an expression of the ability of the plants to pass more rapidly and completely into a dormant condition, in which sensitivity to frost injury is reduced. This latter change is probably connected with the colloidal condition of the cell contents.

If the tentative conclusions reached in this investigation are fully confirmed it will be possible to predict from experimental work the hardiness of a plant under natural winter conditions. This will be of particular importance in the testing of new varieties.

(*Investigation under the direction of Dr. R. Newton, University of Alberta.*)

Bacillary White Diarrhœa in Poultry

Co-operating organization:

University of British Columbia.

Bacillary white diarrhœa is an acute infectious disease of young chicks which is particularly prevalent in British Columbia, where it causes severe losses. As a rule, it affects chicks a few days after hatching. In adult birds the disease is usually chronic but occasionally it may be acute. Greater attention has been drawn to the disease because of the losses to chicks, but there are losses of adults. Further, this investigation has shown that hens suffering from the disease produce less eggs than healthy hens, and that the infected eggs produced possess low fertility and hatchability.

Baby chicks become infected with bacillary white diarrhœa by contact with infected birds or pens, and by being hatched from the eggs of infected adult birds. Mortality of chicks is often very high where the infection has not been controlled and may exceed 80 per cent of the chicks. Methods of control and eradication of the disease have been based upon tests of birds by either the agglutination or the wattle test. Those birds reacting to the tests are removed and thus the infection of healthy birds is prevented.

The agglutination or blood test depends upon the agglutination of a suspension of the bacterial organism by the blood serum of an infected fowl. The serum of healthy birds will not agglutinate the antigen of the *Salmonella pul-*

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lorum organism which causes the disease. Considerable divergence of results of tests reported in the literature had cast doubt upon the efficiency of the test, and accordingly an exhaustive experimental study was made of the factors which could influence the test. It was found that reliable results were secured by a dilution of 1 to 50, followed by incubation for 24 hours at 37°C. and a further 24 hours at room temperature. One ml. of a one per cent solution of sodium hydroxide was added to 100 ml. of the antigen to prevent cloudy or non-specific reactions. The blood serum of a reacting fowl will completely or partially agglutinate *Salmonella pullorum* antigen (0.5 turbidity on the McFarland nephelometer) under these conditions. The antigen used in arriving at a standardized procedure contained four strains of the bacillus.

Tests carried out on thousands of birds in various ways, and repeated in many cases, demonstrated that bacillary white diarrhœa infection may be detected by means of the agglutination test; that the test is highly effective in detecting adult "carriers" and that the accuracy of the test, if properly conducted, cannot be doubted.

(*Investigation under the direction of Professors H. W. Hill and E. A. Lloyd, University of British Columbia.*)

Prairie Mammals

Co-operating organization:

University of Manitoba.

The destruction of crops and grain by rodents of the prairies is considerable, and therefore fuller knowledge of the habits of these mammals is desirable in order to devise methods of controlling their numbers.

During the year under review, the pocket gopher has been studied in its habitat. It has been found that this rodent increases in numbers after settlement of a new country because its natural enemies such as weasels, badgers and owls are largely exterminated.

Field mice are pests of grain, fodder and of fruit trees. It was found that the red-backed mouse is responsible for the girdling of fruit trees, and not the meadow mouse, as has previously been held.

The rodents studied comprise the pocket gopher, the red-backed mouse, Drummond's meadow mouse and the white-footed deer mouse.

(*Investigation under the direction of Mr. Ferris Neave, University of Manitoba.*)

Glucosides of Plants of Western Canada

Co-operating organization:

University of Manitoba.

The aim of this investigation is to isolate extracts from a certain series of plants which grow in western Canada and to search for and identify any glucosides that may be present. It is expected that cultivation of any plant which contains a glucoside of therapeutic value will follow.

A number of glucosidic extracts have been submitted to systematic chemical treatment, and the concentrated products have been tested pharmacologically. The extracts of *Caltha palustris* (marsh marigold), *Cypripedium parviflorum* (downy lady's slipper), *Rhus glabra* (smooth sumac) and *Aralia nudicaulis* (wild sarsaparilla) contain a principle or principles causing vaso-constriction and heart-block in the frog, and fall in blood-pressure and diuresis in mammals. The extracts of *Caltha palustris* were found to be very toxic to mammals, pro-

ducing death from heart-failure. Certain other plant extracts have given less marked results.

(*Investigation under the direction of Dr. A. T. Cameron, University of Manitoba.*)

The Nature of Chromosomes

Co-operating organization:

Queen's University.

This investigation in the genetics and cytology of the genus *Nigella* involves chromosome number and shape, crosses between varieties and species to determine the mode of inheritance of certain characters, the study of chromosome behaviour in aberrant forms, and the effects of X-rays. The chromosome number in four species was obtained and drawings and microphotographs made.

The second generation of several crosses was grown in the garden and good Mendelian ratios obtained. Three aberrant forms were studied and several hundred microscope preparations made. The effects of X-rays were investigated in *Nigella damascena* but the progeny were normal and so far no hereditary results have been obtained in this way.

Some species of *Nigella* are readily crossed and give good Mendelian ratios for contrasting characters. Others will not cross. The chromosome size and shape of species that will cross are apparently identical, while in those that will not cross, they are quite different. This indicates a more distant relationship in the latter case.

(*Investigation under the direction of Dr. R. O. Earl, Queen's University.*)

Sex in the Higher Fungi

Co-operating organization:

University of Manitoba.

Two of the fungi investigated in detail, namely *Omphalia flavida*, the cause of coffee-spot disease, and *Tilletia tritici*, the cause of stinking smut disease of wheat, are of considerable economic importance. New facts discovered help to elucidate their life histories.

The discovery that *Omphalia flavida* is luminous has been made use of in Porto Rico to diagnose the coffee-spot disease in the dark. It has been found that, on a dark night, the disease spots on the leaves can be perceived at a distance of from two to ten feet.

The further discovery that the true basidiospores of the stinking smut fungus are violently discharged has led to experiments on the infection of wheat plants with the parasite. It has thus been proved that the true basidiospores can initiate the production of the stinking smut disease in healthy wheat plants, a fact never before clearly proved.

(*Investigation under the direction of Dr. A. H. R. Buller, University of Manitoba.*)

The Allogenous Flora of Anticosti Island

Co-operating organization:

University of Montreal.

The fundamental flora of Anticosti is made up of the subarctic spruce forest, with extensive peat bogs and numerous lakes. Mixed with this fundamental flora are a number of unexpected elements of different taxonomic affinity

and presumably of different origin, which are considered under the general term "allogenous flora".

The allogenous elements have been classified as: (a) Arctic-Alpine elements, (b) Eurasian elements, often Alpine but not Arctic, (c) western species, or endemic species of Cordilleran affinity, (d) endemic species of Laurentian or Alleghenian affinity, (e) endemics of varied affinity and origin.

The bulk of the endemics and of the relic species is localized on the river gravels, river banks, or gravelly terraces on the southern coast between the rivers La Loutre and McKane. A much smaller number of relic species are sylvatic types and are more generally distributed in the essentially uniform spruce forest.

The information at hand lends support to the assumption that during Tertiary or Pleistocene time, migrations of flora occurred to Anticosti from the Arctic, northern Europe and Newfoundland, and from the Cordilleran area. It may be further assumed that these flora survived the subsequent changes and conditions and constitute relic flora or allogenous flora.

(Investigation under the direction of Prof. Marie-Victorin, University of Montreal.)

Research on Bios

Co-operating organization:

University of Toronto.

The first member of the group now known as vitamines was discovered by Wildiers of Louvain in 1901, and was called "bios" by him. Because of the great physiological importance of Wildiers' bios, a large amount of study has been given to it. Since bios is necessary to reproduction of yeast of certain types, most investigators have used yeast itself as a source of bios. In the present investigation, vegetable and animal tissues have been employed and among them the so-called "malt combings" or malt-house waste has been found the most satisfactory.

It has been shown that the "bios" of malt can be separated chemically into two constituents, both of which must be present together in the culture medium if the results described by Wildiers are to be obtained. Isolation of one of these constituents has been accomplished and has been identified as inactive inosite. The other constituent forms the subject of this research.

It has been discovered that the unkown constituent can be acetylated without destroying its physiological properties, and that the product of acetylation is difficultly volatile. Previous workers have assumed that because the product of acetylation was wholly without influence on the reproduction of yeast, that the unknown constituent of "bios" was destroyed. It was discovered that alkalies, particularly lime, reactivated the acetylation product so that it caused reproduction of yeast cells. Work is under way to isolate the volatile derivative in sufficient quantity that a thorough study of its chemical relationships can be made.

(Investigation under the direction of Dr. W. Lash Miller, University of Toronto.)

The Value of Sunlight and of Foods Containing Antirachitic Vitamines in the Normal Growth of Chicks

Co-operating organization:

Dominion Department of Agriculture.

The primary object of the investigation was to determine the effect of sunlight, artificial ultra-violet light and foods containing vitamin D in the

prevention and cure of rickets in chickens. It was further extended to ascertain the relation of bone composition to leg weakness. Eight pens were used to study the effect on the chicks of direct sunlight, ultra-violet light, sunlight filtered through cel-o-glass as also through vita glass and common glass, of a mash irradiated with ultra-violet light, a mash to which cod-liver oil had been added, and finally a basal ration with no sunlight at all. Both Barred Rocks and Leghorns were used in the tests.

The best development was shown by the birds exposed to direct sunlight. Those exposed to ultra-violet radiation were in almost as good condition. The glass-substitute pens and those fed on cod-liver oil and irradiated mash (equal) followed closely in the order named. Mortality was quite significant in the pen kept under common glass and in that deprived of sunlight.

Following the treatment, radiographs of one tibia and one femur from each bird were taken; the degree of calcification reached under the different treatments was clearly evident. The bones of chicks shielded from sunlight were very poorly formed. Bone formation of the chicks under common glass was not quite so bad; it was better for those fed on a cod-liver oil mash, and on irradiated mash; it was the best in those chicks exposed to sunlight.

The analyses of the bones for moisture, fat, nitrogen, calcium, phosphorus, magnesium and iron content revealed interesting facts. The weight of dry bone was least for those chicks with no sunlight, irradiated mash and sunlight filtered through common glass—the only exception being the Leghorns fed on irradiated mash. It is noteworthy that the ratio of phosphoric acid to lime is not so much affected by the treatment as is the fat content. With direct sunlight, sunlight filtered through common glass and no sunlight these ratios are respectively 0.798, 0.831, 0.802, and the fat contents are, in the same order, 15.88, 5.57 and 4.36 per cent. A difference in fat content between breeds for different treatments is left without explanation. The inference is that, low fat content being associated with imperfect bone formation, cod-liver oil did not have an effect upon Leghorns as beneficial as upon chicks of the other breed. Irradiated mash seems to have the reverse effect. Apart from the apparent breed differences, it seems that low fat content in bone is closely associated with poor bone development and weakness. Contrary to the accepted view it appears that lime content is not the primary factor in bone strength and probably does not possess all the significance which has been attributed to it.

(Investigation under the direction of Mr. F. C. Elford, Dominion Poultry Husbandman.)

Effect of Solar Ultra-violet Light Upon Some Aquatic Organisms

Co-operating organization:

Queen's University.

Previous studies have shown that three species of salt-water organisms remain at a considerable depth in the sea when the illumination is at all intense, and come to the surface only on the darkest nights. Exposure to sunlight for 36 hours, 16½ hours and 16 hours, respectively, is sufficient to kill these small animals.

The much higher resistance to ultra-violet radiation of fresh-water species is shown by the fact that the average time of exposure for *Daphnia pulex* was 104 hours, for *Daphnia magna* 61 hours and for *Cypris reticulata* 192 hours before they were killed by direct sunlight. This shows that while these latter species are resistant to a moderate amount of ultra-violet they can be killed by an overdose.

The eggs of the squid, *Loligo pealii*, are enclosed in a copious gelatinous matrix and are attached in bunches to the larger marine algae, in the inter-

tidal zone. They are consequently at times exposed to the ultra-violet radiation from the sun and it was not to be expected that they would be particularly sensitive to short wave-length radiation. The supposition was borne out by the experiments, but it was found that the eggs were killed by long exposure to ultra-violet.

(Investigation under the direction of Prof. A. B. Klugh, Queen's University.)

Specific Effect of Monochromatic Light on the Growth of Paramoecium

Co-operating organization:

University of British Columbia.

During recent years the effect of ultra-violet radiations has come to be generally appreciated, and use has been made of ultra-violet light in treating certain diseases. More recently it has been recognized that in the radiations being used, there may be present certain wave-lengths which while bactericidal are also definitely harmful to body cells. The specific effects produced therapeutically by artificial sources of ultra-violet radiation are probably due to the major effects of a very narrow range of wave-lengths, but this has not been investigated.

The present study is concerned with the effect of certain wave-lengths upon a common minute organism, paramoecium. The work reported last year was on the effect of certain wave-lengths upon a strain of yeast cells.

Monochromatic light was obtained by resolving the light from a Cooper-Hewitt lamp through a Hilger monochromatic illuminator. Exposures were from four to 24 hours in length, and since a very narrow range of wave-lengths was used at any one time, the intensity was low. As in the case of yeast, the paramoecium responded differently to radiations of different wave-lengths, as follows:

Growth is continuously and constantly stimulated by ray 6152Å—two lines in the red region.

Growth is retarded for six hours, then stimulated by rays 5819-5769Å—two lines in the yellow region.

Growth is retarded by ray 4960-4916Å—one line in the green region.

Growth is stimulated consistently by ray 4359-4348Å—one line in the visible violet region.

Growth is stimulated for six hours, then is markedly retarded by ray 4078-3904Å—two lines at the boundary of the visible spectrum.

Erratic results were noted by exposure to ray 3821Å—. This may be due to the presence of two lines, one of which retards while the other stimulates growth.

Growth was stimulated by ray 3352-3342Å for a short period, but this did not continue.

Growth was stimulated by ray 3132-3216Å after an initial six-hour exposure.

Growth was initially retarded by ray 3028-3022Å.

All rays of shorter wave-length than 2967Å were found to retard growth quite markedly.

These results parallel those for yeast and suggest that within limits the response to radiation of animal and plant protoplasm is similar.

