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# UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER

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# UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER

MOSST
UNIVERSITY BRANCH

NOT FOR PUBLICATION -- FOR DISCUSSION ONLY

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# I INTRODUCTION

This document provides background information on a number of programs and mechanisms which stimulate the transfer of technology between universities and industry. A broad range of approaches are reviewed for Canada as well as other countries.

Particular emphasis is focussed on the Canadian experience, including a discussion of Federal programs and mechanisms, provincial research institutes, university based research institutes and technological and scientific societies. The review of the United States experience is mainly concentrated on recent National Science Foundation Experiments. The last section of this report contains a brief description of various approaches to technology transfer in other selected countries.

Since the work for this study was carried out, the Government has approved the establishment of two university-based Industrial Innovation Centres in Canada. They are located at the Ecole Polytechnique in Montreal, and at the University of Waterloo. These centres are designed to provide a focus for the technical, market, legal and patent advice necessary to effect the transfer of technology, and to establish the entrepreneurial activity needed to spin-off new businesses based on technology developed in, or with the assistance of university laboratories; that provide the technical evaluation of ideas, in order to ensure that the market potential of any idea is adequately explored and to assist in the establishment of new technology-based ventures; and that provide R&D training that is tuned to the needs of industry, and which orients students towards entrepreneurship and innovation.

(See also Appendix VII.)

## II. CANADA

### a) Federal Programs and Mechanisms

The Department of Industry, Trade and Commerce (IT&C) is the principal federal department responsible for the support of science and technology in industry. Of the numerous IT&C industrial support programs, three are designed, in part, to stimulate industrial research through university-based mechanisms. The National Research Council (NRC) and the National Sciences and Engineering Research Council (NSERC) are the major federal agencies responsible for the funding support of university research. Analysis of the various NRC and NSERC programs has revealed that three major activities are specifically designed to stimulate technology transfer from the university to industry. More details on each of these IT&C, NRC and NSERC programs are provided below.

Other federal programs which may indirectly stimulate the transfer of research from the university sector into industry through such indirect mechanisms as consulting or contract work are provided in Appendix I.

The Department of Industry, Trade and Commerce (IT&C)

Industrial Research Institute Program

Since 1967, IT&C has sponsored ten university-based Industrial Research Institutes with the following program objectives[1]:

- to encourage universities to provide scientific services and to conduct research and development projects for industrial firms unable to maintain adequate facilities and personnel of their own;
- to encourage universities to provide specialist services to larger companies wishing to enter new fields or to undertake special research projects which do not justify the acquisition of permanent staff;
- to help alleviate the shortage of scientific and technical resources existing in some areas of Canadian industry;
- to provide universities, through closer association with industry, the opportunity to coordinate more closely their educational and training programs with the current requirements of industry; and

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[1] More detail on each of these Institutes is shown in Appendix II.

- to foster greater interaction between industry and universities, and thus assist universities to gain a better appreciation of industrial problems and enable industry to become aware of pertinent scientific and technical work being undertaken in universities.

Federal assistance takes the form of grants to underwrite the administrative cost of operating an institute during its formative years when income from contracts is insufficient to meet start-up expenditures. Each institute is expected to become self-supporting within five to seven years.

By July of 1978, nine industrial institutes were operating; seven of which were self-supporting. The remaining two institutes, one located at the Université du Québec à Montréal and the other at the University of Manitoba are still receiving financial support as shown in Table 1, and it is anticipated that they will be financially independent by 1980.

The Waterloo Research Institute, the first institute to become self-supporting, has been a major success story and deserves special attention. From 1967 to 1973 this institute received a total grant of $244,557. As of 1975, it had completed its second year of self-supporting operation. For the year 1975, contracts exceeding one million dollars were obtained and the institute has now reported even greater success in obtaining higher dollar value contracts. This success is mainly attributed to increased client confidence. A greater amount of time and effort is now being devoted to the practical exploitation in industry of ideas and developments from within the university and it is hoped that successful completion will give rise to income from royalties.

The establishment of the Waterloo Industrial Research Institute has been instrumental in creating a stimulative industrial environment for fostering innovation and technology transfer. The university has developed an aggressive program to generate external funding through contract research where direct technology transfer from the university to the marketplace is actively encouraged. As well, Waterloo now administers a successful Inventors Assistance Program, the first of its kind in Canada.

A large majority of research institutes are operating now on a self-supporting basis. This is a clear indication that they have been providing satisfactory R&D services to their industrial clients. As well, there are encouraging signs that their activities have been partially successful in bridging the gaps between industry and universities. For example, in 1974, seventy-seven faculty members and seventy-five students were involved in contract activity at McGill, while at Windsor, thirty-nine faculty members and thirty-seven students participated in the work of the institute.

Centres of Advanced Technology Program[1]

This program was introduced in 1970. It was principally designed to encourage universities and others with research capabilities to establish centres of expertise in specific technologies.

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[1] For a detailed analysis of these Centres, see Appendix II.

The major objectives of this program are:

- to provide industrial assistance in basic and applied research;
- to provide industrial technical development assistance;
- to provide graduate and undergraduate training relevant to industrial needs; and
- to promote industrially relevant research by graduate students and universities.

These centres are expected to become self-supporting within a seven year period, at which time they are intended to continue to provide industry with the same services.

Twelve Centres of Advanced Technology have been established by IT&C (seven at the universities, and five with provincial research councils). These centres, established with grants of up to $200,000 per annum for three to seven year periods, are based on an existing technical capability of the patent organization which is thus upgraded and expanded to the point of being able to offer advanced advice and assistance to Canadian industry. Currently, IT&C is funding four university-based centres as shown in Table 1.

Total grants authorized to March 31, 1978 amounted to $6,505,000. Appendix II and Table 1 provide supplementary details on this program.

Management Advancement Program

The Management Advancement Program of IT&C has resulted in the establishment of two management advisory institutes. One institute is located at the University of Alberta, the other at Laval University. Each institute will receive a total grant of $60,000 per year (starting in 1979-80) for a three year period at which time they are expected to be self supporting. It is anticipated by IT&C that these institutes will provide a good base for improving the weak university small business interface which presently exists.

National Research Council (NRC) and the Natural Sciences and Engineering Research Council (NSERC)

Three major programs designed to stimulate university-industry technology transfer were developed by the National Research Council. In 1978 these programs were transferred to the new Natural Sciences and Engineering Research Council (NSERC). Provided below is a discussion of each of these programs.

TABLE 1

ESTIMATE OF 1978-79 GRANTS BY IT&C TO UNIVERSITIES

FOR INDUSTRIAL RESEARCH

| | TERMINATION DATE | ESTIMATED GRANTS 1979 |
|---|---|---|
| Industrial Research Institute | | |
| Université du Québec à Montreal | 1980 | $ 60,000 |
| University of Manitoba | 1980 | 60,000 |
| Sub-Total | | 120,000 |
| Centres of Advanced Technology | | |
| Systems Analysis, Control and Design Activity (Western University) | 1980 | 175,000 |
| Biomedical Instrumentation Development Unit (University of Toronto) | 1981 | 175,000 |
| Waterloo Centre for Process Development (University of Waterloo) | 1983 | 200,000 |
| Centre for the Measurement and Control of Particles and Vapour (University of McGill) | 1984 | 200,000 |
| Sub-Total | | 750,000 |
| Management Advancement Program | | |
| University of Alberta | 1982 | 60,000 |
| University of Laval | 1982 | 60,000 |
| Sub-Total | | 120,000 |
| TOTAL | | $990,000 |

Project Research Applicable in Industry (PRAI) Grants

In 1970 NRC developed Project Research Applicable in Industry (PRAI) Grants to university staff aimed at overcoming some university/industry difficulties in communication. This program provides short-term complementary support for those whose university research has already led to the identification of a specific and novel technique, process or product promising to be of commercial value to Canadian industry. Total NRC (NSERC) expenditures on this program amounted to $254,000 in 1977-78. Thirty-one grants were made in 1973 and numbers have steadily decreased until in 1977-78 there were only five grants. From preliminary discussions with NRC, it appeared that lack of interest and participation by the universities rather than available money were the main causes for the steady decline in the number of grants awarded. The number of applications has been increased to 27 in the calendar year of 1978.

Industrial Post-Doctoral Fellowships (IPDFs)

The Industrial Post-Doctoral Fellowships (IPDF) Program of NRC (prior to 1978) was designed to encourage highly qualified students who had recently received, or who were about to receive their doctoral degrees, to seek careers with industrial organizations in Canada. Applications are accepted only when submitted by a company on behalf of a candidate. The number of IPDFs in 1977-78 was relatively small, totalling 133 awards. Expenditures amounted to about $1.2 million in that same year. NRC, and now NSERC has stated willingness and capability to provide more awards, however, the number of participants is limited by the small number of proposals received from interested companies.

It should be noted that, for a limited period of time, University Post-Doctoral Fellows may also be eligible for Industrial Post-Doctoral Fellowship Grants to facilitate a transfer of researchers from the universities into industry in a situation where the job market for new academic positions is poor.

Senior Industrial Fellowships Program

The Senior Industrial Fellowships Program is designed to encourage stimulating and productive interchange between the university and industry. The program is directed at staff members of Canadian universities who have little or no industrial experience and it is primarily aimed at those who have been on staff for ten years or less. Fellows may spend a minimum period of one year with industrial organizations in Canada or with certain quasi-industrial federal cooperatives and provincial utilities such as Hydro Quebec. The National Research Council (now NSERC) provides a component of their salary as a supplement to the university's contribution to ensure that the Fellow receives a total amount equal to his normal salary. Payment of the NSERC portion is made to the university. In 1977-78, six Senior Industrial Fellowships were awarded at a total cost of approximately $84,000 as shown in Table 2.