More evidence is necessary before a definite principle for the nature of the specificity of radiation is demonstrated. It is evident that intensity of radiation is not of primary importance, if indeed it has any relation to the degree

of the effect of one ray as compared with another, and moreover, intensity does not determine whether the effect shall be positive or negative.

(*Investigation under the direction of Dr. A. H. Hutchinson, University of British Columbia.*)

An Ultra-violet Photometer for Field Use

Co-operating organization:

Queen's University.

Only a few years have elapsed since the importance of the effect of ultra-violet light upon living organisms was first recognized. The results of biological experimentation and therapeutic practice, however, now leave no doubt as to the potency of its radiation with regard to life processes. In view of this fact it becomes desirable to have some simple and accurate instrument for measuring such radiation. Such an instrument should, if possible, be readily portable and capable of use in any situation—on land or under water.

The instrument devised for this purpose consists of a brass box six inches square, with a water-tight lid on the bottom and sliding shutters on the top. Beneath the shutters is a polished chalcedony disc 5 mm. thick, which transmits but also diffuses ultra-violet radiation, an ultra-violet filter and a diaphragm holder in which diaphragms of various sizes can be placed. At the bottom of the instrument, just inside the lid, is a duralumin plate-holder, and in front of this is a movable strip of copper foil, only one one-thousandth of an inch thick, with a narrow slit cut into it. This strip can be moved back and forth across the plate, making possible a series of twelve exposures on a single small plate.

The filter used transmits not only the ultra-violet but also some of the violet and the extreme red. The latter is eliminated by the use of plates which are entirely insensitive to the red end of the spectrum. The instrument then measures the whole of the ultra-violet and a part of the violet in the sun's rays.

(*Investigation under the direction of Prof. A. B. Klugh, Queen's University.*)

Sensory Actions

Co-operating organization:

University of Manitoba.

It has been determined that glandular secretions are governed by exactly the same laws that had previously been found to control the other nervous responses. The same principles have also been extended to the psychological field by the discovery that the process of learning conforms to the same laws as to the responses of senses, muscles and glands. Thus all types of neural and mental activity are found to be based upon a single law of nervous action.

The principles discovered have numerous applications, one of which is the important subject of rest pauses for workers in industry, offices and schools.

An intensive study and testing of the Weber-Fechner law of nervous response to stimulation in the senses of vision, hearing and touch has shown this law to be of extreme accuracy in vision, but it does not apply to the other senses mentioned. The law that applies to hearing and touch has been discovered, but it is somewhat different from the Weber law. The difference arises from the fact that vision is probably an electrochemical sense, while touch and hearing are mechanical. By the same reasoning, the sense of taste which is chemical in its nature should be similar to vision in following the Weber law.

(*Investigation under the direction of Dr. Frank Allen, University of Manitoba.*)

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Method of Preparing Radium Emanation

Co-operating organizations:

Dalhousie University.
Victoria General Hospital, Halifax.

Radium was first used for therapeutic purposes in the form of a radium salt sealed permanently into small glass tubes. This method is gradually being abandoned in favour of the use of radium emanation obtained from solutions of radium salt, for the radium may then be kept in a safe place while the gaseous emanation is regularly pumped off, freed from impurities and sealed into glass tubes. Further advantages in using the emanation lie in the fact that it can be divided in any desired way and distributed where needed, and, because of its greater concentration, the use of smaller tubes is possible.

The emanation, accompanied by a very large proportion of gases, mainly hydrogen and oxygen, is pumped off regularly, a few cubic centimeters being obtained each time. The research problem was to find a simple method for removing the gases from the emanation which would not involve the complicated and difficult procedure and apparatus now employed. Such a method would facilitate the use of emanation in hospitals in smaller centres than is now possible.

In one of the methods worked out in this investigation, the oxygen is caused to burn with the hydrogen and the excess hydrogen is burned by copper oxide carried on a heated platinum spiral. Removal of water vapour was not found necessary. Carbon dioxide is removed by a ring of potassium hydroxide fused to the inside of the tube containing the copper-oxide spiral. After purification, the emanation is pushed up into a connecting capillary by mercury, and the tube is then sealed off.

Another method worked out consisted in burning the oxygen with hydrogen by an electric spark. The excess hydrogen was removed by passage through a heated palladium tube, after which the emanation was collected in a capillary as above.

(*Investigation under the direction of Professors G. H. Henderson and D. MacIntosh, Dalhousie University.*)

The Properties and Use of High-speed Electrons

Co-operating organizations:

University of Toronto.
The Carnegie Corporation.

Two investigations were carried out by the use of high-speed electrons transmissible through the "resistal" window of a Coolidge cathode-ray tube. In one, a study of the phosphorescence of solid nitrogen and of solid argon under bombardment of the cathode rays was made, while the other study was made on acetylene when subjected to such rays.

Phosphorescence of Solid Nitrogen and Solid Argon

The light emitted by solid nitrogen *in vacuo* when irradiated with high-speed cathode rays can be considered to be due to something having the nature of an active metallic centre in a diluting medium. The large frequency differences in two important series of bands in the spectrum of the light suggests that the active centre may be hydrogen. Experiments on the cathode-ray bombardment of solid argon were made to determine whether there was any relation observable between the luminescence spectrum of solid argon and of solid nitrogen, such as would be expected if hydrogen were the active centre. The general characteristics of the cathode-luminescence spectrum of solid argon were found to be very similar to those of solid nitrogen.

The Action of High-speed Cathode Rays on Acetylene

When acetylene is exposed to electric discharges, a solid is formed which is a polymer of acetylene. This study was made in order to find out the kinetics of the reaction in greater detail.

Under bombardment, no change in pressure on the acetylene occurred until the voltage across the tube exceeded 85 kilowatts when a slight mist formed throughout the reaction cell and a pale yellow opaque deposit formed on the walls. This solid had no measurable vapour pressure, and was not affected by further bombardment. Upon heating, it gave off hydrogen, turned black and burned with a luminous flame.

For any given voltage it was found that the rate of decrease of pressure of the acetylene was proportional to the pressure. The velocity constant of the reaction increased with increasing voltage.

The number of electrons passing through the window of the cathode-ray tube was determined by collecting them in a Faraday cylinder placed close to the window, and measuring the current with a microammeter. Calculation showed that the number of molecules of acetylene reacting is of the same order as the number of ions produced by each electron that passes through the window. The observed facts can be explained on the hypothesis that the reaction takes place following ionization of the acetylene by the cathode rays.

(*Investigation under the direction of Prof. J. C. McLennan, University of Toronto.*)

The Auroral Spectrum

Co-operating organizations:

University of Toronto.
The Carnegie Corporation.

The auroral green line at 5577.3 Ångstrom units was resolved into its Zeeman components with a magnetic field of strength of above 2500 gauss. The object in view was to find the energy levels in excited oxygen atoms between which the electronic transitions take place that give rise to the auroral green radiation. A normally spaced spectral triplet was found which permitted definite selection of the two well known low metastable levels of oxygen $^1S_0$ and $^1D_2$ as those involved in the production of the auroral green line.

The intensity of the auroral green line was studied and observed in Saskatchewan, near Toronto, and at Flagstaff, Arizona. While a number of points of minor interest emerged from the investigation, one result of primary importance that was obtained was that the intensity of the auroral green line radiation from the night sky on moonless nights gradually increased after sunset, reached a maximum shortly after midnight and then decreased again to sunrise. This variation of intensity has led to interesting speculations as to the origin of the green radiation of the night sky, but while it points to solar radiation as a contributing factor, definite conclusions have not yet been reached. This matter is being investigated further.

(*Investigation under the direction of Prof. J. C. McLennan, University of Toronto.*)

Spectra of Lead, Thallium and Bismuth

Co-operating organization:

University of Alberta.

The spectra of the elements thallium, lead and bismuth have been photographed and examined. Spectra were obtained by three methods with the spark between metallic electrodes, (a) *in vacuo*, (b) in air, (c) in hydrogen. On com-

paring the spectra obtained by these three methods, the lines could be assigned approximately to the various stages of ionization of the atom.

Some thirty lines in the spectrum of singly ionized thallium have been identified as due to changes between certain states of energy of the atom. In the case of doubly ionized lead some fifty lines have been identified. Measurements have been made from about 2000 Å. to 7000 Å. The spectra of the heavy elements thallium, lead and bismuth have been under investigation for the purpose of assigning the spectral lines arising from the various stages of ionization of these atoms to their respective series. Three research papers have been published during the year, as follows:

(1) Some Multiplets of Singly Ionized Thallium, by S. Smith, Proceedings of the National Academy of Sciences, vol. 14, pp. 951-2, (1928).

(2) Some Multiplets of Doubly Ionized Lead, by S. Smith, Proceedings of the National Academy of Sciences, vol. 14, pp. 878-9, (1928).

(3) Wave-length Measurements in the Vacuum Spark Spectrum of Lead from 2200 Å. to 5000 Å., by S. Smith, Transactions of Royal Society of Canada, vol XXII, Sec. III, pp. 331-5, (1928).

(*Investigation under the direction of Prof. Stanley Smith, University of Alberta.*)

Emission and Absorption Spectra

Co-operating organization:

University of Toronto.

A vacuum spectrograph capable of using gratings of either two or three metres focus and of taking photographic plates 38 cm. long has been about completed. With it, it is expected to obtain spectrograms with a dispersion of five Ångstrom units per mm.

During the year under review two researches have been published, as follows:

(1) The First Spark Spectrum of Thallium, Tl. II, by J. C. McLennan, A. B. McLay and M. F. Crawford, Transactions Royal Society of Canada, III Series, vol. XXII, pp. 241-245, (1928).

(2) The Second Spark Spectrum of Mercury, Hg. II, by J. C. McLennan, A. B. McLay and M. F. Crawford, Transactions Royal Society of Canada, III Series, vol. XXII, pp. 247-251, (1928).

Certain prominent lines in the spark spectrum of thallium were excited by a very weak magnetic field, and the Zeeman effects were photographed. The wave-length 5949 Å. has been resolved into a triplet fine structure with at least 10 Zeeman components.

Fine structures have been obtained for lines of the first spark spectrum of cadmium and of zinc in the visible region, and comparisons have been drawn between them and the structure found by other workers for corresponding lines in the arc spectrum of silver and of copper respectively.

Simple spectra of the ions of lanthanum and cerium have been studied and important extensions to the term structures of the above-mentioned ions have been made by extrapolation of term values from those already known for the analogous spectra of neutral caesium and singly ionized barium. New multiplets have also been identified in the spectrum of the latter.

The term structure of thallium II, derived previously from an analysis of wave-lengths in the ultra-violet spectral regions, has been extended to include some important multiplets in the visible and in the near infra-red regions. Wave-lengths of the spark spectrum in the latter region have been observed and measured for the first time.

The term structure hitherto known for each of the analogous spark spectra gallium II, indium III, thallium III and mercury II consists only of a single doublet scheme built on the lowest state. Several other structures have been located and part of a higher complex term structure has been identified in mercury II, and the single doublet scheme of mercury II and thallium III has been extended.

The spectra of the spark between metallic bismuth terminals, produced under varying degrees of excitation, have been studied in the visible and ultra-violet spectral regions. Many lines of the singly ionized atoms have been picked out by means of their observed characteristics. An analysis of the wave-lengths has revealed a term structure that comprises the low group of terms of the normal atom with outer electronic configuration $6S^26p^2$ and an intermediate and a high group of the atom with an excited electron.

The analysis of the arc spectra of selenium and tellurium has been extended experimentally to the ultra-violet, the visible and the near infra-red spectral regions. All the low terms predicted by theory and the combinations of these terms with additional higher terms have been established.

(Investigation under the direction of Prof. J. C. McLennan, University of Toronto.)

Series Spectra and Atomic Structure

Co-operating organization:

University of Alberta.

Successful work in using a concave grating of six feet radius of curvature and 30,000 lines per inch upon the ruled surface has resulted in the measurement of wave-lengths of light in the Schumann region of the spectrum which have since been used by several investigators as standards of measurement.

During the year under review measurement of various spectra, largely in the Schumann region, has been carried out, and the analysis of the results, so as to lead to further information on atomic structure, has been pressed successfully.

Four research papers have been published during the year as follows:

(1) Lowest terms in the Spark Spectrum of Nickel and Copper (Ni II, Cu II), by R. J. Lang. Physical Review Vol. 31, pp. 773-5 (May, 1928).

(2) On the Spectra of Doubly-ionized Arsenic, Antimony and Bismuth, by R. J. Lang. Physical Review, Vol. 32, pp. 737-45 (Nov., 1928).

(3) Application of the X-ray Laws to Optical Spectra of Higher Rank and the Classification of Ga IV and Ge V, by R. J. Lang, J. E. Mack and Otto LaPorte. Physical Review, Vol. 31, pp. 748-72 (May, 1928).

(4) Series Spectra of Cadmium-like Atoms, by R. J. Lang and J. B. Green. National Academy of Sciences, Vol. 14, pp. 706-10 (Sept., 1928).

(Investigation under the direction of Prof. R. J. Lang, University of Alberta.)

The Effect of Simultaneous Electric and Magnetic Fields on Spectra

Co-operating organization:

McGill University.

Prominent among the developments in physics during this century is experimental and theoretical research on the effects observed when either electric or magnetic forces are applied to radiating atoms—the Stark and Zeeman effects, respectively. The nature of the atoms is more completely revealed by the light which they give out under either of these unusual conditions. The observed

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effects always include changes in the colours normally emitted by the sources of light, but in the case of electric forces, entirely new colours are added to the spectrum of the substance examined. Most of the observations have received detailed interpretation in terms of modern atomic theory.

The present research is the first satisfactory study of the action of simultaneous electric and magnetic forces on spectra. Photographs obtained show that the effects due to electric and magnetic forces are simply additive, providing the forces are parallel and the spectrum contains simple colours, but if the colours in the normal spectrum are complex, then certain fine details in the analysis show that the effects are not exactly additive. Finally, the most interesting case is that in which the electric and magnetic forces act at right angles. The observed magnetic splitting of some of the colours is then much greater than that observed for the same colours where the directions are parallel. In addition, many new colours appear in the spectrum. Some of the observations are understood on present theory, which, however, does not explain all of the details.

(*Investigation under the direction of Dr. G. S. Foster, McGill University.*)

Nocturnal Radiation

Co-operating organization:

McGill University.

Forecasting of weather has become an important factor in the daily life of the country. It has been recognized that a method of forecasting areas and times of unusual frost would be of great value. Radiation of heat from the earth's surface varies with the clearness of the weather, the humidity of the atmosphere and other factors. Measurements of this radiation show that periods of high radiation are accompanied by drops in temperature.

From the results obtained in the experimental work it has been shown that radiation is present at all times, but is diminished by the cloud density. It is more pronounced on a clear, starry night, but is still shown during cloudy or even overcast conditions. For weather forecasting it can be used to advantage. During the past winter the weather was indicated hours beforehand, and local conditions were forecast more accurately than by the meteorological reports. Fine weather was easily predicted, and with just the addition of a barograph and a thermometer the weather changes were reported accurately every day.

(*Investigation under the direction of Dr. H. T. Barnes, McGill University.*)

Velocity of Sound in Liquids Contained in Tubes

Co-operating organization:

University of Alberta.

Uncertainties still exist concerning the velocity of sound in liquids contained in tubes. By utilizing the ultrasonic method in which waves of a frequency so high as to be beyond the range of the human ear are generated and propagated by piezo-electric quartz, some new facts have been discovered. The present work indicates that the dominating factors are those of columnar impedance and selective absorption.

At a critical frequency there occurs a marked selective absorption of energy which causes all the usual characteristics of an absorption band. The wave velocity is greatly diminished immediately on the lower side and greatly increased immediately on the higher side of this frequency, and it is evident that

the phenomenon depends upon the liquid used and on some relation, as yet not discovered, between diameter of the tube and the wave-length of oscillation in the enclosed column of liquid.

No doubt it is at frequencies far removed from the absorption band, where the wave-length is either very large or very small compared with the diameter of the column, that all previous experiments on velocity of sound have been carried out, that is, on the regular and flat portions of the velocity-frequency curves far removed from the frequency of the discontinuity. No doubt in these ranges, theories like the Helmholtz-Kirchoff theory may be applied. At or near the frequency of an absorption band, where the velocity of sound actually changes considerably, such theories yield changes of velocity which are relatively insignificant.

(*Investigation under the direction of Dean R. W. Boyle, University of Alberta.*)

Magnetic Properties of Caesium

Co-operating organization:

McGill University.

Pure caesium was redistilled three times before measurements were made upon it in order to be sure of eliminating iron as an impurity. Use was made of a specially designed null method for determining magnetic field intensity. Measurements of specific susceptibility were made on the metal in the solid and molten states and the values found were 0.22×10^{-6} in the solid and 0.20×10^{-6} in the liquid states, both positive values.

(*Investigation under the direction of Dr. E. S. Bieler, McGill University.*)

Low Temperature Research

Co-operating organizations:

University of Toronto.
The Carnegie Corporation.

The cryogenic equipment in the physical laboratories of the University of Toronto makes possible the production of liquid gases such as air, hydrogen and helium, and as a consequence researches on the properties of substances at temperatures approaching absolute zero are being carried out. During the last year small improvements were made in the equipment, particularly the helium liquifier, which improved its efficiency. The researches carried out during the year include:

(1) *Electrical Conductivities of Some Metals at Low Temperatures.*

The purpose of this research was to test the electrical conductivity of as many metals as possible at very low temperatures in the hope of adding new elements to the list of super-conductors which now numbers six, namely, lead, mercury, thallium, tin, indium and tantalum. The disappearance of resistance at a temperature characteristic of each metal is very abrupt, occurring in a range of less than a tenth of a degree. The presence of an impurity does not seem to mask the phenomenon of super-conductivity. Cadmium was at first thought to be super-conducting, but later this was shown to be due to a trace of lead, less than 1%, although the temperature at which the impure cadmium became super-conducting was much lower than that at which the resistance of pure lead disappeared. A gold-mercury amalgam becomes super-conducting at the exact temperature for pure mercury. A lead-sodium compound was found to be super-conducting at exactly 7.2°K., the temperature for pure lead.

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Hafnium, uranium, zirconium, molybdenum, tungsten and titanium were measured to about 2.3°K. with no evidence of super-conductivity. The specimen of columbium tested gave some evidence of super-conductivity.

(2) *On the Scattering of Light by Liquid Oxygen, Nitrogen and Hydrogen.*

The spectrum of the light scattered by liquid air was found to include four sharp and clearly defined lines not included in the irradiating light, which was that from the mercury arc. The wave-lengths of these lines were approximately 4317Å, 4674.3Å, 4468.9Å and 4849.3Å. The experiment was repeated with pure liquid oxygen and pure liquid nitrogen, when it was found that the lines 4317.7Å and 4674.3Å occurred with liquid oxygen and the other two were from liquid nitrogen.

Experiments with liquid hydrogen irradiated with light from the mercury arc showed three lines in addition to the usual mercury lines. These were at wave-lengths 4426.6Å, 4473.1Å and 4863.5Å. Using suitable light screens, it was found that 4426.6Å and 4473.1Å were excited by radiation 4358.3Å, and 4863.5Å by radiation 4046.6Å.

These results show: (1) that Raman effects can be obtained with homopolar molecules; (2) that part of the energy of light quanta can be taken up directly as rotational energy, the balance appearing as quanta degraded in frequency; (3) that two-quantum rotational transitions can be demonstrated in connection with light-scattering phenomena.

(3) *Photoelectric Effects Obtained with Lead and Mercury at Low Temperatures.*

An investigation was made to reveal whether any discontinuity was observable in the saturation photoelectric current obtainable from the metals lead and mercury, as these metals were cooled with liquid helium and passed from the ordinary to the super-conducting state. Though results were obtained that varied with the type of cell used, it was observed in general that the saturation-point photoelectric current decreased somewhat as the temperatures of the metal film used were lowered. A suitable glass cell has been designed for making experiments with liquid helium to carry on the studies.

(4) *The Crystal Structure and Thermal Expansion of Zinc and Other Metals Investigated at Low Temperatures by X-rays.*

Crystal spacings for the metals zinc and cadmium were obtained at room and liquid air temperatures. From the determined values for different directions in the crystals, coefficients of expansion were determined and corresponding changes in the axial ratios were deduced. The crystal structures of the elements niobium, erbium, and lanthanum were also investigated.

(5) *Duration of Metastable States.*

To measure the time rate of decay of metastable states in inert gases at room temperature, at liquid air temperatures and at liquid hydrogen temperatures, use was made of two alternating currents with a small phase difference. With helium the half life period $^1S_0$ was found to be 2.6×10^{-4} seconds at room temperature and 8.2×10^{-4} seconds at liquid-air temperatures, while the half-life period $^3S_1$ was 1.3×10^{-4} seconds at room temperature and 5.5×10^{-4} seconds in determination made on the 2^1S and 2^3S states by means of absorption of the spectral lines 5016 and 3889Å respectively, under a pressure of 1.1 mm. At pressures of 1.1 mm. it was found that the discharge in the gas became uneven at liquid hydrogen temperatures and satisfactory readings were not obtained. At higher pressures the half-life periods of the states mentioned were found to be much longer.

(6) *The Magnetic Susceptibility of Some Single Metallic Crystals.*

Tellurium, bismuth and antimony were tested with the following results.

For tellurium, the crystal structure is trigonal with crystal axis perpendicular to the cylindrical axis. No effect was observed upon rotation about the cylindrical axis. The magnetic susceptibility obtained was -0.174×10^{-6}. For bismuth a trigonal structure was observed with the crystal axis usually almost 90° from the cylindrical axis. The maximum susceptibility was found to be perpendicular to the crystallographic axis. At room temperature the maximum susceptibility was -1.5×10^{-6} and the minimum was -1.16×10^{-6}. At liquid air temperatures the corresponding values were -1.89×10^{-6} and -7.42×10^{-6} respectively. Experiments with antimony are not complete but it has been found that the direction of maximum susceptibility is along the crystallographic axis as in cadmium and zinc, and not in the basal plane as in bismuth.

(*Investigation under the direction of Prof. J. C. McLennan, University of Toronto.*)

Electric Method of Determining Moisture

Co-operating organization:
University of Toronto.

An electrical appartus has been devised for measuring the moisture in wheat and other substances. It depends for its action upon a disturbance of the plate current in an ordinary radio tube, caused by the energy used up in eddy currents in the sample of wheat when introduced into a coil in an ordinary Hartley oscillatory circuit. This disturbance is recorded on a suitable instrument and is apparently proportional to the amount of water in such substances as wheat, flour, gums, lumber, etc.

The apparatus has been calibrated for wheat by comparing readings with moisture present as determined by the standard Brown-Duvel method. Estimates of moisture content can be made by this method in a few minutes, whereas previous methods required fully one hour.

(*Investigation under the direction of Dr. E. F. Burton, University of Toronto.*)

Hygrometric Problems

Co-operating organizations:
McGill University.
Dominion Department of Mines.
Quebec Forest Industries' Association.

Control of humidity conditions in industrial processes and also in modern buildings has come to be considered essential. This has made necessary the development of better and more accurate methods of measuring moisture content.

Considerable work has been done on modified forms of the Rideal absorption hygrometer. A new hygrometer has been constructed of much larger dimensions than those used heretofore, and having arrangements for inserting thermocouples into various pipettes. Provision is also made to introduce water or prearranged samples of air directly into the sample pipette through a large-bore tube at the bottom of the instrument, thus facilitating calibration. All parts of the instrument are provided with thermocouples so that changes of temperature during an experiment can be followed, and corrections applied. Results of work with this new instrument have shown that the accuracy of repetition is well within 0.5 per cent. Studies of the Toepler gauge are being made with a view to its adaptation to the absorption hygrometer.

Some preliminary work was done to learn if it was possible to correlate the resistivity of leaf tobacco, in bulk, as it comes to the factory, with the moisture

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content. Readings obtained by the use of a megger, on different grades of tobacco under actual factory conditions, suggest that a more careful laboratory study of this problem is desirable.

A record has been kept through one winter of the resistivity of trees together with the corresponding temperature and relative humidity readings. A preliminary study of the data shows that changes of resistivity synchronize with changes of relative humidity with an apparent definite lag. The systematic accumulation of data, using the megger method, should give valuable information about the way in which standing timber behaves with respect to existing moisture in the air.

A weight method of measuring the moisture content of the surface of the forest floor was used in the Province of Quebec with interesting results. A piece of the forest floor was carved out one inch deep and placed in a wire basket without any ventilation. This basket was put back in the excavation and was weighed at intervals and at such times the duff was tested for inflammability. In this way the effect of rain, moisture, drying out and other factors may yield knowledge of value in forest fire protection.

(*Investigation under the direction of Dr. A. N. Shaw, McGill University.*)

Adhesion of Ice to Aeroplanes

Co-operating organization:

McGill University.

In the remarkable development of aerial navigation there are many new problems arising from day to day. With the introduction of the air mail, with the subsequent necessity for night flying in all weathers, a very serious menace has arisen in the formation of ice on the struts, wings and propeller of the aeroplane. It is generally acknowledged that very little is known of this phenomenon and that the pilot is often brought down by the serious interference, both in stream-line flow and weight, when this formation occurs on the plane.

The forms of ice which occur in the air are snow, hoar frost, hail, sleet and sand. All these forms are produced and occasioned by the temperature, humidity and velocity of the air currents, and are profoundly influenced by nocturnal or terrestrial radiation.

In investigations of formation of anchor ice, bodies of different kinds were immersed in water, and the rate of formation of ice upon them was studied to determine the nature of the surface and the adhesive properties of ice to that surface. The result of these experiments has been to show that surfaces differ very much in their power of holding ice, or developing ice, but as yet no scientific rule can be given. Thus polished steel will attract ice to its surface much more rapidly than the rough surface of cast iron. It was subsequently found that these experiments of adhesion had an important bearing on the sticking of ice to aeroplanes, and these results have indicated how further research in this direction should be carried out.

One of the remarkable results of the investigation was a method of producing the precipitation of ice on suitable surfaces immersed in water before the actual freezing-point was reached.

On several different materials and surfaces immersed in water and subjected to ice formation, it was found impossible to obtain a growth of ice. Surfaces coated with Scutan paint or with goose oil are particularly resistant to ice adhesion. Goose oil has been supplied to one of the big aviation companies and it is hoped that shortly it will be possible to give Scutan paint a trial in actual flight.

(*Investigation under the direction of Dr. H. T. Barnes, McGill University.*)

The Generation of Electricity by Windmills

Co-operating organization:

University of Saskatchewan.

The object of this study has been to obtain performance and cost data on a wind-power electric generator plant which might meet the requirements of an isolated prairie farm where wind is abundant. The power generated intermittently by a windmill is put into storage batteries in order to make current available continuously.

What was believed to be the best wind-electric plant on the market was secured and erected three years ago. The power generated by this plant has been found to vary from 44 to 217 k.w.h. per month during the three years and has averaged 118 k.w.h. per month, which is ample power for the needs of an ordinary farm. From the considerable amount of information obtained so far, it appears that the cost of electricity from such a plant may be expected to run from 15 cents to 43 cents per k.w.h., depending chiefly upon the amount of power actually used. The initial cost of the installation must be amortized and this with interest on the initial investment amounts to 90 per cent of the cost. The storage batteries, which are of limited life, account for fully half of the cost of the energy.

A really satisfactory plant would have to be so constructed as to last twice as long as present plants, and the windmill should be capable of generating power from winds of six miles per hour upwards. This would cut down periods of calm and thereby lessen storage battery requirements.

(*Investigation under the direction of Prof. A. R. Greig, University of Saskatchewan.*)

Structural Welding

Co-operating organization:

University of Toronto.

That welding is coming to occupy an important place in the fabrication and erection of structural steel is shown by the fact that during the past decade fully eighty instances of its commercial application have been reported. In addition to structural advantages, the suppression of noisy riveting machines is made possible by welding, and this is very desirable in residential and business districts.

A substantial portion of a comprehensive programme of fundamental and applied research on the general problem of welding, evolved by the American Bureau of Welding, has been completed by the University of Toronto, and two bulletins have been published by the School of Engineering Research.

As a result of this and other investigations, it is expected that the clauses of specification and building codes relating to the fabrication of structural steel will be modified so as to permit of structural welding, at the same time safeguarding the interests of the public. The new process appears to offer marked advantages and economies under certain conditions. The aim of the whole investigation is to afford information to structural designers generally.