TABLE 2

ESTIMATE OF 1977-78 SUPPORT BY NSERC TO UNIVERSITY-RELATED INDUSTRIAL RESEARCH

| | SUPPORT (77-78) |
|---|---|
| Project Research Applicable in Industry Grants | 254,000 |
| Industrial Post-Doctoral Fellowships | 1,200,000 |
| Senior Industrial Fellowships | 84,000 |
| TOTAL | 1,538,000 |

b) Provincial Research Institutes

The provincial governments in eight of the provinces have established research institutes to provide technical support to provincial industries and to assist in the exploitation of provincial natural resources. The main activities of these institutes is research and development. Although these institutes accounted for only one percent of the estimated R&D in 1975, they play an important role in the transfer of technology from laboratories to production units and act as an interface between the scientific and business community.

Although none of these provincial research institutes are located at Canadian universities most are situated near the university campuses. As such, they have the potential to stimulate the transfer of research results from the universities to industry through mechanisms such as the joint use of university laboratory facilities, consulting and contracting.

NOVA SCOTIA RESEARCH FOUNDATION

The objective of this institute "is to assist in the economic development of Nova Scotia by promoting, stimulating and encouraging the effective utilization of science and technology by industry and government and for this purpose to undertake, either singly or in conjunction with others, such

TABLE 3

SOURCE OF REVENUE NOVA SCOTIA RESEARCH FOUNDATION

| | 1976-77 | | 1975-76 | |
|---|---|---|---|---|
| | $ | % | $ | % |
| Grant - Province of N.S. | 750,000 | 33 | 770,000 | 35 |
| Contracts | 1,423,737 | 63 | 1,322,565 | 61 |
| Investment Income | 91,618 | 4 | 91,629 | 4 |
| Total Revenue | 2,265,355 | 100 | 2,184,194 | 100 |
| | | | | |
| Industrial Contracts | 925,429 | 65 | 740,636 | 56 |
| Government Contracts | 498,308 | 35 | 581,929 | 44 |
| Total Revenue | 1,423,737 | 100 | 1,322,565 | 100 |
| | | | | |
| Industrial Contracts | | | | |
| Nova Scotia | 185,085 | 20 | 171,933 | 23 |
| Other Canadian | 640,682 | 69 | 502,575 | 68 |
| Foreign | 99,662 | 11 | 66,128 | 9 |
| Total Industrial Contracts | 925,429 | 100 | 740,636 | 100 |
| | | | | |
| Government Contracts | | | | |
| Provincial | 128,136 | 26 | 211,620 | 36 |
| Federal | 370,172 | 74 | 357,093 | 62 |
| Foreign | -- | -- | 13,226 | 2 |
| Total Government Operations | 498,308 | 100 | 581,939 | 100 |

SOURCE: Nova Scotia Research Foundation, Annual Report, 1976-77 research, development, surveys, investigations and operations which in the opinion of the Board be deemed appropriate".

The institute is funded by a grant from the provincial government, contracts and invested income. The contracts are from both governments and industry. The government contracts are from the provincial government, federal government and foreign governments. The industrial contracts are from Nova Scotia, other Canadian industries and foreign industries. Total revenue for the institute showed an increase of 7.6 percent in 1976-77 over the previous year. Table 3 shows a detailed account of revenue.

In the year 1976-77 there was a total staff of 94 at the institute made up of a president, vice-president, 2 scientific consultants, 5 managers, 32 professionals, 37 technicians and 16 support staff.

The Corporation is divided into six divisions which include Geophysics, Engineering Physics, Centre for Ocean Technology, Chemistry, Industrial and Information Services, and Operations Research and Marketing.

Fields of research at the institution consisted of industrial research corrosion, pollution control, coal, heavy water processing, chemistry, analytical services, surveys, etc. Major facilities at the institute include an analytical laboratory, pilot plant and glass blowing facilities. The institute's main concern is R&D 50 percent, followed by service and consultation 30 percent, quality control and testing 15 percent and evaluations and surveying 5 percent.

## NEW BRUNSWICK RESEARCH AND PRODUCTIVITY COUNCIL

The Council carries out research, problem-solving and consulting on a cost-recovery basis for clients both in Canada and abroad.

Funding of the institute is by government grants, contracts, etc. Total revenue for the Council showed a 14 percent increase over the previous year. Table 4 shows more detail on revenue for the years 1975-76 and 1976-77.

Fields of application at the institution were natural resources, primary industries, manufacturing industries, service industries, developing countries and the environment.

TABLE 4

NEW BRUNSWICK RESEARCH AND PRODUCTIVITY COUNCIL

| REVENUE | 1976 | 1977 |
|---|---|---|
| Province of New Brunswick Grant | $ 600,000 | $ 600,000 |
| Contract and Income | 1,026,610 | 1,395,622 |
| Total Revenue | 1,626,610 | 1,995,622 |
| % Increase over Previous Year | 14.0 | 13.6 |
| SOURCE OF FUNDS | | |
| Canadian Industry | % 32 | % 23 |
| Canadian Government | 36 | 37 |
| Canadian Provincial Government | 32 | 40 |
| Total | 100 | 100 |

SOURCE: New Brunswick Research and Productivity Council, Fifteenth Annual Report, 1976-77

CENTRE DE RECHERCHE INDUSTRIELLE DU QUEBEC (CRIQ)

The main purpose of the Centre is to contribute to the economic development of Quebec by encouraging innovation in manufacturing enterprises and in particular to the small and medium-sized industries which are in need of research.

In the 1969 Charter, amended in 1970, the National Assembly made a five year subsidy of $20 million to CRIQ on a progressive scale ending in 1974-75. For the year 1975-76, the Centre had to use its own resources. The government approved a new five year subsidy of $30 million for the years 1976-77 to 1980-81. This further financial support will allow the Centre to carry out its basic task of encouraging Quebec's modernization of industry through the development of technological innovation in its enterprises. The Centre provided five types of projects in the electronics, mechanical and material research sectors. These projects were classified as exploratory work, internal projects, technical information, external drafts and external projects.

As of March 31, 1976, the Centre was staffed by 53 engineers and scientists, 16 specialists, 65 technicians and 51 others, a total of 185 employees.

## THE ONTARIO RESEARCH FOUNDATION

Over the past ten years the Ontario Research Foundation has geared its services more closely to the needs of small industry whose problems are generally of short-term duration. Income from industrial sources increased by approximately 4.7 times over this same period. The institute has continued its trend of increasing industrial work in spite of a decline in industrial R&D in Canada.

In 1976 the Ontario Research Foundation examined many aspects of the energy question and to this end formed an interdisciplinary Energy Group. Concerning the environment, the institute involved itself in projects for the government, industry and consultants. Also, the institute served several companies in material technology. Every segment of the institute is engaged in technology transfer in transforming resources, materials and ideas into goods and services.

Funding of the institute is made up of government grants and contracts as well as income from industry and other miscellaneous sources (see Table 5).

TABLE 5

THE ONTARIO RESEARCH FOUNDATION

| SOURCE OF REVENUE | 1976 $ | 1976 % |
|---|---|---|
| Ontario Government Grant | 2,854,000 | 31 |
| Ontario and Federal Government Contracts | 1,331,000 | 15 |
| Canadina Industry | 4,758,000 | 52 |
| Other Income | 229,000 | 2 |
| Total Revenue | 9,172,000 | 100 |

SOURCE: Ontario Research Foundation, 1976 Annual Report

SHERIDAN PARK

Another effort for industry/university interface is "Sheridan Park". This park located near Toronto was created and financed with the help of the Ontario Government and has succeeded in attracting numerous R&D laboratories. The purpose of this enterprise, although not fully achieved, is to reduce the overhead costs at R&D centres and to promote scientific exchange.

THE MANITOBA RESEARCH COUNCIL

The purpose of this Council is to stimulate and facilitate the effective application of technology in Manitoba and to advise the Minister of Industry, Trade and Commerce on matters relating to science and technology.

The Council is assisted by four technical committees which identify research projects, advise on applications for research projects, and monitor and evaluate research projects. The Council, apart from a small food processing laboratory, does not operate research laboratories. Research projects are carried out in cooperation with universities or manufacturers in the province.

During 1976 programs and projects of the Manitoba Research Council achieved results that should have a favourable economic impact on the province.

In 1976 the Council had a staff of 10 with expertise in different fields and with varying responsibilities.

## THE SASKATCHEWAN RESEARCH COUNCIL

The research activities of this Council for the year 1976 were tailored to meet the following goals:

- to undertake studies on how to best utilize Saskatchewan's resources, with emphasis on agriculture and agricultural processing;
- to promote the industrialization of Saskatchewan, with emphasis on in-Province upgrading of the primary resources; and
- to undertake environmental studies that contribute to the above and also help preserve or improve Saskatchewan's environment.

Funding of the Council is by provincial grants, other grants, contracts and fees from industry. There was an increase of approximately 16 percent in total revenue over the previous year. (See Table 6.)

TABLE 6

SASKATCHEWAN RESEARCH COUNCIL
(for the years ending March 31, 1976 and 1977)

| SOURCE OF REVENUE | 31/3/76 | | 31/3/77 | |
|---|---|---|---|---|
| Province of Saskatchewan | $ | % | $ | % |
| - grants | 2,100,000 | 56.9 | 2,281,400 | 53.5 |
| - other grants, contracts fees from industry | 1,475,550 | 40.0 | 1,889,430 | 44.3 |
| - other income | 25,996 | 0.7 | 33,413 | 0.8 |
| - research grants | 88,275 | 2.4 | 58,304 | 1.4 |
| TOTAL | 3,689,821 | 100.0 | 4,262,547 | 100.0 |

SOURCE: Saskatchewan Research Council, 31st Annual Report, 1977

The institute is divided into several divisions namely: administration, chemistry, engineering, industrial services, physics and a management services division. Each division provides some service to be used by all divisions. These services include general shops, precision instrument lab, electronics lab, chemical and radiochemical analytical labs, tritium and carbon dating facility, cartographic and drafting units, photographic lab, library and information retrieval services. These facilities enable the multi-disciplinary scientific staff to undertake a wide range of both field and laboratory projects.

The main activities at the institute in 1976 were in the categories of agriculture and agricultural processing, resource and development, industrialization, environmental studies (particularly relating to Saskatchewan's energy resources) and services.

THE ALBERTA RESEARCH COUNCIL

The primary goal of the Council is to encourage the economic and social development of Alberta by research in needed areas and the provision of technical services and information to both industry and government.

Funding of the Council is largely by the Alberta Government but is also obtained from research contracts with Alberta industry and Federal Government grants and contracts. Unavailable, at this time, is the total revenue of the Council and the percentage of funds contributed by each of the above sectors.

The main activities of the Council are in the fields of engineering, physical sciences and earth sciences. Some work is also conducted in microbiology, economics and information sciences. Although not directly engaged in social science research, social goals form part of the planning process. The activities of the Council can be divided into five main areas, namely: industrial development, resource evaluation, primary industry, transportation and environmental studies. The Council makes every effort to balance short and long-term projects its view being that problems which arise are equally as important as those already in existence.

The Council had a total staff of 346 in 1976 made up of 152 professionals, 120 technical, 59 clerical and 15 temporary and part-time employees. This represents an increase in staff of 10 percent over the previous year.

THE BRITISH COLUMBIA RESEARCH COUNCIL

B.C. Research is the technical operation of a non-profit independent society, the British Columbia Research Council. The institute provides R&D services to industry, business, and various government departments.

The institute is funded by a B.C. government grant, industrial contracts, other government contracts, royalties and other miscellaneous funds (see Table 7 for further details). The annual grant by the B.C. government allows for high-risk technological research. The high failure rate of this type of research is too risky for private funds. The grant also allows the institute to provide a free technical information service.

Activities at the institute consist of research, development and other technical work under contract and offers services in the fields of applied biology and chemistry, engineering physics, economics, market research, operations research, industrial engineering, management training, technical information and ocean engineering. The contracting system of the institute allows small companies use, on an interim basis, of technical expertise for new or improved technology and enables larger companies to supplement their own research and technological facilities.

As of 1974 the B.C. Research Institute had a permanent staff of over 150 persons.

TABLE 7

THE B.C. RESEARCH INSTITUTE

| SOURCE OF REVENUE | December 31, 1976 $ | % |
|---|---|---|
| Contract Research | 3,241,738 | 86.3 |
| B.C. Government Research Grant | 320,000 | 8.5 |
| Other Income | 195,945 | 5.2 |
| Total Revenue | 3,757,683 | 100.0 |

SOURCE: The B.C. Research Institute, Annual Report, 1976 c.) <u>University-Based Research Institutes</u>

As of 1976, there were an estimated 234 university-based research institutes (including the university-based centres supported by IT&C). Quebec had the highest percentage (44 percent), followed by Ontario (26 percent), the West (19 percent) and the Atlantic Region (11 percent).

These centres carry out a large variety of activities, including functions such as research on economic development, language and communication, oceanographic and marine studies, and Canadian ethnic and regional studies. The majority of research institutes concern themselves with medical research (15 percent), foreign studies (6 percent), education (5 percent), and northern development (4 percent).

Most Research Centres in the Western Provinces are concerned with northern development, followed by agriculture, water, natural resources, medicine and space. In Ontario the highest concentration of the centres is in health fields, followed by industry, computing and other service fields. Quebec Institutes have their highest concentration in health fields, followed by education and foreign studies. The Atlantic Region, with the smallest number of institutes, has a concentration in community services followed by health and foreign studies (see table 8).

Although these numerous university-based research institutes have the potential to transfer technology from the university to industry, the extent to which this process occurs cannot be assessed. A limited amount of information exists concerning factors such as the number of research personnel, the size of the budget and program objectives. For example, MOSST was able to obtain only 29 annual reports from the 234 institutes and many of these reports did not cover the same period of time. However, it is not unreasonable to assume that a large number of institutes are rather small, with very limited resources. Centres such as the Institute for Materials Research (with a staff of 41 professionals, 1977), and the Pulp and Paper Research Institute of Canada, are the exception rather than the norm.

d) <u>Technological and Scientific Societies</u>

Another mechanism which aids in the transfer of technology between universities and industry is Canada's many scientific and technical societies.

At the national level there are approximately 125 societies while at the provincial, regional, and local levels there are well over 250. Membership in these organizations is wide ranging. For example, the Canadian Thoracic Society has a membership of only 54 while the Canadian Nurses Association membership numbers over 87,000.

The aims and objectives of these associations include:

- exchanging knowledge;
- providing advice on pertinent legislative matters;
- promoting a knowledge of the profession to the public;
- cooperating with other societies in matters of mutual interest;
- promoting science in the interest of society
- publishing journals;
- providing information to the public
- acting as a national voice.

This list is not exhaustive but indicates the potential of scientific and technological societies to contribute to technology transfer.

Members are employed in all sectors of the economy and the numerous meeting-point mechanisms such as national and regional conferences, and symposiums serve to stimulate the transfer of research results between these sectors. In addition, many societies have a large component of industrial members who contribute to technology transfer from the university through student awards, scholarships and bursaries. For example, the Canadian Institute of Mining and Metallurgy (CIMM), whose membership is chiefly from industry, awards prizes, trophies, and plaques to over fifty students each year.

TABLE 8

RESEARCH CENTRES ASSOCIATED WITH CANADIAN UNIVERSITIES

| PURPOSE | ACTIVITY | WESTERN | ONTARIO | QUEBEC | ATLANTIC | TOTAL |
|---|---|---|---|---|---|---|
| Economic Development | Economic | - | 2 | 2 | - | 4 |
| Urban Development | Urban | - | 2 | 2 | 1 | 5 |
| Northern Development | Northern | 5 | - | 4 | - | 9 |
| Developing Countries | Developing | - | - | 1 | - | 1 |
| Foreign Studies | Foreign | 1 | 4 | 6 | 3 | 14 |
| International Relations | International | 1 | 2 | - | - | 3 |
| Public Admin. | Public | - | 2 | 1 | 1 | 4 |
| Industrial Relations & Mgt. | Management | 1 | 2 | 2 | - | 5 |
| Language & Communication | Language | - | 2 | 3 | 1 | 6 |
| Education | Education | 1 | 3 | 7 | 1 | 12 |
| Behaviour & Mental Retardation | Behaviour | 2 | 1 | 2 | - | 5 |
| Community Service | Community | 2 | - | 1 | 5 | 8 |
| Cdn. Ethnic & Regional Studies | Regional | 1 | 1 | 1 | 2 | 5 |
| Culture, Sport & Recreation | Culture | - | 1 | 5 | - | 6 |
| Law | Law | 2 | 1 | 5 | - | 8 |
| Historical Studies | History | 1 | 3 | 2 | - | 6 |
| Administrative or Organizational Service | Organization | - | 3 | - | 2 | 5 |
| Agriculture | Agriculture | 4 | - | 2 | - | 6 |
| Forestry | Forestry | 1 | - | 3 | 1 | 5 |
| Oceanographic and Marine Fisheries | Ocean | 1 | - | 4 | 2 | 7 |
| Water Resources and Inland Fisheries | Water | 3 | - | 4 | - | 7 |
| Energy | Energy | 1 | - | 1 | - | 2 |
| Mineral Location and Extraction | Mineral | 1 | 2 | 2 | - | 5 |
| Other unspecified Natural Resources | Natural | 3 | 1 | - | - | 4 |
| Mfg. and Other Industry | Industry | 1 | 7 | 2 | 1 | 11 |
| Transportation and Telecommumications | Transtel | 2 | 6 | 3 | - | 11 |
| Environmental Studies and Pollution | Environment | 2 | 3 | 5 | 1 | 11 |
| Medicine, Hygiene & Nutrition | Medicine | 3 | 7 | 24 | 4 | 38 |
| Computing and Other Services | Computing | - | 3 | 2 | - | 5 |
| Space | Space | 3 | 4 | - | - | 7 |
| Other | Other | 6 | 7 | 14 | 3 | 30 |
| TOTAL | | 48 | 69 | 110 | 28 | 255 |

NOTE: There are about 255 centres, some centres may be counted more than once, due to the multiplicity of functions performed.

SOURCE: Statistics Canada, Univeristies and Colleges of Canada, Cat. No. 81-230, Annual, 1976 and Department of Industry, Trade and Commerce, Office of Science and Technology Annual Reports

## III. UNITED STATES

In the United States, the links between universities and industry appear to have weakened in the two decades following World War II, approaching their nadir in the early seventies. The reasons for this are complex, but three principal factors have been isolated. First, the rapid growth of federal funds for academic research gave universities less incentive to maintain or increase their ties with industrial firms. Second, during the post-war growth phase of the university sector, new PhD's chose academia over industry. As well, professors tended to train their best students for careers in academic research. Third, industry reduced its role in basic research in favour of applied research, making working relationships with universities more difficult[1].

Since the early seventies, efforts have been made to improve university/industry relationships through a number of experimental programs. These included

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[1] For a more detailed discussion see: Bruce L.R. Smith and Joseph J. Kennedy, The State of Academic Science, the Universities in the Nations Research Effort, (New York: Change Magazine Press, 1977), pp. 51 - 78.

direct corporate funding of university research projects; cooperative research program; university/industry research consortia; joint industry/university laboratories; technology licensing and technological brokers; development of university extension services; university industrial associates; industrial parks; university business development centres; and the innovation centres. Examples of these mechanisms are provided in Appendix III.

The most successful programs have been the Innovation Centres Experiment and the Cooperative Research Centres Experiment sponsored by the National Science Foundation[1]. Both initiatives have resulted in a significant increase in non-federal R&D investment and the direct application of university R&D results.