(*Investigation under the direction of Prof. P. Gillespie, University of Toronto.*)

The Oxidation of Petroleum Hydrocarbons

Co-operating organization:

University of Toronto.

In crude petroleum there are present varying proportions of hydrocarbons of the methane series depending upon the source of the oil. Certain of the

heavier or higher boiling hydrocarbons are a potential source of fatty acids which are of industrial interest, since oxidation of hydrocarbons in the vicinity of those represented by the formula $C_{18}H_{38}$ to the correct stage, would yield fatty acids closely related to those found in the combined state in naturally occurring fats. The sodium salts of these acids are known commercially as soaps.

Preliminary work on analytical methods is under way and an apparatus has been designed for the controlled oxidation of the hydrocarbons in the presence of a catalyst.

(Investigation under the direction of Dr. M. C. Boswell, University of Toronto.)

The Deterioration of Concrete in Alkali Soils

Co-operating organization:

University of Saskatchewan.

Experimental work on the deteriorating action of the sulphates of sodium, calcium and magnesium on concrete has been carried out for several years. The deterioration is quite marked and widespread in the western prairie provinces where "alkali" soils are prevalent, and resulting losses are severe. Previous work has been along the lines of an intensive study of the exact nature of the deterioration and means have been found for determining the resistance of a given concrete without waiting for actual disintegration to occur.

During the year under review the work has been concentrated upon means to overcome the action of the sulphate salts on concrete. It has been found that cements from different plants, though of uniform physical characteristics, vary widely in resistance to alkali action, while cements from the same plants, working on uniform raw materials, have uniform resistance. Work with composite cements made from pure cement components has indicated how the chemical composition of the mill mix should be varied in order to increase the sulphate resistance of the product. The results obtained are in agreement with the observed variation in resistance of mixes actually found in different cement plants in Canada. With proper burning, it appears that the chemical composition of the mix determines the resistance of the product to alkali action. One of the Canadian manufacturers of cement is gradually modifying the mix used at on mill in accordance with these findings in an attempt to increase the resistance of the product.

Proper steam curing may be considered to render the cement of the mortar or concrete entirely resistant to the action of sodium and calcium sulphates, and while it does not entirely prevent disintegration by magnesium sulphate it slows it up so much that in rich mixes of concrete the disintegration is negligible. The effect of a certain combination of damp and dry curing of mortars in increasing the resistance of lean mortars to the action of sodium and calcium sulphates, is very marked, even with cements having very low resistance when used under conditions of damp curing alone.

Very active siliceous materials used as integral compounds will make concrete entirely proof against the action of the sulphates of sodium and calcium and will slow up the action of magnesium sulphate to a small percentage of its normal rate. Marked increases in resistance to sulphate may be obtained by adding certain salts to the mixing water, but the disadvantage is that the presence of salts in moderate quantities lowers the structural strength of the material. Where strength of material can be sacrificed to the extent of perhaps 25 per cent, this method may be the simplest and cheapest one to combat sulphate action.

The studies made on the efficiency of protective coverings show that these are much more effective against the action of solutions of magnesium sulphate than of sodium sulphate. It is rather doubtful if the use of high alumina cements in regions where alkali action is prevalent is likely to become general on account of the high cost and the apparent uncertainty of their behaviour under adverse weather conditions.

Studies on the purely chemical phases of the problem included hydration of aluminates, hydrolysis of silicates, action of lime on silica, thermo-chemical studies and X-ray studies. A number of scientific papers descriptive of the results are in preparation.

(*Investigation under the direction of Dr. T. Thorvaldson, University of Saskatchewan.*)

IV. POSTGRADUATE RESEARCH SCHOLARSHIPS

Three classes of scholarships are awarded by the National Research 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 application for a studentship must have had at least one year of postgraduate 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 twelve years ending March 31, 1929, the National Research Council awarded two hundred and eight bursaries, one hundred and fifty-three studentships and sixty-one fellowships. These four hundred and twenty-two awards were held by two hundred and fifty-four persons in fifteen departments of science at twelve Canadian universities. Each grantee carried on his work under the direction of a 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 forty-one graduates have secured the degree of M.A., or M.Sc., and one hundred and nine the degree of Ph.D. According to the latest returns which it has been possible for the Council to secure, seven hundred and ninety-three scientific papers have been published by these grantees.

At the end of the year under review, two hundred and thirteen persons had completed their training in science under these awards. The Council has, therefore, during the past twelve 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, one hundred and fourteen persons held a bursary, studentship, or fellowship for one year, fifty-six persons held awards for two years, and forty-three persons received the maximum assistance available and held awards for three years.

It will perhaps be of interest to note the present occupation of the two hundred and thirteen persons who have completed their training under these awards. Of these, twenty-five persons are continuing their postgraduate 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 department of science; sixty-two persons are engaged in the teaching profession, fifty-six of these having received appointments to the staffs of Canadian universities, where the majority of them will have an opportunity of continuing their scientific training and of engaging in research work. Fifty-five persons are employed in the industries and thirty-two have accepted positions in the technical branches of the Federal and Provincial Governments. Fifteen grantees are employed in various capacities on the staffs of university and other laboratories, and fifteen persons, for various reasons, are not at present actively engaged in research work. One grantee has died and eighteen have failed to furnish the Council with information regarding their present occupation.

Four fellowships, seventeen studentships and twenty-nine bursaries were awarded by the National Research Council during the year under review. These fifty awards were won by graduates of the following ten Canadian universities: University of British Columbia, five awards; University of Alberta, two awards; University of Saskatchewan, seven awards; University of Manitoba, one award; University of Toronto, six awards; University of Western

Ontario, four awards; Queen's University, eight awards; McGill University, ten awards; Laval University, one award; and Dalhousie University, six awards.

50 Scholarships held during the Year 1928-29

RAMSAY MEMORIAL FELLOWSHIP

Grantee	Graduated	Where held	Subject to Research
W. H. Barnes.....	B.Sc., M.Sc., Ph.D., McGill.	Royal Institution Physical Chemistry, London, England.	The crystal structure of ice.

FELLOWSHIPS

C. C. Coffin.....	B.A., Dalhousie, M.Sc., Ph.D., McGill.	Department of Physical Chemistry, McGill University.	Molecular structure and molecular attraction.
A. M. I. A. W. Durnford.	B.A., M.A., W. Ontario.	Department of Physics, University of Toronto.	The Zeeman effects for platinum.
B. P. Sutherland.....	B.A.Sc., British Columbia, M.Sc., Ph.D., McGill.	Department of Physical Chemistry, McGill University.	The viscosity of gases.

STUDENTSHIPS

Miss E. Allin.....	B.A., M.A., Toronto.	Department of Physics, University of Toronto.	The fine structure of some lines in the spectra of certain elements.
W. G. Brown.....	B.Sc., M.Sc., Saskatchewan.	Department of Physical Chemistry, University of Saskatchewan.	The thermochemistry of compounds of the system CaO-Al_2O_3-SiO_2 as they occur in the clinker of Portland cement.
Wm. Chalmers.....	B.A., M.A., British Columbia.	Department of Organic Chemistry, McGill University.	Investigation into the influence of constitution upon the ability of organic compounds to polymerize.
Miss E. Cohen.....	B.A., M.A., Ph.D., Toronto.	Department of Physics, University of Toronto.	Magnetic properties of single crystals of certain elements.
D. LeB. Cooper.....	B.Sc., King's, M.Sc., Dalhousie.	Department of Physical Chemistry, McGill University.	Aberrations from the ideal gas laws in systems of one and two components.
M. F. Crawford.....	B.A., Western Ontario, M.A., Toronto.	Department of Physics, University of Toronto.	Spectrum analysis in the ultra-violet.
A. C. Cuthbertson.....	B.Sc., M.Sc., Ph.D., McGill.	Department of Physical Chemistry, McGill University.	The preparation and properties of pure hydrogen peroxide.
A. C. Hill.....	B.Sc., Dalhousie, M.Sc., Ph.D., McGill.	Department of Chemistry, McGill University.	Oxidation of organic compounds with special reference to hydrogen peroxide.
H. W. Johnston.....	B.Sc., M.Sc., Ph.D., McGill.	Department of Cellulose Chemistry, McGill University.	Penetration of wood by aqueous solution including the sulphite making liquors.
C. T. Lane.....	B.Sc., M.Sc., McGill.	Department of Physics, McGill University.	The determination of the magnetic susceptibility of caesium.
Miss M. E. MacKay...	B.A., M.A., Dalhousie.	Department of Physiology, McGill University.	The relation between the secretory and motor phenomena in the alimentary tract.
L. E. Marion.....	B.Sc., M.Sc., Queen's, Ph.D., McGill.	Department of Organic Chemistry, McGill University.	Isolation and identification of some lignin constituents.
G. C. McCartney.....	B.A., B.Sc., M.Sc., Manitoba.	Department of Geology, University of Wisconsin.	A petrographic analysis of sediments from a definite oil field of economic importance.
O. M. Morgan.....	B.A., M.A., Western Ontario.	Department of Physical Chemistry, McGill University.	Measuring the conductivities and viscosities of solutions of the alkaline halides ranging in concentration from saturation down to .01 M.F.
A. W. H. Needler.....	B.A., M.A., Toronto.	Department of Marine Biology, University of Toronto.	The life history of the haddock.
A. S. Townshend.....	B.Sc., M.Sc., Queen's M.A., Toronto.	Department of Organic Chemistry, University of Toronto.	The reaction of small amounts of potassium hydroxide on esters in solutions in various alcohols.
M. S. Whelan.....	B.Sc., M.Sc., Saskatchewan, Ph.D., McGill.	Department of Chemistry, Chemistry. McGill University.	Cyclic acetal formation.

BURSARIES

Grantee	Graduated	Where held	Subject to Research
J. M. Anderson.....	B.A., M.A., Toronto.	Department of Physics, University of Toronto.	The duration of certain metastable states at low temperatures.
R. H. Ball.....	B.A., M.A., British Columbia.	Department of Organic Chemistry, McGill University.	Cellulose ethers.
Miss A. A. Berkeley...	B.A., British Columbia, M.A., Toronto.	Department of Marine Biology, University of Toronto.	The anatomy and life history of pandalus danae and some related forms.
Miss M. Campbell.....	B.A., M.A., British Columbia.	Department of Zoology, University of British Columbia.	Quantitative investigation of the zooplankton of the waters of the Straits of Georgia.
A. S. Cook.....	B.A., M.A., Dalhousie.	Department of Organic Chemistry, University of Toronto.	Investigation of certain nitrogen and sulphur compounds in fish muscle.
W. Gallay.....	B.A., M.Sc., McGill.	Department of Organic Chemistry, McGill University.	Studies of polymerization.
N. E. Gibbons.....	B.A., M.A., Queen's.	Department of Bacteriology, Queen's University.	The effect of autolysis in animal tissues on bacterial decomposition. Rabbit and guinea pig abscesses caused by Hemophilus sp. and Neisseria sp.
N. S. Grace.....	B.Sc., M.Sc., Saskatchewan.	Department of Inorganic Chemistry, University of Saskatchewan.	A quantitative study of the hydration of tricalcium aluminate.
L. E. Howlett.....	B.A., British Columbia, M.A., Toronto.	Department of Physics, University of Toronto.	Electrical conduction at low temperatures.
J. A. Jenkins.....	B.Sc., M.Sc., Saskatchewan.	Department of Genetics and Cytology, University of Saskatchewan.	Genetical and cytological study of the third generation hybrids of two wheat crosses and first generation of another cross.
L. W. Koch.....	B.A., Queen's, M.A., Toronto.	Department of Plant Pathology, University of Toronto.	Spur blight of raspberries.
H. C. Laird.....	B.A., W. Ontario, M.A., Toronto.	Department of Geology, University of Toronto.	A field and laboratory study of the nature and origin of the Silurian chert beds exposed at Hamilton, Ont.
G. O. Langstroth.....	B.A., Dalhousie.	Department of Physics, McGill University.	The relative intensities of the Stark components in helium.
J. K. L. MacDonald...	B.Sc., M.Sc., McGill.	Department of Physics, McGill University.	Hydrogen secondary spectrum experiments.
K. A. MacKinnon.....	B.Sc., M.Sc., Queen's.	Department of Physics, Queen's University.	Studies in the high frequency electrodeless discharge.
W. E. K. Middleton...	B.Sc., M.Sc., Saskatchewan.	Department of Physics, University of Saskatchewan.	To extend to alternating current discharges Langmuir's method of exploring discharges through gases at low pressure.
J. G. Morazain.....	C.D., Laval.	Department of Cellulose Chemistry, McGill University.	The study of the cooking reaction in the manufacture of sulphite pulps.
Wm. H. Mueller.....	B.Sc., Alberta, M.Sc., McGill.	Department of Chemistry, McGill University.	Comparative studies in oxidation.
A. J. O'Leary.....	B.Sc., M.Sc., Queen's.	Department of Physics, Queen's University.	Investigation of the properties of β-rays scattered by gases, vapours and liquids.
J. B. Phillips.....	B.Sc., M.Sc., McGill.	Department of Chemistry, McGill University.	A study of the resins found in certain Canadian conifers.
E. C. Powell.....	B.Sc., M.Sc., Saskatchewan.	Department of Chemistry, University of Saskatchewan.	Iso ureas and cyclic iso urea ureaides.
Miss C. E. Rice.....	B.A., M.A., Queen's.	Department of Bacteriology, University of Toronto.	The effect of X-rays upon the dissociation of various bacteria.
C. A. Sankey.....	B.A.Sc., Toronto, M.Sc., McGill.	Department of Chemistry, McGill University.	Some studies on cellulose, lignin and related derivatives.
D. O. Sproule.....	B.Sc., M.Sc., Alberta.	Department of Physics, University of Alberta.	Investigations on the elastic and other properties of matter by the ultrasonic and other methods.
I. Walerstein.....	B.A., Toronto, Ph.D., Chicago.	Department of Physics, University of Toronto.	The absorption spectra of certain excited gases.
C. V. Wilson.....	B.Sc., M.Sc., Saskatchewan.	Department of Chemistry, University of Saskatchewan.	Diurethanes and their decomposition products.
W. R. Wyman.....	B.Sc., Dalhousie.	Department of Physical Chemistry, McGill University.	Calorimetric measurements in relation to crystal forms and surface effects.
J. M. Young.....	B.Sc., M.Sc., McGill.	Department of Physics, McGill University.	The characteristics of the electric discharge between cylindrical electrodes in rare gases.