Innovation Centres Experiment

Commencing in 1973, Innovation Centres were introduced as vehicles within universities for stimulating technological innovation and for increasing the

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[1] These experiments were two of several initiatives sponsored under the Experimental R&D Incentives (RDI) program of the NSF which began in 1973. Other experiments included: Federal Laboratory Validation; Federal Specification and Testing; Federal R&D Applications; and R&D Linkages to State Government.

entrepreneurial inclinations of graduates as they pursued their careers. Using university business and engineering skills for training entrepreneurs and inventors, the centres were designed to evaluate ideas, technology and R&D results, develop new products and services, provide assistance to inventors, and establish new business ventures.

At present, there are four centres, located at the Massachusetts Institute of Technology (MIT), Carnegie-Mellon University (CMU), the University of Oregon, and the University of Utah. Each of the innovation centres has as a common objective the demonstration that university-based activities can stimulate innovation and entrepreneurship in the external business community.

In pursuing their common objective to stimulate innovation and entrepreneurship, the activities of these centres are geared to[1]:

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[1] See R.M. Burger, "An Analysis of the National Science Foundations, Innovation Centres Experiment", Research Triangle Institute, 1977.

- idea/invention evaluation;
- assistance for new business start-ups;
- development of new products for existing businesses;
- development of innovation/entrepreneurship education curricula; and
- research on the innovation/entrepreneurship processes.

In practice, each centre has a slightly different emphasis which gives it particular individuality[1]:

- At MIT, the focus is on a learn-by-doing research wherein ideas are generated and developed into new products or services that can be licensed to an existing company or become the basis of a new venture;
- at CMU, the focus is on new venture initiation and support to the stage where the business can qualify for venture capital assistance; and
- at Oregon, the focus is on idea or invention evaluation and upon transfer of technology from the independent to the entrepreneurial and corporate sectors.

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[1] No discussion in this report will be devoted to the Utah Innovation Centre since little documentation exists given that it was only recently established.

Each centre offers courses in entrepreneurship and innovation, exposes students to the entrepreneurial process and actively promotes innovation as an integral part of the academic regimen. The educational curricula of each centre varies in accordance with its special interests as well as its institutional setting[1]. The MIT Innovation Centre is based in the engineering school. Its aim is to provide an education and training in which various disciplines are linked to enhance the entrepreneurial ability of participating students. Direct involvement by students in innovation and risk-taking is actively encouraged. Typical courses offered include Introduction to Innovation, Invention, Entrepreneurship, Invention Development Laboratory, and Internship in New Enterprise Development. In contrast, the Oregon Innovation Centre concentrates upon invention evaluation. Its academic and educational programs are located in the College of Business Administration; most courses relate to the invention evaluation process

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[1]See, for example, R.M. Burger, "RANN Utilization Experience, Report to the National Science Foundation", Case Study No. 33, Research Triangle Institute.

which includes examination of factors such as business risk, demand analysis, environmental impact and investment costs. More details on each of these institutes is contained in Appendix IV.

In addition to educational activity, the centres have also provided facilities for the evaluation of ideas and inventions. In this they have been very successful. In the first year of operation, alone more than 500 ideas were brought to the centres. Although, only a few of these ideas were recommended for continued development, discussions with submitters of these ideas established that they were very satisfied with the services offered. Because of the evident need for such evaluation, and the apparently inadequate service provided by commercial firms, this aspect of the centres' work has received considerable public attention.

Although long-term results are not yet available, it is difficult to avoid the conclusion that thus far, this experiment has been a demonstrable success (see tables 9 and 10.)[1] Each of the centres has established a supportive constituency; at Oregon, the independent inventor, at Carnegie-Mellon, the local business community, and at MIT, the university and participating industries[2]. All centres are attracting the attention of government mission agencies for their ability to respond to specific needs.

Participating students have shown considerable enthusiasm and satisfaction. The number of students enrolled expanded from 400 to 700 and the total number of courses offered by all centres increased from 14 to 30 in the first few years of operation.

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[1] The NSF is in the process of evaluating the long-term results. For example, prior to and after leaving the centres, each potential entrepreneur/innovator is surveyed/interviewed by the NSF. The results are being evaluated against those obtained from a comparison group which is also being surveyed for an equivalent period. These longer-term results will not be known for some time. See, Robert M. Colton and Gerald G. Udell, Ibid., pp. 11-12.

[2] See, R.M. Burger, Ibid., p. 26; and Robert M. Colton and Gerald G. Udell, "The National Science Foundation Innovation Centres: An Experiment in Training Potential Entrepreneurs and Innovators", Journal of Small Business Management, (April 1976).

## TABLE 9

### SOME FACTS ON INNOVATION CENTRE PERFORMANCE

| | 1974 | 1975 | 1976 |
|---|---|---|---|
| 1) Students | 400 | 565 | 681 |
| 2) Courses | 15 | 25 | 29 |
| 3) Faculty | 44 | 53 | 53 |
| 4) Professional | 43 | 46 | 46 |
| 5) Ideas evaluated | 542 | 625 | 752 |
| 6) Projects Initiated | 37 | 55 | 61 |
| 7) New Products Developed | 6 | 16 | 20 |
| 8) New Ventures Initiated | 7 | 12 | 11 |
| 9) New Venture Employees (Entr.) | 109 (21) | 206** (33) | 250** (40) |
| 10) Private Venture Capital Invested in New Ventures | 280,000 | 464,800 | 750,000 |
| 11) New Venture Sales | 740,000 | 2,700,000 | 30,000,000 |
| 12) NSF Funding | 670,000 | 715,000 | 845,000 |
| 13) Estimated Federal Taxes from 9 - 11 | 250,000 | 600,000 | 2,000,000 |
| 14) Estimated Federal Taxes from Distribution of Wages Under 9 (Multiplier Effect) | 750,000 | 1,800,000 | 6,000,000 |
| 15) ROI***(Not Counting Return from Direct Expenditure of 12) | 1.1 | 2.6 | 9.3 |

MIT ** Does not include 400 employees at sub-contractor plants

CMU

ORE *** ROI equals line 14 divided by line 12

SOURCE: National Science Foundation

## TABLE 10

## ACTIVE BUSINESSES INITIATED OR ASSISTED BY INNOVATION CENTERS

| BUSINESS | PRODUCT | 1976 SALES | 1976 ORDER BACKLOG |
|---|---|---|---|
| Kemtech, Inc. (Executive Games) | TV Games | $5,000,000 | $ 5,000,000 |
| Transcomm Data Systems Corp. | Timesharing Computers | 2,000,000 | |
| Compu-Guard | Security Devices | 1,000,000 | 10,000,000 |
| Fisher Stoves, Inc. | Wood Burning Stove | 400,000 | 1,000,000 |
| Peoples Cab Co. | Transportation | 250,000 | |
| ECD Corp. | Capacitance Meter | 200,000 | 1,500,000 |
| Three Rivers Computer Co. | Computer Hardware | 175,000 | |
| Sun Publications, Inc. | Newspapers | 135,000 | |
| Transportation Concepts, Inc. | Three Wheel Car | 117,000 | 2,000,000 |
| Myers Motors, Inc. | Automobile | 69,000 | |
| Computer Controls Corp. | Control Systems for HVAC | 50,000 | |
| Peoples Travel, Inc. | Transportation Broker | 50,000 | |
| Rehabilitation Equipment, Inc. | Prosthetics Sales and Service | 30,000 | |
| MBA Consultants | Business Services | 20,000 | |
| Klein Corp. | Bicycle Framesets | 15,000 | |
| Richards Frames | Wood Picture Frame | 12,000 | |
| Wrench Knives, Inc. | Knives | 12,000 | |
| Royal Industries | Nite Trainer | 10,000 | |
| Redi-Grill | Wine Rack | 10,000 | |
| Vectran Corp. | Remote Control Devices | 10,000 | |
| Graphic Forms, Inc. | Wood Printing | 2,000 | |
| SICO | Folding Table | -- | 50,000 |
| Health Spa, Inc. | | -- | 250,000 |
| TOTAL | | $9,567,000 | $19,800,000 |

SOURCE: R.M. Burger, Ibid., p. 19.

According to the centres' directors, this trend is expected to continue. Furthermore, similar trends have also been reflected in the university community external to the NSF experiment. Upward of 80 schools in the United States now offer courses in entrepreneurship education as compared to only 10 a decade ago[1]. The effects are also spreading to the Small Business Administration where university-based small business centres are being developed for encouraging entrepreneurship.

In the short period of time since the program began the Centres have also been successful in stimulating the transfer of technological entrepreneurs from university to industry. For example, within the first 2½ years of operation 54 entrepreneurs had already moved out of the Centres into the economy[2]. It has also been reported by the NSF that students from the Centres become involved in entrepreneurial and innovative activity, approximately 3 years after graduation rather than the normal 8 to 10 years[3].

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[1] K.H. Vesper, Entrepreneurship Education - A Bicentennial Compendium, Society for Entrepreneurship Research and Application, Milwaukee, Wiscousin 1976 (sponsored by National Science Foundation).

[2] Robert M. Colton and Gerald G. Udell, Ibid. p. V-18.

[3] The Department of Industry, Trade and Commerce highlighted this aspect in the documentation of their recent site visits to the U.S. Innovation Centres.

This is further supported by a recent study of Oregon graduates which indicated that this Centre has been a significant factor in the number of entrepreneurs entering the economy[1]. From an economic standpoint, the centres are also demonstrating successful results. By the end of 1976, 23 active businesses were initiated or assisted by the innovation centres. Total sales (1975), and backlog (1976), of these businesses was in excess of $30 million. Direct taxes alone (estimated at $16 million) from these ventures already exceeds the total five-year cost to NSF. At Carnegie-Mellon, the centre director estimates that eight dollars in taxes have been created through new ventures for every tax dollar spent by the institute.

During the early stages of the centres development minor start-up problems were evidenced. The three major causes of these difficulties were:

1. A unique staff is required to deal with the large variety of inventors, students, consultants, and ideas coming to the centre. The atmosphere of

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[1] Gerald G. Udell, et al, "A Breeding Ground for Entrepreneurs and Innovators", a working paper in "Experiments in Invention and Innovation", University of Oregon, January 1976.

such an operation is charged with the pressures attendant to heavy work loads, high risks and opportunities. Finding staff members capable of working in this situation has been a challenge.

2. With the increased volume of inventors seeking the services of the centre, developing procedure has been a difficult problem. At this point, routines for handling inventions have largely been developed, but some matters still require further resolution.

3. Potential conflicts of interest have caused some preliminary problems. Ideas have come to the centre from university and centre staff members. Previous associates of centre personnel have negotiated for invention rights. These conflict of interest possibilities are being removed through new centre policies prohibiting any past, present, or possible future financial involvement by centre personnel in any invention processed through the centre.

Despite these minor start-up problems, each centre in its own way has been demonstrating an encouraging efficacy in the academic environment. The most important factors contributing to this success are[1] :

1. A well defined experiment duration;
2. an initial commitment to full and sufficient funding of the program;
3. a multi-objective structure which permits program flexibility;
4. experienced and reputable centre directors;
5. early demonstrated success which has been instrumental in attracting a strong core of innovative expertise;
6. liberal patent policies established by the institutes.

The relative importance of these factors has been further documented in a recent NSF report[2] :

> The success (of the innovation centres) in no small measure stems from the fact that the experiment is funded at an adequate level and for an adequate duration; but other essential ingredients -- management flexibility, dedicated Centre Directors, competent participants, an enlightened patent policy, and early demonstrations of success -- have also been important.

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[1] A more detailed elaboration of these and other factors influencing the utilization of the Innovation Centres Experiment is contained in Appendix VI.

[2] R.M. Burger, Case Study No. 33, Ibid., pg. 33-34.

The conclusions of an independent review of the NSF Innovation Centre Experiment provide a useful synopsis of its relative success :

> The centres seem to have gone well beyond their primary educational objective. Venture capital is being attracted to centre projects: ventures are being started; results of centre sponsored or conducted research is beginning to appear in the literature; new channels for transferring technology from the independent to the corporate sector are being developed; an increasing number of small businesses are seeking new products, business development and managerial assistance from the centres. A surprising number of large corporations have expressed an interest in the centres as a source of new products and insight into the innovation process; and an increasing number of universities and colleges have expressed an interest in this method of bridging the gap between classroom theory and the reality of the business world.

Cooperative Research Centre Experiment (CRCE)

This experiment was established in 1973 under NSFs Experimental R&D Incentives Program. At present, the NSF sponsors programs at three universities: Carnegie-Mellon University, North Carolina State University and MIT. This experiment is similar

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Robert M. Colton and Gerald G. Udell, Ibid., p. V-22.

to the Industrial Research Association Program of IT&C in Canada, in that the centres are designed to support R&D dealing with technological activities common to a specific industry and to be self-supporting within a specified period of time. It differs from the Canadian program in that the centres are located at universities with the further benefit of encouraging graduate students to work in problem-oriented research directly relevant to industrial needs. For example, the Processing Research Institute (PRI) at Carnegie-Mellon was funded by NSF mainly to develop a Master of Engineering program oriented towards the processing industries.

Unlike the NSFs Innovation Centres Experiment, a complete review of the CRCE has not yet been undertaken. However, the following more detailed discussion of the MIT Program (where some recent documentation exists) supplemented by recent discussions with the NSF should prove informative.

The Industry Polymer Processing Program at MIT was established with the purpose of identifying and testing federal incentives for improving technological innovation and transfer for public benefit. Although one of the principal goals of the program was to "recommend alterations in public policy which would result in increased R&D investments and efforts by small firms", the five initial industrial participants were large corporations with annual sales ranging from $40 million to over $10 billion.

The program began with a $100,000 grant from NSF in 1973 and by the 1977 fiscal year a total of $874,000 had been expended on the program ($446,000 by industry and $428,000 by the NSF). NSFs financial support is expected to terminate in the 1978 fiscal year. It is unknown whether the program can become self-supporting by that time.

As of 1976, the program was staffed by about 20 faculty, staff and student researchers. Eighteen projects had been initiated, of which 6 to 10 had been active at any given time.

One of the important by-products of the centre has been the development of student researchers. Particularly important is the experience gained from having to describe a research plan, the applicable theories, the work accomplished and implications of the results. From this experience, students are industry-ready and in demand on the job market.

There is some reason to believe that MIT has been reasonably successful in undertaking this program. "A great deal of informal interaction exists between the program staff and industrial members ... and a high degree of satisfaction with the program is indicated by member firms". The major reasons for this success are:

1. Before the program was instituted there was already some significant institutional or personal

contacts in existence. All companies who did join mentioned some form of previous connection. For example, most of the companies were associated with MITs industrial liaison program and had at least one MIT graduate among the two or three people who made the decision to join.

2. The establishment of a program organization which encourages and promotes interaction between the program staff, students, and industrial members. For example, a primary structural mechanism is the Industrial Advisory Committee. This group meets four times a year. In addition to developing rules on such commercial matters as patents and licensing, it provides a forum for an exchange of informal views and a mechanism for open and honest discussion. As a result, this rather unusual working group has developed considerable trust and ease of interaction. As well, students are given exposure to the whole R&D process (through the Bimonthly Meetings) which increases their perspective and prepares them for industry employment.

3. The entrepreneurial, innovative and administrative abilities of the program director have been crucial since the initiation of the experiment. For example, one of the industrial members said that while they were considering joining they received problem-solving help from the director which provided a concrete example of what might be expected.
4. The existence of an established industrial base where a few large firms control the industry market has been an unexpected but necessary criterion.

The MIT initiative represents a positive effort to use federal funds to reorient university research towards industrial interests. However, this is only one of the three CRCE university-based institutes. Final judgement as the usefulness of this type of cooperative approach will have to await a complete review of the other two experimental centres.

## IV. OTHER COUNTRIES

In this section, a brief summary of some of the mechanisms for technology transfer is provided for a selected number of other countries, namely, France, Sweden, Switzerland, Norway and the Netherlands, Great Britain, Denmark, West Germany, Belgium and Japan.

### a) France

Although several mechanisms for industry/university technology transfer exist in France, only two of major importance are noted here. First, the government encourages university and industry to submit joint proposals for research support by paying fifty percent of the industrial share of the project and one hundred percent of the university share. Second, when a majority of firms in a sector insist, the government will mandate the creation of an industrial research centre and a para fiscal tax is placed on all firms to support this centre. For example, the French centre for the study of plastic materials, which is similar to the MIT Polymer Processing Program of the United States, had a budget in 1972 of three million francs and employed forty-two people, including fifteen professionals. Although formally separate facilities are located at the Ecole Nationale Supérieure des Arts-et-Métiers (ENSAM), the director of this program is a professor and three faculty members are active participants.

b) Great Britain

Many mechanisms for university/industry technology transfer exist in Britain. For example, numerous British universities have a formal policy to promote industrial consultation by staff members. The industrial liaison officers at some universities and many technology institutes, with the help of the Department of Trade and Industry (formerly the Ministry of Technology) have the function of promoting industry/university links in every possible way. Other types of liaison exist at many universities. For example, the industrial innovation centre at Strathclyde University carries out work for industry and keeps in continuous contact with 650 staff members in order to direct industry to the right scientists. This centre, being relatively new, has not as yet achieved full success.

Not unlike Canada, Great Britain has a policy of supporting research associations. Although this provides a potential for stimulating university/ industry technology transfer the extent of this interchange is limited since the associations are not located at the universities.

c) Germany

The tradition here, of appointing industrial scientists to university posts, would appear to be one of the main reasons why German universities are more industry oriented than either the French or British. These appointments form the bridge for technology transfer from university to industry by allowing these teachers direct contact with students thus enabling them to help industry find the right graduates. A secondary, but important, offshoot of this integrated approach is the fact that all chemistry teachers receive, at regular intervals, a sum of money from a fund financed by the chemical industry which they are expected to spend on research.

Another mechanism for stimulating industry/university technology transfer is known as the "teachersparty", whereby all newly appointed chemistry teachers are invited to industrial headquarters for a period, extending from three to four weeks. Here they are entertained, informed of company research being carried out and queried about their past and future plans. Other industries use similar mechanisms but not to the same extent as the chemical industry. The importance of this interaction should not be underestimated since this has proved to be a key mechanism responsible for the success of MIT's Polymer Processing Program.

d) <u>Sweden, Switzerland, Norway and the Netherlands</u>

The major thrust in Holland is the encouragement of industrial scientists to teach at the universities. This direct approach was developed in Holland but exists also in Germany, Belgium, Switzerland and Sweden.

Dutch senior researchers from every large industrial laboratory and many small companies spend approximately fifteen percent of their working time teaching at the university. This is done in full agreement with their companies who know that it is to the ultimate interest of industry to contribute to the universities. This institutional flexibility in higher education is rare elsewhere and is a modern expression of an old tradition for survival. Today one quarter of all Dutch university professors in science and technology are active industrial researchers, having found this to be one of the most important mechanisms for stimulating technology transfer.

Research in the technical universities of these small countries seems to have played a major role in increasing university/industry links. Unlike the elite schools in France and Britain (for example), the Ecole Polytechnique in Paris and Imperial College in London) these technical universities are geared directly to industrial research needs. Here there is close association between industrial research institutes and technical universities as the bulk of research in these universities is of direct interest to national industry. As a result, the universities train students for industry not only through their curriculum but also by giving them industrial attitudes and motivations. This concentration on industrial research needs is reflected in the policy of institutes which require new students to work approximately six months in industry prior to enrolment. Also, for teaching appointments, industrial experience is a definite asset and in some cases even a requirement.