BURSARIES—*Continued*

Grantee	Graduated	Where held	Subject to Research
W. H. Zinn.....	B.A., M.A., Queen's.	Department of Physics, Queen's University.	The scattering of X-rays by thin films of liquids and solutions.

213 Scholarship Graduates—1917-1928

Grantee	University where undergraduate training received	Present Occupation
F. B. Adamstone, B.A., M.A., Ph.D....	Toronto.....	Associate in Zoology, University of Illinois, Urbana, Ill.
D. S. Ainslie, B.A., M.A., Ph.D.....	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., M.A., Ph.D....	Acadia.....	No information.
N. J. Atkinson, B.Sc., M.Sc...	Saskatchewan.....	No information.
W. F. Baker, B.A., B.Sc., M.Sc.....	Manitoba.....	With Anglo-American Company, South Africa.
H. C. Bates, B.A., M.A.....	Toronto.....	Research Physicist, Corning Glass Works, Corning, N.Y.
C. H. Bayley, B.A.Sc., M.A.Sc., M.A...	Toronto.....	No information.
R. W. Beattie, B.Sc., M.Sc.....	Queen's.....	Fellowship holder of the Bakelite Corp., at Pennsylvania State College, State College, Pa.
A. H. Bell, B.A., Ph.D.....	Toronto.....	Geologist, Petroleum Section, Illinois State Geological Survey, Urbana, Ill.
H. P. Bell, B.Sc., M.Sc., M.A., Ph.D...	Dalhousie.....	Associate Professor of Botany, Dalhousie University, Halifax, N.S.
L. V. Bell, B.Sc., M.A.....	Alberta.....	Geologist, Department of Mines, Quebec.
P. A. Berard, B.A., L. es Sc. Ch.....	Montreal.....	Milk Analyst, City Hall, Montreal.
C. H. Berkeley, 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., Ph.D.....	McGill.....	Geological Staff, Anglo-American Corporation of South Africa, Broken Hill, N. Rhodesia.
Miss E. L. Bishop, B.A., M.A.....	Toronto.....	Teacher of Mathematics, Georgetown High School, Georgetown, Ont.
L. L. Bolton, B.A., M.A.....	British Columbia..	Instructor in Zoology, University of Washington, Seattle, Wash.
E. H. Boomer, B.Sc., M.Sc., Ph.D.....	British Columbia..	Professor of Chemistry, University of Alberta, Edmonton, Alta.
Miss M. A. Borden, B.A., M.A.....	Dalhousie.....	Graduate student, University of London, London, England.
H. A. Braendle, B.A., M.A.....	Toronto.....	Technical Dept., Binney & Smith Co., New York, N.Y.
O. C. Bridgeman, B.A., M.A., Ph.D.....	Saskatchewan.....	Research Associate, Bureau of Standards, Washington, D.C.
B. S. W. Buffam, B.Sc., M.Sc., Ph.D...	McGill.....	With Anglo-American Company, Northern Rhodesia, Africa.
J. W. Burns, B.Sc., M.Sc.....	New Brunswick...	Assistant Professor of Chemistry, University of Western Ontario, London, Ont.
K. H. Butler, B.A., M.A., Ph.D.....	Dalhousie.....	Research Assistant, Massachusetts Institute of Technology, Cambridge, Mass.
Miss F. M. Cale, B.A., M.A.....	Toronto.....	Married.
G. B. Carpenter, B.A., M.A., Ph.D.....	British Columbia..	Research Chemist, Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology, Cambridge, Mass.
P. Cartier, B.Sc., L. es Sc. Ch.....	Montreal.....	Assistant Professor of Chemistry, University of Montreal, Montreal.
H. M. Cave, B.A., M.A.....	Queen's.....	Graduate Student, Cavendish Laboratory, Cambridge, England.
Miss M. L. Chalk, B.A., M.Sc., Ph.D...	McGill.....	Research in Physics, King's College, London University, London, Eng.
G. C. Chamberlain, B.S.A.....	Ontario Agricultural College....	Plant Pathologist, Dominion Experimental Farms, St. Catharines, Ont.
Miss H. D. Chataway, B.A., B.Sc., M.Sc. Ph.D.....	Manitoba.....	Research Assistant, Lehigh University, Bethlehem, Pa.
E. Chauret, I.Ch., L.es Sc.....	Montreal.....	Chief Chemical Engineer, Concrete Department, Laboratory for Testing Materials, Montreal, Que.
H. R. Chipman, B.A., M.A., Ph.D.....	Dalhousie.....	Chemist, Fisheries Experimental Station (Atlantic), Halifax, N.S.

Grantee	University where undergraduate training received	Present Occupation
N. D. Clare, B.Sc., M.Sc.	Manitoba	Roessler & Hasslacher Chemical Co., Niagara Falls, N.Y.
Miss M. L. Clark, B.A., M.A.	Toronto	Teacher of Mathematics, Collegiate Institute, Collingwood, Ont.
R. J. Clark, B.A.	McGill	Graduate student, Physical Laboratory, The University, Edinburgh.
Miss L. Corbett, B.A., M.A.	Queen's	Married.
R. G. Corneil, B.Sc.	Queen's	No information.
R. N. Crozier, B.A., M.A., Ph.D.	British Columbia	In Research Department, A. E. Staley Manufacturing Co., Decatur, Ill.
B. W. Currie, B.Sc., M.Sc.	Saskatchewan	Instructor, Department of Physics, University of Saskatchewan.
Miss A. E. Dempsey, B.A., M.A.	McMaster	Married.
A. B. de Passille, B.Sc.A., I.C., I.Ch.	Montreal	Professor of Chemistry, Ecole Polytechnique, University of Montreal.
E. P. Dolan, B.Sc., M.A.	St. Francis Xavier	Deceased.
V. H. Emory, B.A.Sc.	Toronto	Chief Chemist, Canada Paper Company, Windsor Mills, P.Q.
A. B. A. Evans, B.Sc., M.Sc.	Birmingham	Publisher, Agard & Co., Ltd., Birmingham, Eng.
T. S. C. Fawcett, B.A.Sc., M.A.Sc.	Toronto	No information.
J. H. Findlay, B.A., B.Sc., M.Sc.	Queen's	Fellow in Physics, Princeton University, Princeton, N.J.
R. E. Foerster, B.A., M.A., Ph.D.	British Columbia	Research Biologist in charge of Pacific Salmon Research Station, Cultus Lake, B.C.
J. C. Forbes, B.A., M.A., Ph.D.	Saskatchewan	Research Professor at Medical College of Virginia, Richmond, Va.
H. R. Foreman, B.A., M.A.	Toronto	President & Sales Manager, H. R. Foreman & Co., Ltd., Heating and Refrigerating Engineers, 75 King St. W., Toronto, Ont.
J. H. Fox, B.A., M.A.	Western Ontario	Teacher of Physics, Collegiate Institute, Windsor, Ont.
Miss C. W. Fritz, B.A., M.Sc., Ph.D.	McGill	Timber Pathologist, Forest Products Laboratories, Ottawa, Ont.
Miss M. A. Fritz, B.A., M.A., Ph.D.	McGill	Assistant in Palaeontology, Royal Ontario Museum, and Instructor in Palaeontology, University of Toronto, Toronto, Ont.
D. K. Froman, B.Sc., M.Sc.	Alberta	Assistant, Department of Physics, University of Chicago, Chicago, Ill.
W. A. Gale, B.A.Sc., M.A.Sc.	British Columbia	Assistant Director of Research, American Potash and Chemical Corporation, Trona, Cal.
J. F. L. Germain, B.A., A.R.C.Sc.	Montreal	No information.
B. E. Gilbert, B.A., M.A., Ph.D.	McMaster	Director and Plant Physiologist, Rhode Island Agricultural Experiment Station, Kingston, R.I.
Miss K. F. Godwin, B.A., M.Sc.	McGill	Married. Lecturer in Zoology, McGill University, Montreal, Que.
W. L. Gordon, B.S.A., M.Sc.	McGill	Plant Pathologist, Dominion Rust Research Laboratory, Winnipeg, Man.
A. R. Graham, B.S.A., M.Sc.	McGill	Assistant Entomologist, Dominion Department of Agriculture, Parasite Laboratory, Belleville, Ont.
W. E. Graham, B.A.Sc., M.A.Sc., M.A., Ph.D.	British Columbia	Industrial Fellow, Mellon Institute of Industrial Research, Pittsburgh, Pa.
C. Greaves, B.Sc., M.Sc., Ph.D.	McGill	Junior Chemist, Forest Products Laboratories, Ottawa, Ont.
H. Greenberg, B.Sc., M.Sc., Ph.D.	McGill	Research Chemist, U.S. Industrial Alcohol Company, Baltimore, Md.
H. B. Hachey, B.Sc., M.Sc.	St. Francis Xavier	Hydrographer to the Biological Board of Canada, Atlantic Biological Station, St. Andrews, N.B.
R. Hamer, B.A., M.A., Ph.D.	Saskatchewan	Professor of Physics, Acadia University, Wolfville, N.S.
R. H. Harris, B.Sc., M.Sc.	Saskatchewan	Chemist, in charge of laboratory of Quaker Oats Company, Saskatoon, Sask.
J. L. Hart, B.A., M.A.	Toronto	Fisheries Investigator with Biological Board of Canada and Province of British Columbia, Pacific Biological Station, Nanaimo. B.C.
W. H. Hatcher, B.A., M.Sc., Ph.D.	McGill	Assistant Professor of Chemistry, McGill University, Montreal, Que.
E. Hearle, B.S.A., M.Sc.	Toronto	Assistant Entomologist, Dominion Entomological Laboratory, Kamloops, B.C.
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	Not engaged in research.
G. W. Holden, B.A., M.Sc., Ph.D.	Bishop's	Analytical and Research Chemist, Charles E. Frosst & Co., Montreal, Que.
C. Y. Hopkins, B.A., M.A., Ph.D.	Queen's	Research Fellow, New York University, New York.

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Grantee	University where undergraduate training received	Present Occupation
E. O. Houghton, B.Sc., M.Sc.	McGill	Assistant Chemist, Fraser Companies Ltd., Edmundston, N.B.
W. V. Howard, B.A., M.Sc., Ph.D.	McGill	Assistant Professor of Geology, University of Illinois, Urbana, Ill.
H. J. C. Ireton, B.A., M.A.	Toronto	Demonstrator, Lecturer and Research Associate, University of Toronto, Toronto, Ont.
A. B. Jackson, B.S.A., M.A.	Toronto	Farmer.
W. F. James, B.A., M.Sc., Ph.D.	St. Francis Xavier	Consulting Geologist, Amos, Que.
R. S. Jane, B.A.Sc., M.Sc., Ph.D.	British Columbia	With Department of Plant Research, Shawinigan Chemicals, Shawinigan Falls, Que.
C. M. Jephcott, B.A., M.A., Ph.D.	Toronto	No information.
I. W. Jones, B.A., B.Sc., Ph.D.	Alberta	Geologist, Department of Mines, Province of Quebec, Quebec, Que.
W. A. Jones, B.A.Sc., M.A.Sc., M.A.	British Columbia	Graduate Student and Demonstrator, Department Mineralogy, University of Toronto, Toronto, Ont.
Miss M. B. Kearney, B.A., M.A.	Toronto	Registrar and Instructor in Physics, Converse College, Spartanburg, S.C.
E. J. King, B.A., M.A., Ph.D.	McMaster	Biochemist, Department of the Banting Medical Research, University of Toronto, Toronto, Ont.
K. H. Kingdon, B.A., M.A., Ph.D.	McMaster	Physicist, Research Laboratory, General Electric Co., Schenectady, N.Y.
A. L. Kuehner, B.A., M.A.	Queen's	Lecturer in Chemistry, University of Lennoxville, Lennoxville, Que.
P. Larose, B.Sc., M.Sc., Ph.D.	McGill	Professor of Physics and Physical Chemistry, Laval University, Quebec, Que.
G. C. Laurence, B.Sc., M.Sc.	Dalhousie	Research student, Cavendish Laboratory, Cambridge, Eng.
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., Ph.D.	Alberta	Physicist, Synthetic Ammonia and Nitrate, Ltd., Billingham, Stockton-on-Tees, Eng.
S. Lehman, B.A., M.A.	Toronto	No information.
A. H. Leim, B.A., Ph.D.	Toronto	Director, Fisheries Experimental Station, Halifax, N.S.
Miss M. Levi, B.A., M.A., Ph.D.	Toronto	Married.
S. G. Lipsett, B.Sc., M.Sc., Ph.D.	Manitoba	Research Chemist, J. T. Donald & Co., Montreal, Que,
F. R. Lorriman, B.A., M.A., Ph.D.	Toronto	Lecturer in Chemistry, University of Toronto, Toronto, Ont.
G. H. W. Lucas, B.A., M.A., Ph.D	Toronto	Assistant Professor in Pharmacology, University of Toronto, Toronto, Ont.
A. D. Macallum, B.A., M.Sc., Ph.D.	Toronto	Research Chemist, Roessler & Hasslacher Chemical Co., Perth Amboy, N.J.
P. A. Macdonald, B.Sc., M.Sc.	Manitoba	Research student, University of Manitoba, Winnipeg, Man.
Miss A. P. MacDougall, B.A., M.A.	McMaster	Married. Independent research in entomology.
D. G. MacGregor, B.A.	Dalhousie	Professor of Physics, Mt. Allison University, Sackville, N.B.
J. E. Machacek, B.S.A., M.S.A., Ph.D	Saskatchewan	Teaching Assistant in Mycology, Plant Pathology, and Botany, 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	Research student, Yale University, New Haven, Conn.
W. M. Martin, B.S.A., M.Sc., Ph.D.	Alberta	Assistant Chemist, University of Montana Agricultural Experiment Station, Bozeman, Mont.
G. L. Matheson, B.Sc., M.Sc., Ph.D.	McGill	With Standard Development Co., Elizabeth, N.J.
L. A. Matheson, B.A., M.A.	Western Ontario	Graduate student, Department of Physics, University of Michigan, Ann Arbor, Mich.
J. E. Maynard, B.A., B.Sc., M.Sc., Ph.D.	Manitoba	No information.
A. W. McCallum, B.Sc.F., M.A.	Toronto	Forest Pathologist, Department of Agriculture, Central Experimental Farm, Ottawa, Ont.
W. H. McCurdy, B.A., M.A., Ph.D.	Dalhousie	With Research Laboratory, Westinghouse Electric Co., Bloomfield, N.J.
J. L. McDonald, B.A., M.A.	St. Francis Xavier	No information.
S. R. McDougall, B.A.Sc., M.A.Sc.	British Columbia	Chemical Engineer, Technical Department, Northern Electric Company, 1261 Shearer Street, Montreal, Que.
J. W. McKinney, B.Sc., M.Sc., Ph.D.	Alberta	Research Chemist, Brown Company, 112 Spring Street, Berlin, N.H.
C. G. McLachlan, B.A.Sc., M.A.Sc.	British Columbia	Mill Superintendent, The Horne Copper Corpn. Noranda, Que.
H. R. McLarty, B.A., M.A.	McMaster	Pathologist-in-Charge, Field Laboratory of Plant Pathology, Summerland, B.C.
A. B. McLay, B.A., M.A., Ph.D.	McMaster	No information.

Grantee	University where undergraduate training received	Present Occupation
S. McLean, B.A., M.A.	McMaster	Experimental Engineer, Lamp Development Laboratory, Incandescent Lamp Department of General Electric Company, Cleveland, Ohio.
J. H. McLeod, B.Sc., M.A.	Saskatchewan	Instructor in Physics, Harvard University, Cambridge, Mass.
T. C. McMullen, B.A., M.A., Ph.D.	Toronto	Teacher of Chemistry and Dean of Albert College, Belleville, Ont.
Miss A. I. McPherson, B.A., M.Sc.	McGill	No information.
W. C. McQuarrie, B.A., M.A., Ph.D.	Toronto	Asst. Professor of Physics, Lafayette College, Easton, Pa.
J. A. McRae, M.A., Ph.D.	Queen's	Professor of Chemistry, Queen's University, Kingston, Ont.
J. Melville, B.A.Sc., M.A.Sc.	British Columbia	Assay Office, Consolidated Mining & Smelting Co., of Canada, Ltd., Trail, B.C.
J. H. Mennie, B.A., M.A., B.Sc., Ph.D.	British Columbia	Physical Chemist, Experimental Station for Fisheries, Halifax, N.S.
G. Molleur, I.C.	Montreal	With the Quebec Streams Commission, Quebec, Que.
C. F. Morrison, B.E., M.Sc.	Saskatchewan	Lecturer in Civil Engineering, University of Toronto, Toronto, Ontario.
D. M. Morrison, B.Sc., M.Sc., Ph.D.	British Columbia	Chief Technologist, Arkansas City Refinery, Shell Petroleum Corpn., Arkansas City, Kansas.
D. D. Mossman, B.Sc., M.A.	McGill	Research Student, Columbia University, New York, N.Y.
Miss B. K. E. Mossop, B.A., M.A.	Toronto	Specialist in Science and Art, Clinton Collegiate Institute, Clinton, Ont.
Miss I. Mounce, B.A., M.A., M.Sc., Ph.D.	British Columbia	Asst. Plant Pathologist, Central Experimental Farm. Ottawa, Ont.
M. J. Mulligan, B.A., M.A.	Toronto	Research Chemist, General Motors Research Laboratories, Detroit, Mich.
L. A. Munro, B.A., M.A., Ph.D.	Dalhousie	Department of Chemistry, Queen's University, Kingston, Ont.
Miss D. E. Newton, B.S.A., M.Sc.	McGill	Studying Systematic Botany at Berlin Botanical Gardens and Kew Botanical Gardens, England.
Miss M. Newton, B.S.A., M.Sc., Ph.D.	McGill	Senior Plant Pathologist, Dominion Rust Laboratory, Agricultural College, Winnipeg, Man.
J. L. Nickerson, B.A., M.A.	Dalhousie	Instructor in Physics at Princeton University, Princeton, N.J.
C. D. Niven, B.Sc., M.A., Ph.D.	Aberdeen	No information.
Miss M. K. O'Brien, B.A., M.A.	Toronto	Sister M. Emerentia, St. Joseph's Convent, Toronto, Ont.
H. G. Oddy, B.A., M.A., Ph.D.	McMaster	Asst. Professor of Chemistry, Oregon State Agricultural College, Corvallis, Oregon.
H. B. O'Heir, B.A., B.Sc., M.Sc.	McGill	Salesman, Riordon Sales Corpn., Montreal, Que.
Miss M. Olding, B.A.	McGill	Married.
A. L. Patterson, B.Sc., M.Sc., Ph.D.	McGill	Associate, Division of Biophysics, Rockefeller Institute for Medical Research, 66th Street & York Ave., New York, N.Y.
D. S. Pasternack, B.Sc., M.Sc., Ph.D.	Queen's	Department of Industrial Chemistry, University of Alberta, Edmonton, Alta.
Miss I. J. Patton, B.A., M.Sc.	McGill	No information.
Miss L. E. Paynter, B.Sc., M.Sc.	Saskatchewan	Laboratorian, Fort Qu'Appelle Sanatorium, Fort San, Sask.
C. R. Peaker, B.Sc., M.Sc., Ph.D.	Saskatchewan	Holder of University Fellowship, Stanford University, Berkeley, Calif.
R. A. Pelletier, B.Sc., M.Sc., Ph.D.	McGill	Employed by the Anglo-American Corpn. of South Africa, Broken Hill, Northern Rhodesia, Central Africa.
J. F. Phillips, B.A.Sc., M.A.	Toronto	Teacher at Riverdale Technical School, Toronto, Ont.
L. M. Pidgeon, B.A., M.Sc., Ph.D.	Manitoba	Ramsay Memorial Fellow, Oxford University, Oxford, England.
R. A. Prosser, B.Sc., M.A.	Acadia	Chemical Engineer, American Potash and Chemical Corporation, Trona, Calif.
H. N. Racicot, B.A.	McMaster	Pathologist-in-Charge, Laboratory of Plant Pathology, Ste. Anne de la Pocatiere, Que.
D. S. Rawson, B.A., M.A., Ph.D.	Toronto	Assit. Professor of Zoology, University of Saskatchewan, Saskatoon, Sask.
C. D. Reid, B.Sc., M.Sc., A.M.	Alberta	Instructor in the Department of Physics, Harvard University, Cambridge, Mass.
Miss C. E. Robertson, B.Sc., MSc., Ph.D.	McGill	Married.
A. D. Robinson, B.A., M.A., Ph.D.	Saskatchewan	Assistant in Agrcultural Biochemistry, University of Minnesota, St. Paul, Minn.
H. L. Robson, B.Sc., Ph.D.	Saskatchewan	Research Chemist, Synthetic Iron Color Co., Richmond, Calif.
D. C. Rose, B.Sc., M.Sc., Ph.D.	Queen's	Lecturer in Physics, Queen's University, Kingston, Ontario.
P. V. Rosewarne, B.A., M.A.	McMaster	Engineer in charge Oils and Natural Gas Section, Fuel Testing, Mines Branch, Ottawa, Ont.
W. W. E. Ross, B.A.	Toronto	Assistant Magnetician, Meteorological Service. Toronto, Ontario.

Grantee	University where undergraduate training received	Present Occupation
W. Rowles, B.Sc., M.Sc., Ph.D.	Saskatchewan	Lecturer in Physics, Macdonald College, Que.
J. Russell, B.A., M.Sc., Ph.D.	British Columbia	Research Chemist, Eastman Kodak Company, Rochester, N.Y.
E. W. Samson, B.Sc., M.Sc.	Manitoba	Research Student in Physics, Princeton University, Princeton, N.J.
J. W. G. Sanderson, B.Sc., M.Sc., Ph.D.	Alberta	Geologist, Imperial Oil Ltd., Calgary, Alta.
B. W. Sargent, B.A., M.A.	Queen's	Research in Radioactivity, Cavendish Laboratory, Cambridge, England.
J. E. Saunders, B.A.Sc., M.Sc.	McGill	Anglo-American Corporation of South Africa, Broken Hill, N. Rhodesia, Africa.
W. R. Sawyer, B.Sc., M.Sc.	Queen's	Graduate Student, McGill University, Montreal, Que.
D. A. Scott, B.A., M.A., Ph.D.	Toronto	Assistant Director of the Connaught Laboratories, University of Toronto, Toronto, Ont.
W. F. Seyer, B.A., M.Sc., Ph.D.	Alberta	Associate Professor of Electro & Industrial Chemistry, University of British Columbia, Vancouver, B.C.
B. Shaffer, B.A.Sc., M.A.Sc.	Toronto	No information.
Miss E. Shanly, B.A., M.Sc.	McGill	Not engaged in research.
W. W. Shaver, B.A., M.A., Ph.D.	Toronto	Research Physicist at Corning Glass Works, Corning, N.Y.
G. M. Shrum, B.A., M.A., Ph.D.	Toronto	Associate Professor of Physics, University of British Columbia, Vancouver, B.C.
W. W. Simpson, B.A., M.A., Ph.D.	British Columbia	Instructor in Physiology, University of California, Berkeley, Calif.
H. desB. Sims, B.A., M.A.	Toronto	Research work for private firm.
C. Sivertz, B.A.Sc., M.Sc., Ph.D.	British Columbia	Instructor in Chemistry, University of Western Ontario, London, Ont.
V. Sivertz, B.Sc., M.Sc., Ph.D.	Washington	Instructor in Chemistry, University of Washington, Seattle, Wash.
C. W. Small, B.Sc., M.A.	Acadia	Associate Professor of Chemistry, Acadia University, Wolfville, N.S.
H. G. Smith, B.A., M.A., Ph.D.	Toronto	Meteorologist for the Dominion Meteorological Serivce, Toronto, Ont.
Miss C. M. Spence, B.A., M.A.	Queen's	Married.
Miss J. D. Spier, B.A., M.Sc.	McGill	Demonstrator, Department of Botany, McGill University, Montreal, Que.
H. D. Squires, B.A., M.Sc., Ph.D.	New Brunswick	No information.
E. W. R. Steacie, B.Sc., M.Sc., Ph.D.	McGill	Lecturer in Chemistry, McGill University, Montreal, Que.
H. N. Stephens, B.A., M.A., Ph.D.	McMaster	Assistant Professor of General Inorganic Chemistry University of Minnesota, Minneapolis, Minn.
M. G. Sturrock, B.Sc.	Alberta	Graduate Student and Demonstrator, McGill University, Montreal, Que.
C. W. Sweitzer, B.A., M.A., Ph.D.	Toronto	Research Student, Mellon Institute, Pittsburgh, Pa.
Miss E. M. Taylor, B.A., M.A., Ph.D.	Toronto	Research Assistant, Connaught Laboratories, University of Toronto, Toronto, Ont.
F. R. Terroux, B.A., B.Sc., M.Sc.	Montreal	Research Student, Cavendish Physical Laboratory, Cambridge, England.
K. Thomson, B.A., M.A.	Western Ontario	Lecturer in Physics, Queen's University, Kingston, Ont.
W. W. Thomson, B.Sc., M.Sc., Ph.D.	McGill	Professor of Chemistry and Director of the Department, Broaddus College, Philippi, W. Va.
Wm. Ure, B.A.Sc., M.A.Sc., Ph.D.	British Columbia	Assistant Professor of Chemistry, University of British Columbia, Vancouver, B.C.
W. H. Vining, B.Sc., M.Sc.	Queen's	With Roessler & Hasslacher Company, Niagara Falls, N.Y.
O. J. Walker, B.A., M.A., Ph.D.	Saskatchewan	Associate Professor of Chemistry, University of Alberta, Edmonton, Alta.
E. E. Watson, B.Sc., M.Sc.	McGill	Research Student, Cambridge University, Cambridge, England.
Miss M. Weinberg, B.A., M.A., M.Sc.	Manitoba	Married.
E. F. Whyte, B.A., M.A., Ph.D.	Dalhousie	Dominion Analyst, Dominion Department of Health, Halifax, N.S.
J. O. Wilhelm, B.Sc., M.A.	Saskatchewan	Technical Assistant, Department of Physics, University of Toronto, Toronto, Ont.
D. Wolochow, B.A., M.A., B.Sc.	Saskatchewan	Department of Chemistry, Univ. of Saskatchewan, Saskatoon, Sask.
C. A. H. Wright, B.Sc., M.Sc., Ph.D.	British Columbia	Chemical and Fertilizer Department, Consolidated Mining & Smelting Company, Trail, B.C.
K. S. Wyatt, B.A., B.Sc.	Mount Allison	Research Chemist, Detroit-Edison Co., Detroit, Mich.
W. S. Yarwood, B.Sc., M.Sc.	Manitoba	With Dr. F. B. Williams, Consulting Geologist, Calgary, Alta.
F. H. Yorston, B.Sc., M.Sc., Ph.D.	McGill	With J. T. Donald & Co., 42 Belmont Street, Montreal, Que.
E. C. 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	Assistant Professor of Physics, University of Manitoba, Winnipeg, Man.

FINANCIAL STATEMENT FOR THE FISCAL YEAR ENDING MARCH 31st, 1929.

RECEIPTS

Appropriation from Parliament		$300,000.00
Grant from Sun Life Assurance Company		10,000.00
Miscellaneous revenue, including refunds		13,366.56
		$323,366.56

EXPENDITURES

Grants in aid of research		$193,977.16
Fellowships	$5,470.00	
Studentships	16,800.00	
Bursaries	21,450.00	
		43,720.00
Laboratory equipment and operation		2,533.15
Publication of reports and bulletins		819.27
Administrative expenses of associate committees		1,465.85
General administration		11,867.64
Travelling expenses of members of National Research Council and staff		9,200.14
Travelling expenses of associate committees		13,496.00
Salaries and honoraria		42,925.61
Library		3,107.42
		$323,112.24
Refund to Receiver General		254.32
		$323,366.56

APPENDIX "A"

14–15 GEORGE V.

Chap. 64

THE RESEARCH COUNCIL ACT.

(Assented to July 19th, 1924.)