Some institutional mechanisms created by governments of these countries towards support of industrial research are:

1- NETHERLANDS-TNO (Central Organization for applied research);

2- NORWAY-NTNF (Norwegian Council for scientific and industrial research; and

3- SWEDEN-STU (Swedish Board for Technical Development).

These government institutes are major clearing houses of industry and university knowledge and are important links for technology transfer. In all countries, these bodies which draw both sides together prove to be a very valuable mechanism for university/industry links.

e) Japan [1]

The most important and distinctive aspect of Japan's Science and Technology Policy is a well-defined consensus on an industrial or economic goal. This has resulted in clear guidelines in the development of criteria for technological innovation and the R&D process. Science and Technology is thus considered a tool for achieving a specified national goal.

The approach is pragmatic and directed - a goal is established, and when required, technology is imported and adapted through domestic R&D.

The universities and their research institutes, numbering well over 100, provide the major source for absorbing and integrating the transferred core technology into the total system of industrial production. A large proportion of university research activity is of the "basic" nature. However, this research is primarily directed towards satisfying the economic and social needs of the country. Thus, when foreign technology is imported, the university community has a base of potential expertise capable of adapting and improving this technology to suit domestic needs.

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[1] For a more detailed discussion, see "Japan's Economic Growth and her Science and Technology Policy"; Lecture given by Professor K. Oshima in Brussels on December 9, 1975, at a conference organized jointly by the Japanese Embassy in Belgium and by l'Office Japonais d'Etudes Economiques. This paper drew heavily from Professor Oshima's report. The other major source documents for this report were: Guide to World Science, Vol. 17 Japan, 2nd Edition, 1976; "Procedures of Distribution of Federal Funds for Science in Japan", Dr. M. Yoshiki, American Association for the Advancement of Science, 140th Meeting; and National Research and Development Program, (Background Information), Ministry of International Trade and Industry, Japan, 1975.

A more detailed discussion of Japan's approach follows.

In the 30 years since World War II, Japan has made remarkable success of reconstructing her industry and has achieved a high economic growth virtually unequalled by any other industrialized nation. Science and Technology policies have played a crucial contributory role in this development, the importance of which is reflected by the active involvement of the Prime Minister. For example, the two major contributors to science policy are the Science and Technology Agency (STA) and the Science Council of Japan, both of which are affiliated to the Office of the Prime Minister. As well, numerous other advisory organizations such as the Council for Science and Technology and Commissions such as the Atomic Energy Commission, report to the Prime Minister's Office.

The promotion of science is a significant part of Japan's Science Policy. The Minister of Science and Technology usually has two press conferences a week. As well, the STA provides lectures and films to many exhibitions and seminars, organizes conferences the aim of which is to improve communications between scientists and Governments, is responsible for a radio series "Science for Tomorrow" and special televised presentations.

There is also a "Science and Technology Week" annually involving schools, research institutes, government and industry. During this special week there are lecturers, films, exhibitions, open days and award-giving ceremonies honouring those who make conspicuous advances in science and technology fields.

Historically, the Japanese Government has considered science and technology as a tool or a means for achieving a well-defined national goal. The main features of this policy have been referred to as "absorptive". Core technology has been transferred from abroad in most cases; and local R&D has been essential in absorbing and intepreting the transferred core technology into the Japanese system of industrial production. Government policies have encouraged enterprises to take a progressive attitude toward introduction of advanced foreign technology and have promoted efforts for domestic R&D to bring this technology into commercialization rapidly. A few following examples will help clarify this philosophy.

During the second phase of Japan's industrial recovery, which was developed in the early 1950s, a national goal was to "strengthen Japan's competitive capacity in international trade", by transferring its industrial structure towards the heavy and chemical industries. The definition of "heavy and chemical industries"was somewhat arbitrary but it consisted of machinery, electronic machinery, metals, chemicals and included, in the later period, electronics. Researchers took the attitude that the government should encourage development of indigenous technology by protectionist policies. Industrialists insisted that there was immediate need to be competitive and that government policy should encourage the importation of advanced technology. On the whole, industry views pervailed and except for a few sectors most of the new technologies were imported. However, in giving approval for the import of technology, the Government gave priority to groups already developing technology on their own.

Japan is now in the third phase of its industrial policy, which is oriented to place more emphasis on knowledge-intensive industries. Japan has made it a national goal to gain dominance of the world's computer and electronics markets. They have thus established a $250 million joint government/industry Very Large Scale Integration (VLSI) program whose stated aim is to develop all the necessary highly advanced processes, manufacturing techniques, and components to reach this goal by the end of 1980. As a result, Japanese businessmen are agressively gathering information in the centre of the U.S. electronics industry. Samples of innovative tools and instruments are bought and sent back to Japan for further improvements through domestic R&D.

This unique feature of the Japanese R&D policy has resulted in a relatively high proportion of R&D expenditure being funded by industry. In 1973, R&D expenditures funded by industry were 66%. Figures for other countries were, 29% for Canada, 39.3% for the United States, 35.8% for France, 54.9% for West Germany, and 42.7% for the U.K. in 1971.

A second notable characteristic of Japan's R&D is the high proportion of support to basic research (23% of total R&D expenditures), most of which is performed by the universities. Even in industry, however, expenditures classified as basic research are relatively larger than they are in other countries (97% of its 1970 R&D expenditures, compared with 3% to 5% for Western countries).

The role of the universities in Japan is to improve the scientific and technological base through teaching, research training and basic research: "Basic research activities have been mainly to supply a scientific and technological soil of high standard to cultivate active technological innovations through transfer of technology from abroad". In essence, little effort by the universities is devoted to originating new technological development. This is evidenced by the contribution of universities to Japan's total basic research activities. Some 65% of the expenditures for basic research is spent by the universities. However, it should be noted that the strong influence of Japan's economic objectives is represented by the high proportion of basic research in the engineering field (42%), and the proportionately high number of engineering students (14%) which compares to 8% (1974-75) for Canada. In summary, the major research responsibility of the universities is to perform basic research of an applied nature; and thus, the extent of cooperative research between industry and universities in Japan is minor although industry does employ the services of universities from time to time.

## APPENDICES

APPENDIX I

## OTHER MAJOR FEDERAL PROGRAMS THAT INDIRECTLY STIMULATE TECHNOLOGY TRANSFER

Industrial Research Association Programs (IT&C). This program was introduced to encourage industrial sectors to aid in support of establishing and maintaining R&D facilities dealing with technological activities common to industry. To date, there have been three associations, two of which are still being funded (see Appendix II). Assistance for this program is similar to that of the Centres of Advanced Technology Program.

Enterprise Development Program (IT&C). Several of the development incentive programs of the Department of Industry, Trade and Commerce (PAIT, PEP and IDAP) have been consolidated into this program. The program will provide financial support for product development, studies for pre-production design and engineering productivity and determine market feasibility and strategies. The program will cover up to 50 percent of eligible costs of specific innovation projects and assist firms when the project appears commercially viable and represents a significant burden on the firm's resources. EDP contributed $26.2 million, made loans of $6 million and guaranteed loans of $720 million in 1978-79.

Defence Industry Productivity (IT&C). This program is the combination of the former Industry Modernization for Defence Exports Program and the Defence Development Sharing Program. Its purpose is to sustain the technological capability of the Canadian Defence Industry. The grant includes cost-sharing of up to 50 percent of current and capital R&D expenditures for defence-oriented R&D. In 1978-79 contributions of $40 million and loans of $6 million were made.

Program for Industry/Laboratory Projects (NRC). The program (PILP) is intended to assist in the application of research results from the laboratories of NRC to situations where there are important Canadian industrial opportunities. The program assists in the transfer of federal government funded development technologies to Canadian industry.

Government funding is provided mainly through the use of contracts to industry. Companies eligible for such contracts should be:

(a) companies incorporated and resident in Canada; and

(b) have the required financial, managerial, technical,manufacturing and marketing capability to succeed with the project, either alone or with other compatible companies.

Proposals for specific projects usually originate in the NRC laboratories, however, unsolicited proposals from industry are given significant consideration. Since the initiation of the program in 1975, 118 contracts have been placed with 73 companies for a total expenditure (1975-1979) of $16.5 million.

Cooperative Projects with Industry (COPI). This program was established in 1978 and is designed to assist in the transfer of research results from federal government to industry. Five federal departments now participate in the program. Expenditures in 1978-79 were $2.1 million. PILP is the equivalent program to transfer research results from NRC.

Industrial Research Assistance Program (NRC). This program is designed to encourage long-term applied research. Under this program, grants of up to 50 percent of salaries and wages for R&D staff and of the cost of certain fixed assets are available to all companies incorporated in Canada. The grants reduce both current R&D expenditures and the capital cost of fixed assets for income tax purposes. A group of companies may combine to select a project of mutual interest. Federal contributions to this program were $18 million in 1978-79. A mini-IRAP assists firms which are not large enough to maintain their own separate R&D facilities. In 1978-79 federal contributions to this program were $500,000.

Waste Recycling and Recovery (Dept. of Environment). Any Canadian company or individual may apply for contracts to perform research and development in the area of waste recycling and recovery. Expenditures amounted to $772,000 in 1978-79.

Scientific and Technical Employment Program (STEP and STEPEX) (NSERC). STEP is designed to encourage permanent job opportunities for scientific personnel in industry by subsidizing unemployed scientists, engineers and technicians. STEPEX is an extension of STEP to allow subsidization of researchers by universities to perform research for private sector firms. Federal contributions in 1978-79 were $5.5 million. Both programs were scheduled to terminate in mid-1979 but may be extended.

Strategic Grants in Aid of Research (NSERC). Grants are awarded in the areas of food and agriculture, communications, energy, oceans and environmental toxicology. Research is to be carried out by individuals or groups at Canadian universities in areas of national concern. Grants awarded in 1978-79 totalled $6 million.