HIS MAJESTY, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:

1. This Act may be cited as The Research Council Act, 1924.

2. In this Act, unless the context otherwise requires,—

(a) "Committee" shall mean the Committee of the Privy Council on Scientific and Industrial Research;

(b) "Chairman" shall mean the Chairman of the Committee of the Privy Council on Scientific and Industrial Research;

(c) "Council" shall mean the Honorary Advisory Council for Scientific and Industrial Research;

(d) "President" shall mean the President of the Honorary Advisory Council for Scientific and Industrial Research.

3. There shall be a Council to be called The Honorary Advisory Council for Scientific and Industrial Research.

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.

(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.

(3) Any retiring members shall be eligible for reappointment.

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.

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.

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.

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.

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 payments for travelling and other expenses in connection with the work of the Council as may be approved by the Governor in 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 industires 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;

(d) To 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;

(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.

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.

(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.

12. All the receipts and expenditures of the Council shall be subject to examination and audit by the Auditor General.

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.

(2) The Council shall, after the conclusion of the fiscal year, make a report to the committee containing the report of the President of 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.

14. Chapter twenty of the statutes of 1917 is repealed.

APPENDIX "B"

List of Papers covering Researches carried out with Assistance from the National Research Council

Title of Paper	Author	Where Published	Date Published
ANATOMY			
The Rate of Growth of the Sea Mussel (*Mytilus edulis L.*) at St. Andrews, N.B., Digby, N.S., and in Hudson Bay.	Mossop, Miss B. K. E.	Trans. of the Royal Can. Institute.	1922
A Study of the Sea Mussel (*Mytilus edulis* L.)	Mossop, Miss B. K. E.	Cont. to Can. Biology.	1921
ANIMAL HUSBANDRY			
A Statistical Study of the Head Length Variability of Bovine Spermatozoa and its Application to the Determination of Fertility.	Savage, A., Williams, W. W. and Fowler, N. M.	Trans. of Roy. Soc. of Can. Sec. V.	1927
Methods of Determining the Reproductive Health and Fertility of Bulls; a review with additional notes.	Williams, W. W. and Savage, A.	Ithica, N.Y., Cornell Veterinarian.	Oct., 1927
BACTERIOLOGY			
Effect of Bacillary White Diarrhoea Infection on Egg Production.	Asmundson, V. S. and Biely, Jacob.	Poultry Sci. Vol. VII, No. 6.	Sept., 1928
Control of Bacillary White Diarrhoea Infection of Poultry in British Columbia.	Biely, Jacob.	Scientific Agri. Vol. IX, No. 7.	Mar., 1929
Red Discolouration of Cured Codfish.....	Harrison, F. C. and Kennedy, Miss M.	Ottawa, National Research Council, Report No. 11.	1922
Red Discolouration of Cured Codfish (Scientific Data).	Harrison, F. C. and Kennedy, Miss M.	Roy. Soc. of Can. Sec. V.	
Discolouration, Smut or Blackening of Canned Lobster.	Harrison, F. C. and Hood, E. G.	Ottawa, National Research Council, Report No. 12	1923
Discolouration, Smut or Blackening of Canned Lobster (Scientific Data).	Harrison, F. C. and Hood, E. G.	Roy. Soc. of Can. Sec. V.	
Bacteriology of Certain Sea Fish.....	Harrison, F. C., Perry, Miss H. M. and Smith, P. W. P.	Ottawa, National Research Council, Report No. 19.	1926
Motility of Bacteria as Effected by Hydrogen-ion Concentration.	Reed, G. B. and MacLeod, D. J.	Journal of Bacteriology.	Mar., 1924
Pigments of Pseudomonas Pyocyaneus.....	MacLeod, D. J.	Thesis for M.A. degree, Queen's University, Kingston, Ont.	Apr., 1923
Effects of Hydrogen-ion and Salt Concentration upon the Morphological Structure and upon Formation of Certain Bacteria.	MacLeod, D. J.....	Thesis for M.A. degree, Queen's University, Kingston, Ont.	Apr., 1923
Discolouration in Canned Lobsters.....	Reed, G. B. and MacLeod, D. J.	Report of Biological Board of Canada.	1924
The Bacterial Content of Graded Butter....	Sadler, W. and Vollum, R. L.	Trans. Roy. Soc. of Canada, Sec. V.	1923
An Attenuated Streptococcus Lacticus Strain (Kruse).	Sadler, W. and Vollum, R. L.	Trans. Roy. Soc. of Canada, Sec. V.	1923
The Relation or Bacteria to the Quality of Graded Butter.	Sadler, W. and Vollum, R. L.	Ottawa, National Research Council, Report No. 16.	1926
The Duration of B. Welchii Antitoxin Immunity in Rabbits.	Reed, G. B. and Spence, Miss C. M.	Jour. of Infectious Diseases.	1927
The in vivo Action of B. Welchii Toxin in Erythrocytes in Comparison with other Haemotoxins.	Reed, G. B., Orr, J. H. and Spence, Miss C. M.	Jour. of Infectious Diseases.	1927
BIOCHEMISTRY			
The Parathyroid Gland.....	Collip, J. B.....	Harvey Lectures for 1925-26	1927
The Purification of Pepsin, its Properties and Physical Characters.	Forbes, J. C.....	Jour. of Biol. Chemistry	Feb., 1927
Some Problems of the Fox-raising Industry	Hunter, Andrew.....	Ottawa, National Research Council, Bulletin No. 8.	1920
The Antipressor Fraction from Liver Tissue and its Physiologic Action.	James, A. A., Laughton, N. B. and Macallum, A. Bruce.	American Medical Association Jour. Vol. 87.	July 31, 1926
Preliminary Note on the Distribution of Glucosides in Western Canadian Plants.	McCullagh, D. Roy....	Trans. Roy. Soc. of Canada, 1926, XX, Sec. V.	1926
Food Requirements of the Ranch Fox.....	Smith, G. Ennis.....	Ottawa, National Research Council, Bulletin No. 9.	1921
The Enzymes of B. Coli Communis.....	Young, E. G. and Gray, E. C.	Proc. Roy. Soc. London, Vol. 92.	1921
On the Optical Rotatory Power of Crystalline Ovalbumin and Serum Albumin.	Young, E. G.....	Proc. Roy. Soc. London, Vol. 93.	1922
The Coagulation of Protein by Sunlight..	Young, E. G.....	Proc. Roy. Soc. London, Vol. 93.	1922
BIOLOGY			
The Distribution and Economic Importance of Mollusca in Lake Nipigon.	Adamstone, F. B.....	Univ. of Toronto Studies, Biol. Series No. 22.	1923

Title of Paper	Author	Where Published	Date Published
BIOLOGY—*Con.*			
The Bottom Fauna of Lake Nipigon.....	Adamstone, F. B.....	Univ. of Toronto Studies, Biol. Series No. 22.	1924
The Bottom Organisms of Lake Nipigon....	Adamstone, F. B. and Harkness, W. J. K.	Univ. of Toronto Studies, Biol. Series No. 24.	1923
The Distribution and Economic Importance of the Bottom Fauna of Lake Nipigon with the Appendix on the Bottom Fauna of Lake Ontario.	Adamstone, F. B.....	Univ. of Toronto Studies, Biol. Series No. 25.	1924
The Life History of Exeristes Roborator Fab., a Parasite of the European Corn Borer, Pyrausta Nubilalis Hubn.	Fox, J. H.....	Ottawa, National Research Council, Report No. 21.	1927
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On the Tracks of X-ray in Helium and other Gases.	McQuarrie, W. C.....	Trans. Roy. Soc. of Can., Vol. 17.	1923
The Electrochemical Behaviour of Silicate Glasses III. Cathode and Anode Gases.	Mulligan, M. J., Ferguson, J. B. and Rebbeck, J. W.	Jour. Phys. Chem., Vol. XXXII.	May, 1928
The Electrochemical Behaviour of Silicate Glasses. IV. Solid Electrolytic Deposits.	Mulligan, M. J., Ferguson, J. B. and Rebbeck, J. W.	Jour. Phys. Chem., Vol. XXXII.	June, 1928
The Electrochemical Behaviour of Silicate	Ferguson, J. B.,	Jour. Phys. Chem., Vol.	July, 1928

Title of Paper	Author	Where Published	Date Published
PHYSICS—*Con.*			
Glasses. V. The Electrical Properties of the Anode Layers.	Mulligan, M. J. and Rebbeck, J. W.	XXXII.	
The Scattering of Electrons from Single Crystals of Nickel.	Patterson, A. L.....	Nature.	July 9, 1927
Uber das Gibbs-Ewaldsche reziproke Gitter und den dazugehorigen Raum (On the Reciprocal Lattice of Gibbs and Ewald and the Space Connected with it).	Patterson, A. L.....	Zeitschrift für Physik	1927
Uber die Messung der Grosse von Kristallteilchen mittels Roentgen Strahlen.	Patterson, A. L.....	Zeitschrift für Physik Kristallographie.	1927
Intensity Measurements of Spectral Lines.	Robertson, J. K.....	Jour. Op. Soc. of Am.	Nov., 1923
A Method of Exciting Spectra of Certain Metals.	Robertson, J. K.....	Phil. Magazine.	Apr., 1926
Intensities in the Argon Spectrum.....	Lowe, P. and Rose, D. C.	Trans. R.S.C., Vol. XVIII	1924
The Ranges of β-Rays.....	Sargent, B. W.....	Trans. R.S.C., Vol. XXII, Section III.	1928
Note on the Extreme Ultra-violet Spectrum of the Carbon Arc.	Shaver, W. W.....	Trans. Roy. Soc. of Can., Vol. 17, III.	1923
Arc, Spark and Absorption Spectra of Argon.	Shaver, W. W.....	Trans. Roy. Soc. of Can., Vol. 16, III.	1922
Note on the Electrodeless Discharge in the Vapours of Phosphorous and Sulphur.	Shaver, W. W.....	Trans. Roy. Soc. of Can., Vol. 18, III.	1924
On the Extreme Ultra-violet Spectra of Alkali Metals.	Shaver, W. W.....	Trans. Roy. Soc. of Can., Vol. 18, III.	1924
The Doublet Separation of the Balmer Lines.	Shrum, G. M.....	Proc. Roy. Soc. London, A. Vol. 105.	1924
On the Prism Method of Determining the Refractive Indices of Metallic Vapours.	Smith, H. G.....	Trans. Roy. Soc. of Can., Vol. 16.	June, 1922
Changes in the Refractivities of Excited Atoms and Molecules.	Smith, H. G.....	Trans. Roy. Soc. of Can., Vol. 17.	June, 1923
On the Fine Structure of the Band Spectra of Sodium, Potassium, and Sodium-potassium Vapours.	Smith, H. G.....	Proc. Roy. Soc., Vol. A106.	June, 1923
On the Depression of the Centre of a Thin Circular Disc.	Smith, Stanley.....	Trans. Roy. Soc. of Can.	1922
A Note on the Spectrum of Doubly Ionised Scandium.	Smith, Stanley.....	Proc. National Academy of Science, Wash.	Feb., 1927
Wave-length Measurements in the Vacuum Spark Spectrum of Lead from 2200A to 5000A.	Smith, Stanley.....	Trans. Roy. Soc. of Can.	1928
Some Multiplets of Doubly Ionized Lead.	Smith, Stanley.....	Proc. Nat. Acad. Sc., Vol. 14, No. 11.	Nov., 1928
Some Multiplets of Singly Ionized Thallium.	Smith, Stanley.....	Proc. Nat. Acad. Sc., Vol. 14, No. 11.	Dec., 1928
A New View of Surface Forces.....	Taylor, Wilson.....	Book published by the University Press, Toronto.	
On the Electrical Discharge in Mixed Gases.	Terroux, F. R.....	Physical Review.	Dec., 1926
Dispersion of an Electron Beam.....	Watson, E. E.....	Phil. Magazine.	April, 1927
On the Critical Frequency of Pulsation of Tones.	Weinberg, Miss M. and Allen, Frank	Phil. Mag. Series 6, Vol. XLVII, No. 277.	Jan., 1924
On the Effect of Aural Fatigue upon the Critical Frequency of Pulsation of Tones.	Weinberg, Miss M. and Allen, Frank	Phil. Mag., Series 6, Vol. XLVII, No. 277.	Jan., 1924
On the Effect of Fatiguing the Ear with a Combination of Two or more Tones.	Weinberg, Miss M.....	Phil. Mag., Series 6, Vol. XLVII, No. 277.	Jan., 1924
The Spark Spectra of Indium and Gallium in the Extreme Ultra-violet Region.	Weinberg, Miss M.....	Proc. Roy. Soc. of Can., Sec. A., Vol. 107.	1925
The Crystal Structure of Solid Oxygen.	Wilhelm, J. O.....	Phil. Magazine.	Feb., 1927
An Extension of the Graphical Method of Determining Crystal Structures to the Orthorhombic System.	Wilhelm, J. O.....	Trans. Roy. Soc. of Can., Vol. 21, Sec. 3.	1927
Application of the Theory of Magnetism to the Calculation of Atomic Diameters.	Young, J. F. T.....	Proc. Roy. Soc. of Can., Vol. XVI.	1922
A Method of Increasing the Dispersion of a Constant Diviation Spectroscope.	Young, J. F. T.....	Jour. Op. Soc. Am., Vol. 7.	1923
The Crystal Structure of Various Hensler Alloys by the use of X-ray.	Young, J. F. T.....	Phil. Magazine, XLVI.	1923
Survey of General Conditions of Industrial Hygiene in Toronto.	Assoc. Committee on Ind. Fatigue.	Ottawa, National Research Council, Report No. 7.	1921
Histamine and Salivary Secretion.....	MacKay, Miss M. E...	Am. Jour. of Physiology	1927
The Vascular Reaction of the Pilocarpinized Submaxillary Gland to Histamine.	MacKay, Miss M. E...	Jour. of Pharmacology and Exper. Therapeutics.	1927
The Relationship between Rigor Mortis and the Glycogen, Lactic Acid and Free Phosphorus of Fish Muscle.	Leim, A. H., Macleod, J. J. R. and Simpson, W. W.	Contr. to Can. Biology	1927
The Immediate Post Mortem Changes in Fish Muscle.	Macleod, J. J. R. and Simpson, W. W.	Contr. to Can. Biology.	1927
Changes Occurring in Mammalian Muscle immediately after Death.	Macleod, J. J. R. and Simpson, W. W.	Proc. Soc. Expt. Biol. and Med.	1926
The Effects of Asphyxia and Isletectomy on the Blood Sugar of Myoxocephalus and Ameiurus.	Simpson, W. W.....	Am. Jour. Physiol.	July, 1926
Immediate Post Mortem Changes in Mammalian Muscle.	Simpson, W. W. and Macleod, J. J. R.	Trans. Roy. Soc. of Can., S. 5.	1926

Title of Paper	Author	Where Published	Date Published
PLANT BIOCHEMISTRY			
Is the Apparent Winter-killing of Sweet Clover and Red Clover a Result of Disease Injury?	Newton, R. and Brown, W. R.	Sc. Agriculture, Ottawa.	Nov., 1924
Seasonal Changes in the Composition of Winter Wheat Plants, in Relation to Frost Resistance.	Newton, R. and Brown, W. R.	Jour. of Agricultural Sci., Cambridge.	Oct., 1926
The Extraction of Plant Tissue Fluids and Their Utility in Physiological Studies.	Newton, R., Brown, W. R. and Martin, W. M.	Plant Physiology, Vol. 1, No. 1.	Jan., 1926
Apparatus for Continuous Dialysis at a Low Temperature.	Newton, R. and Martin, W. M.	Plant Physiology, Vol. 2, No. 1.	Jan., 1927
ZOOLOGY			
Bionomics of the Tabanidae of the Canadian Prairie.	Cameron, A. E.....	Bulletin of Entomological Research, Vol. 17, Pt. 1.	July, 1926
A Local Outbreak of the Winter or Moose Tick (Dermacentor Albipictus) in Saskatchewan.	Cameron, A. E.....	Bulletin of Entomological Research, Vol. 17, Pt. 3.	March, 1927
The Occurrence of Cuturelva (Diptera, Oestridae) in Western Canada.	Cameron, A. E.....	Parasitology, Vol. 18, No. 4	Dec. 14, 1926
The Hydromedusae of the West Coast of North America, with Special Reference to those of the Vancouver Island Region.	Foerster, R. E.....	Contr. to Can. Biol., N.S., Vol. 1.	1923
Studies in the Ecology of the Sockeye Salmon (Oncorhynchus Nerka).	Foerster, R. E.....	Contr. to Can. Biol., N.S., Vol. 11, Pt. 2.	1925
The Larva and Breeding-place of Aedes Aldrichi.	Hearle, E.....	Can. Entomologist.	Feb., 1921
Mosquito Control Investigations in British Columbia.	Hearle, E.....	Sc. Agriculture.	Feb., 1921
The Importance of Mosquitoes, with Notes on B.C. Species.	Hearle, E.....	Proc. B.C. Ent. Soc. Nos. 13 and 15.	1921
Some Mosquito Problems of British Columbia.	Hearle, E.....	Ont. Ent. Soc. Report No. 51.	1921
An Aerial Survey of Mosquito Breeding Places.	Hearle, E.....	Agr. Gazette, Ottawa, LX. 3	1923
A New Mosquito from British Columbia..	Hearle, E.....	Can. Entomologist.	Jan., 1923
Mosquitoes of the Lower Fraser Valley, B.C. and their Control.	Hearle, E.....	Ottawa, National Research Council, Report No. 17.	1926
The Mosquito Control Act of British Columbia.	Hearle, E.....	Agr. Jour. B.C. VI.	1921
ZYMOLOGY			
A Study of Bacterial Association. (1) The Biochemistry of the Production of Lactic Acid.	Speakman, H. B. and Phillips, J. F.	Jour. of Bacteriology.	Mar., 1924

APPENDIX "C"

Regulations Governing 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 seven 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, and concise statement of adequacy of general equipment of laboratory wherein investigation is to be carried on. If the applicant has asked for or has received 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 of 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 materials 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 expenditures, 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.

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 will make due acknowledgment 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.

15. No grant shall be awarded unless the applicant has submitted a satisfactory resumé of the previous work and the present state of knowledge in connection with the proposed research.

16. No research assistant may be appointed nor may any grant be paid by the Council until a detailed statement of the training, experience, and general qualifications of the proposed assistant has been submitted to the National Research Council and the proposed salary rate approved by the Council.

APPENDIX "D"

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 of 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 (a) be a *bona fide* graduate of a university or college in which special attention is given to scientific study, or (b) 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, Physics and Mathematics.

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. 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, must be submitted. All such recommendations must be forwarded to the National Research Council by the professor recommending the candidate and through the head of the department concerned. The candidate 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 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.

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: 40 per cent on October 1; 50 per cent on February 1, or thereafter, on receipt of a satisfactory first half-yearly report; 10 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 $750.00.

16. Applicant 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 $1,000.00.

21. Application for a studentship must be made not later that 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 $1,200.00.

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.

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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.

Address all communications to,

The Secretary,
National Research Council,
Ottawa, Ontario.

January, 1929.

APPENDIX "E"

Publications of the National Research Council

Report Number	Title	Author
1	The Briquetting of Lignites	R. A. Ross, E.E., D.Sc., 1918.
2	The Recovery of Vapours from Gases	Harold S. Davis, M.A., Ph.D., and Mary Davidson Davis, B.A., 1918.
3	The De-tarring of Gas by Electrical Precipitation.	J. G. Davidson, Ph.D., 1918.
4	Nicotine and Tobacco Waste	A. D. Hone, M.A., 1919.
5	Canadian Waste Sulphite Liquor as a Source of Alcohol	V. K. Krieble, 1919.
6	An Investigation into the Question of Early Putrefaction of Eviscerated Fish in Which the Gills have been Left	L. Gross, M.A., 1919.
7	Survey of General Conditions of Industrial Hygiene in Toronto	The Associate Committee on Industrial Fatigue of the National Research Council, 1921.
8	A Method of Smelting Titaniferous Iron Ore	W. M. Goodwin, 1921.
9	Food Requirements of the Ranch Fox	G. E. Smith, B.A.Sc., 1921.
10	Fuel Saving Possibilities in House Heating	L. M. Arkley and James Govan, 1922.
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., 1922.
12	The Discolouration, Smut, or Blackening of Canned Lobster	F. C. Harrison, D.Sc., F.R.S.C., and E. G. Hood, Ph.D., 1923.
13	Cultural Criteria for the Distinction of Wood-destroying Fungi	Clara W. Fritz, B.A., M.Sc., 1924.
14	The Utilization of the Low Grade Iron Ores of Canada	Sub-committee on Iron Ores of the National Research Council, J. G. Morrow, Steel Company of Canada, Hamilton, Ontario, Chairman, 1924.
15	Marine Borers on the Atlantic Coast of Canada	R. H. M'Gonigle, B.A., 1925.
16	The Relation of Bacteria to the Quality of Graded Butter	Wilfrid Sadler, N.D.D., B.S.A., M.Sc., and R. L. Vollum, M.A., 1926.
17	The Mosquitoes of the Lower Fraser Valley, British Columbia and their Control	Eric Hearle, M.Sc., 1926.
18	Investigations on the Treatment of Nova Scotia Oil Shales	A. E. Flynn, A.R.S.M., 1926.
19	Bacteriology of Certain Sea Fish	F. C. Harrison, D.Sc., F.R.S.C., 1926.
20	Consideration of the Relation Between the Distribution of Teredo Navalis and Temperature and Salinity of its Environment	R. H. M'Gonigle, B.A., 1926.
21	The Life History of Exeristes Roborator Fab., a Parasite of the European Corn Borer	J. H. Fox, M.A., 1927.
22	An Experimental Study of Sieving	J. B. Porter, Ph.D., D.Sc., 1928.
23	The Storage of Apples in Air-cooled Warehouses in Nova Scotia	S. G. Lipsett, Ph.D., 1928.
24	The Drying of Wheat	Associate Committee on Grain Research, 1929.

BULLETINS

Bulletin Number	Title	Author
1	The Need of Industrial Research in Canada	Frank D. Adams, Sc.D., LL.D., F.R.S., 1918.
2	Researches on Sound Measurement with Reference to the Testing of Fog Signal Machinery	L. V. King, M.A., D.Sc., F.R.S.C., 1918.
3	How to Handle Frozen Fish	E. E. Prince, D.Sc., LL.D., 1918.
4	Hints on Frozen Fish	E. E. Prince, D.Sc., LL.D., 1918.
5	Science and Industry	Prof. J. C. Fields, Ph.D., F.R.S., 1918.
6	The Heating of Houses, Coal and Electricity Compared. (Out of Print)	A. S. L. Barnes, 1918.
7	The Manufacture of Ethyl-alcohol from Wood Waste. (Out of Print)	G. H. Tomlinson, B.A., 1919.
8	Some of the Problems of the Fox Raising Industry. (Out of Print)	Andrew Hunter, M.A., M.B., Ch.B. (Edin.), 1920
9	The Honorary Advisory Council for Scientific and Industrial Research and its Work. A brief Resumé of the activities of the Council up to 1921	Frank D. Adams, Sc.D., LL.D., F.R.S., 1921.
10	A Plan for the Development of Industrial Research in Canada	F. R. Ruttan, B.A., M.D., F.R.S.C., 1921.
11	Nitrogen Fixation	Nitrogen Fixation Committee, Prof. J. C. McLennan, Chairman, 1924.
12	Nitrogen in Industry	Nitrogen Fixation Committee, Prof. J. C. McLennan, Chairman, 1926.
13	Interim Report on Protein Content as a Factor in Grading Wheat	Associate Committee on Grain Research, 1929.

APPENDIX "F"

Canadian Engineering Standards Association.

List of Specifications Published March 31, 1929.

No.

A1 —1928—Standard Specification for Steel Railway Bridges (3rd edition).

A1a—1928—Material Specifications, Steel Railway Bridges (2nd reprint).

C2 —1920—Standard Requirements for Distribution Type Transformers.

C3 —1924—Standard Specification for Galvanized Telegraph and Telephone Wire (reprint).

B4 —1921—Standard Specification for Wire Rope for Mining, Dredging and Steam Shovel Purposes.

A5 —1927—Standard Specification for Portland Cement (2nd edition).

A6 —1929—Standard Specification for Steel Highway Bridges (2nd edition).

D7 —1922—Standard Specification for Flexible Steel Wire Rope and Strand for Aircraft Purposes.

G8 —1923—(replaced by G26—1929 and G27—1929. See below.)

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 Gates.

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.

A19—1926—Standard Classification of Items of Highway Expenditure.

A20—1927—Standard Specification for Movable Bridges.

C21—1927—Standard Specification for Control Cable for Electrical Power Plant Equipment.

C22—1927—Canadian Electrical Code—Part I.

G24—1929—Standard Specification for Sampling for Check Analysis of Steel Billets, Bars and Shapes.

G25—1929—Standard Specification for Carbon Steel Billets and Bars of Forging Quality.

*G26—1929—Standard Specification for Commercial-quality Hot-rolled Bar Steels.

*G27—1929—Standard Specification for Commercial Cold-finished Bar Steels and Cold-finished Shafting.

NOTE:—G26—1929 and G27—1929 are published in one volume.

APPENDIX "G"

List of Associate Committees

Associate Committee on Grain Research
Associate Committee on Wool
Associate Committee on Tuberculosis Research
Associate Committee on Cereal Rust
Associate Committee on Field Crop Diseases
Associate Committee on Coal Classification and Analysis
Associate Committee on Magnesite
Associate Committee on Mining and Metallurgy
Associate Committee on Nitrogen Fixation
Associate Committee of Chemists
Associate Committee on Spray Painting
Associate Committee on Biology
Associate Committee on Heating and Insulation
Associate Committee on Engineering Standards
Associate Committee on Physics and Engineering Physics
Associate Committee on Aeronautical Research
Associate Committee on Helium
Associate Committee on New Brunswick Forest Problems
Associate Committee on Accurate Plot Work
Associate Committee on Oceanography
Associate Committee for British Columbia
Associate Committee on Library
Associate Committee on Animal Diseases
Associate Committee on Apple Slacks
Associate Committee on Biophysics
Associate Committee on Electrical Measuring Instruments
Associate Committee on Patents and Awards

APPENDIX "H"

LIST OF MEMBERS OF ASSOCIATE COMMITTEES

Associate Committee on Grain Research

H. M. Tory, M.A., D.Sc., LL.D., F.R.S.C., F.R.H.S., Chairman — President, National Research Council, Ottawa, Ont.

F. J. Birchard, B.A., Ph.D — Research Chemist, Dominion Grain Laboratory, Winnipeg, Man.

W. F. Geddes, B.S.A., M.A., F.C.I.C — Professor of Agricultural Chemistry, Manitoba Agricultural College, Winnipeg, Man.

T. J. Harrison, B.S.A — Professor of Field Husbandry, Manitoba Agricultural College, Winnipeg, Man.

W. C. Murray, M.A., LL.D., F.R.S.C — President, University of Saskatchewan, Saskatoon Sask.

Robert Newton, Ph.D — Professor of Field Crops and Plant Biochemistry, University of Alberta, Edmonton, Alta.

Edgar Stansfield, M.Sc — Professor of Industrial Research, University of Alberta, Edmonton, Alta.

T. Thorvaldson, Ph.D — Professor of Chemistry, University of Saskatchewan, Saskatoon, Sask.

Associate Committee on Wool

H. M. Tory, M.A., D.Sc. LL.D., F.R.S.C., F.R.H.S., Chairman — President, National Research Council, Ottawa, Ont.

H. Barton, B.S.A — Dean of the Faculty of Agriculture and Professor of Animal Husbandry, Macdonald College, Que.

Alfred Burton, Esq — Manager, Middlesex Mills, London, Ont.

S. Chagnon, Esq — Live Stock Branch, Department of Agriculture, Quebec, Que.

A. E. Craig, Esq — Sales Manager, Barrymore Cloth Company, 1179 King St. W., Toronto, 2, Ont.

D. C. Dick, Esq — President, Textile Dyers Corporation, Cobourg, Ont.

W. H. Fairfield, Esq — Superintendent, Experimental Farm, Lethbridge, Alta.

J. H. Grisdale, B.Agr., D.Sc.A — Deputy Minister, Department of Agriculture, Ottawa, Ont.

Major D. Hallam — Secretary, Canadian Woollen and Knit Goods Manufacturers Association, 530 Bay Street, Toronto, 2, Ont.

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