Unsolicited Proposals for Research and Development (Dept. of Supply and Services). A fund is administered by the Department of Supply and Services to encourage research and development related to existing government programs. Any Canadian firm may apply. Expenditures in 1978-79 were $15.5 million.

Contracting-Out (Supply and Services) As a general principle, the governments mission-oriented Science and Technology requirements are to be contracted out to the private sector. When a Canadian industrial performer cannot be identified, the requirement is to be contracted out to other performers such as universities. The Science Centre of the Department of Supply & Services publishes a monthly "Research & Development Bulletin" listing the projects which are to be contracted-out.

Agricultural Engineering Research and Development (Agr. Canada). This program is designed to assist Canadian industry in increasing agricultural engineering R&D effort. Proposals must be solicited through the Science Procurement System of the Department of Supply and Services.

APPENDIX II

Detailed Analysis of IT&C Programs Designed to Improve University-Industry Technology Transfer

IT&C provides support through a number of programs to improve the transfer of technology from the University research laboratory to the production floor. Grants have been made available to universities, provincial research organizations and industrial associations to encourage the establishment of Industrial Research Institutes, Centres of Advanced Technology and Industrial Research Associations.

Started in 1967, the Industrial Research Institute Program assists with the establishment of institutes capable of stimulating the use of university expertise and laboratory facilities by industrial companies.

Subsequently, grants have been awarded to universities and provincial research organizations under the Centres of Advanced Technology Program to encourage the establishment of research and development facilities in specific technologies of importance to the expansion of Canada's industrial capability.

Four Industrial Research Associations have been established three of which are still receiving support from IT&C. Under this program industrial sectors are encouraged to establish and maintain R&D facilities common to one industry.

Altogether 26 proposals have been supported under these IT&C programs. Two institutes have ceased to function. Of the 24 remaining organizations, nine are still receiving support from IT&C (1978). Selected details are provided below.

INDUSTRIAL RESEARCH INSTITUTES

| UNIVERSITY | GRANT & TERM | TERMINATION |
|---|---|---|
| Nova Scotia Tech | $270,000 . 7 yrs | Mar 31-74 |
| Windsor* | 236,895 . 7 yrs | June 30-74 |
| McMaster | 358,000 . 7 yrs | Sept 30-74 |
| Waterloo* | 244,557 . 6 yrs | Nov 30-73 |
| Ryerson* | 150,000 . 5 yrs | July 31-77 |
| McGill* | 204,000 . 4 yrs | Aug 15-75 |
| Ecole polytechnique* | 260,000 . 5 yrs | Sept 30-76 |
| U. du Québec à Montréal* | 300,000 . 5 yrs | May 31-78 |
| Manitoba* | 505,000 . 7 yrs | Sept 30-80 |

Grants payed to March 31/79 = $2,404,312

* Detailed in following pages

## INDUSTRIAL RESEARCH INSTITUTE

Waterloo Research Institute
Office of Research Administration
University of Waterloo
Waterloo, Ontario N2C 3G1
(519) 885-1211

Director: Dr. Holmes (1979)

### DOMAIN OF ACTIVITY

Specialized general research and technical advice for industry.

Examples: Licencing agreement with CORMA Ltd, granting rights relating to the polymer extruder.

The Inventor's Assistance Program in 1978 received in an average of 20 registration per month, for a large variety of projects.

Microwave Drying Process. Microwaves are used to dry materials such as animal protein and may also be used to cure rubber.

Magnetic Electrolytic Plating Process. Fundamental work on electroplating in the presence of a matnetic field has been undertaken. The new process are now available for pilot-scale testing.

A newly and highly efficient process was developed for producing Barium Carbonate from Barium Sulphate.

A vibratory device patented in Canada, U.S.A. and Australia with produces uniform pellets ranging in size from 3/16" to 1" diameter was developed.

A new low energy scrubber which removes sub-micron particles from gaseous effluents was developed and patented.

Other patent and research projects: Cyanide Removal for Mining Effluents, Magnesium Production Process, Zirconium-Hafnium Separation Process, Pollution Control.

### MAJOR FACILITIES

The institute rents all facilities from the University of Waterloo.

### HUMAN RESOURCES

5 permanent staff (1977)

### BUDGET

The total federal government support was $244,557 over six years. Since November 1973, the institute has been financially self-sufficient.

It has not been possible to establish a financial statement from the figures available.

## INDUSTRIAL RESEARCH INSTITUTE

Ryerson Applied Research Ltd.,
Ryerson Polytechnical Institute
380 Victoria St.,
Toronto, Ontario M5B 1W7
(416) 595-5033

General Manager: W.A. Hunter (1976)

### DOMAIN OF ACTIVITY

a) carry out projects in original concept and design
b) conduct practical work in analytical research
c) create an applied research component with Ryerson Polytechnical Institute, as a link between the academic and practical phase of faculty and student development.

Examples: Construction of prototype models of fibreglass shells for shoe display, follow up evaluation.

Development and application of training programs in electronics related to maintenance of automatic mail sorting equipment.

Evaluation of public response to radio broadcasts relating to use of automobile seat belts.

Testing programs for various rubber and plastic products.

Evaluation as to uniqueness, technical competence, and production status of mechanical, electrical, chemical and other devices.

Development of an analytical approach to the evaluation of retarded persons' progress under treatment.

Identification of design requirements (specifications) for a smoke and heat sensing device.

### MAJOR FACILITIES

The institute uses the Ryerson's existing facilities.

### HUMAN RESOURCES

No available information.

### BUDGET (1974)

The federal government supported this institute for $150,000 over 5 years. The contract ended in July 1977.

Detailed budgets are not available. The institute ceased activity (1978).

# INDUSTRIAL RESEARCH INSTITUTE

Office of Industrial Research,
McGill University,
853 Sherbrooke St., W.
Montreal, Québec H3A 2T2
(514) 392-4963

Director: A. Monsaroff (1978)

## DOMAIN OF ACTIVITY

Large variety of applied or mission-oriented research projects requested and sponsored by industrial and other organizations.

Examples: For SOQUEM, (Société Québecoise d'exploration minière) feasibility study of power, on a commercial scale, for the exploitation of salt deposits in the Magdalen Islands.

For Inovan-Consulting Corp. improved process for the sterilization of chocolate.

For Raybestos-Manhattan Inc./Occupational Health and Safety Unit determined the level of airborne asbestos fibers, and investigated asbestos fibers in the work environment.

For Centres of Resource Studies located at Queen's University, to study the "National Impact of the Mineral Industry."

For U.S. Government, variety of projects.

## MAJOR FACILITIES

The institute mainly uses the University's facilities.

## HUMAN RESOURCES (1978)

Permanent administrative staff; 3 secretaries; temporary staff (professional and non-professional) 78 man/years.

## BUDGET (1978)

Total grant from the federal government was $240K over 4 years. Since August 1975 the office has been financially self-supporting.

| | 1974/75 | 1975/76 | 1976/77 | 1977/78 |
|---|---|---|---|---|
| REVENUE<br>Contract Billings | $1,499,322 | $2,001,714 | $1,910,782 | $2,248,225 |
| EXPENSES | $1,217,967 | $1,675,210 | $1,544,909 | $1,880,616 |
| EXCESS REVENUE - GROSS | $ 281,355 | $ 326,504 | $ 365,873 | $ 367,609 |
| I.R. McGILL EXPENSES | $ 98,641 | $ 97,658 | $ 108,265 | $ 97,700 |
| EXCESS REVENUE - NET | $ 182,714 | $ 228,846 | $ 257,608 | $ 269,909 |
| DEDUCTION FOR BAD DEBT | -- | $ 29,960 | -- | -- |
| NET INCOME | $ 182,714 | $ 198,886 | $ 257,608 | $ 269,909 |

## INDUSTRIAL RESEARCH INSTITUTE

Office of Industrial Research
University of Manitoba
Winnipeg, Manitoba R3T 2N2
(204) 474-5463

Director: R.E. Chant (1976)

### DOMAIN OF ACTIVITY

Large variety of applied R&D projects requested and sponsored by industries or other organizations.

Examples: For Canadian Electrical Association, the design and evaluation of thermoplastic ducts for power cable distribution.

Inter-City Manufacture Ltd. Research and development directed at improving materials components and systems used in the solar heating industry.

Nutritional and functional significance of phytate in phytate in rapeseed protein preparation for Agriculture Canada.

C.R.C. Microstrip Aerospace Antennas.

Canadian Wildlife Services; Research study using radio telemetry of field-feeding Mallarda in the Vicinity of Big Grass Marsh.

Triple E Manufacturing Ltd. Noise contrale and flammability testing.

Atomic Energy of Canada Ltd. - Laser Holagraphic interferometry development for the support of FAXMOD & FULMOD code development.

### MAJOR FACILITIES

The institute uses mostly the University's existing facilities. Special equipment and tools were purchased from Officer of Industrial Research budget.

### HUMAN RESOURCES

Permanent staff administrative, 2, Secretary 1, Research associate 3, Non-permanent staff (ad hoc basis) no information available.

### BUDGET (1978)

The total support from the federal government was $285,000 over 5 years. This support ended in September 1978.

| REVENUES | 1976/77 | 1977/78 |
|---|---|---|
| Value of Industrial Contracts | $145,500. | $200,197. |
| Value of Government Contracts | | $213,246. |
| Income from industrial contracts | | $ 27,043. |
| Income from government contracts | $ 30,304. | $ 40,622 |
| OIR surplus (deficit) | | (454) |
| | $ 30,304. | $ 67,212. |
| Expenses | $ 90,769. | $123,931. |
| OIR Income | $ 30,304. | $ 67,212. |
| OIR Surplus (deficit) | $(60,454). | $(56,719.) |
| IT&C Grant | $ 60,000. | $ 60,000. |
| OIR net Surplus (deficit) | $ (454) | $ 3,280 |

## INDUSTRIAL RESEARCH INSTITUTE

Centre de développement technologique (CDT)
Ecole Polytechnique de Montréal
(514) 344-4720

Directeur: D. Robert Hay (1979)

### DOMAIN OF ACTIVITY

Mission-oriented and applied research for the public service sector and small and medium sized business in Quebec.

Examples: Agreement with the Montreal Urban Community Transportation Commission to solve technological problems in a number of areas.

Research concerning the recycling of oil undertaken for the provincial and federal departments of environment and industries situated in the Montreal area.

Study of variety of .caracteristics of cement for the Laboratoire de Béton Inc.

Uniroyal contract for evaluation of latex mortar.

The study of the caracteristics of insolation material for Foster Refrigeration Ltd.

Hydro-Québec financed a study on caracteristics of clay at Outard 2 dam site.

C.I.L. Evaluation and environmental study of electromagnetic radiation in explosives industries.

Bibliographic review for the provincial Department of Transportation on traffic simulators.

34 projects for industry, 25 for federal departments, 19 for public service sector, 14 for consulting companies completed in 1974-75.

### MAJOR FACILITIES

The centre uses existing facilities of the Polytechnique and the Université de Montréal.

### HUMAN RESOURCES (1977)

Four full-time positions - 4 professional
2 secretarial
Part-time consultant: average of 85 professors and 50 students per year.

### BUDGET (1975)

The total amount of funding received from the federal government was $260K over four years. The agreement was terminated in August 1975 and since then the Centre has been financial self-supporting.

| | 1971-1972 | 1972-1973 | 1973-1974 | 1974-1975 |
|---|---|---|---|---|
| Revenue | 6 807.53 | 27 691.77 | 42 318.84 | 58 330.53 |
| Expenses | 43 437.79 | 66 630.73 | 73 410.73 | 74 669.42 |
| Surplus (Deficit) | (36 630.26) | (38 938.96) | (31 091.89) | (16 338.89) |
| Income from Grant | 30 000.00 | 60 000.00 | 60 000.00 | 60 000.00 |
| Surplus (Deficit) net | (6 630.26) | 21 061.04 | 28 908.11 | 43 661.11 |

# INDUSTRIAL RESEARCH INSTITUTE

Industrial Research Institute
University of Windsor
N9B 3P4
(519) 253-8862

General Manager: Ms. G. Lucas (1979)

## DOMAIN OF ACTIVITY

Large variety of applied or mission-oriented projects requested and sponsored by industries or other organizations.

Examples: Noise and vibration research projects, contracted by Ontario Ministers of Environment and Ontario Industries.

Product testing, the Windsor Star retained the institute services for testing of lead in the water from electric kettles.

Metallurgical research on industrial equipment failures, and metal products quality auditing.

Motor home safety and flammability of interior materials; installation of Safety Standards Programs at two motor home plants.

Air quality monitoring, and courses given in stock sampling techniques, for federal and provincial governments.

Ceramic research for U.S. clients, biological technical services, diffractography research, heat transfer research, shoreline erosion study on Lake Erie.

## MAJOR FACILITIES

The institute uses mostly the university's existing facilities.

## HUMAN RESOURCES (1974)

3 permanent administrative staff; 141 part-time profesionnal and non-professional staff.

## BUDGET (1974)

Total grant from the federal government $237.K for 7 years. Since June 1974 the institute has been financially self-sufficient.

| | 67/68 | 68/69 | 69/70 | 70/71 | 71/72 | 72/73 | 73/74 |
|---|---|---|---|---|---|---|---|
| Dept. of Industry Grant | 19,206 | 28,794 | 36,000 | 27,332 | 36,000 | 45,000 | 45,000 |
| Client Fees | 16,146a | 17,026a | 59,518 | 44,693 | 101,239 | 169,866 | 170,295 |
| Course Registration | 5,920 | 5,026 | 1,660 | Ø | 2,872 | 5,540 | 15,880 |
| TOTAL INCOME | 41,272 | 50,846 | 97,178c | 72,025 | 140,111 | 220,406 | 231,175 |
| Total Direct Expense | 13,373 | 15,826 | 50,884c | 31,462 | 85,851 | 146,480 | 120,777 |
| Total Gen. & Admin. Expense | 27,229 | 42,493 | 38,484 | 30,184 | 54,351 | 67,431 | 84,938 |
| TOTAL EXPENSES | 40,602 | 58,319 | 86,368c | 61,646 | 140,202 | 213,911 | 205,715 |
| NET GAIN | 670 | (4,063) | 7,258 | 7,875 | 1,211 | 13,285 | 22,182 |

Centre de recherches en sciences appliqués à
l'alimentation. (CRESALA)
Université du Québec à Montréal
Montréal, Québec H3C 3P8
(514) 282-6954

Director: Marcel Gagnon

DOMAIN OF ACTIVITY

The Centre de Recherches en Science Appliquées à l'Alimentation (CRESALA) has three major domains of activity:

a) Scientifics research (in food)
b) Training of specialists
c) Service to industry.

Examples: Organization of a International Seminar (April 14-15, 1978) on conservation of perishable foods.

Development of new techniques in yogurt freezing for the Canadian Milk Board

Feasibility testing of a new method for evaluating bacterial quality of milk, Quebec Department of Agriculture.

Study of methods to prevent the development of undesirable bacteria in meat Agriculture Canada.

MAJOR FACILITIES

The Centre mainly uses the university's facilities but also makes use of other universities, and hospitals in the Montreal area.

HUMAN RESOURCES (1978)

2 support and administrative staff; 15 professionals and technical staff and 14 consultants from UQAM.

BUDGET

Total grant from IT&C over 5 years was $200K. This funding expired in May 1978, and the Centre is now financially self-supporing.

| YEARS | 72-73 | 73-74 | 74-75 | 75-76 | 76-77 | 77-78 |
|---|---|---|---|---|---|---|
| Total Revenues | 176,475 | 194,995 | 248,338 | 254,177 | 280,145 | 320,560 |
| Expenses | | | | | | |
| Salaries | 147,573 | 147,141 | 197,858 | 198,047 | 210,114 | 255,276 |
| Benefits | 4,632 | 5,178 | 5,890 | 7,282 | 9,242 | 19,996 |
| Travel | 15,734 | 8,030 | 6,560 | 6,422 | 11,935 | 5,216 |
| Hospitality | - | 5,458 | 9,479 | 11,151 | 10,973 | 15,150 |
| Supplies | 6,023 | 10,437 | 14,702 | 12,163 | 12,285 | 17,959 |
| Computing | - | - | - | 1,000 | 2,400 | 450 |
| Rent | 928 | 2,816 | 3,290 | 3,131 | 6,326 | 1,803 |
| Investment | 1,582 | 618 | 3,080 | 1,525 | 8,332 | 1,137 |
| Professional Services | 24,269 | 27,360 | 37,113 | 35,394 | 52,252 | 42,717 |
| Total Expenses | 176,475 | 179,681 | 240,862 | 240,724 | 271,610 | 317,991 |
| Annual Surplus | - | 5,313 | 7,476 | 13,453 | 8,535 | 2,560 |
| Cumulative Surplus | - | - | 12,789 | 26,242 | 34,778 | 37,348 |

## CENTRES OF ADVANCED TECHNOLOGY

| CENTRES AND PARENT INSTITUTIONS | GRANT AND TERMS | TERMINATION |
|---|---|---|
| Centre for Powder Metallurgy<br>Ontario Research Foundation | $ 450,000 . 3 yrs | June 30-74 |
| Systems Building Centre*<br>University of Toronto | 300,000 . 3 yrs | Sept. 30-74 |
| Canadian Institute of Metalworking<br>McMaster University | 830,000 . 6 yrs | Sept. 30-76 |
| Centre for Ocean Engineering<br>B.C. Research | 1,225,000 . 3 yrs | Mar. 14-76 |
| Centre de Technologie* de l'environment<br>Université de Sherbrooke | 300,000 . 3 yrs | Oct. 31-76 |
| Systems Analysis, Control and Design Activity*<br>University of Western Ontario | 1,195,000 . 7 yrs | Oct. 31-80 |
| Canadian Food Products Development Centre<br>Manitoba Research Council | 550,000 . 5 yrs | Mar. 31-79 |
| Health Industry Development Centre<br>Manitoba Research Council | 225,000 . 3 yrs | Dec. 31-79 |
| Centre for Ocean Technology<br>Nova Scotia Research Foundation | 1,075,000 . 7 yrs | May 31-81 |
| Waterloo Centre for Process Development<br>University of Waterloo | 1,000,000 . 5 yrs | Oct. 31-83 |
| Centre for the Measurement and Control of Particles and Vapours<br>McGill University | 1,000,000 . 5 yrs | Nov. 30-84 |
| Biomedical Instrumentation* Development Unit<br>University of Toronto | 875,000 . 5 yrs | Feb. 28-81 |

*Detailed in following pages.

## CENTRE OF ADVANCED TECHNOLOGY

Centre de technologie de l'Environnement
Université de Sherbrooke,
Sherbrooke, Québec JIK 2RI
(819) 565-4423

Director: M. Cossette (1976)

### DOMAIN OF ACTIVITY

Undertake the development of new techniques to solve problems arising from the pollution that must be dealt with by Canadian industry.

Acquire marketable expertise in the field of recycling and disposal of industrial and mining wastes.

Examples: Studies on climate, physiography and topography of waste sites, study the microbiological activity of mining wastes and determining the factor limiting growth for Quebec Cartier Mining Co. on mining wastes.

Development of peat moss drying techniques for Fallinger Corporation.

In collaboration with Brace Research Institute, Donner Foundation and the McGill Department of Architecture development seeking of new construction materials for use in experimental housing for the native peoples of Canada.

For P.C. Aitcin and Quebec Asbestos Mining Association study of the use of asbestos mine tailings in roadbeds.

For Hurley Canada the centre carried out an investigation of the performance of activated charcoal filters for polluted water.

For Clairol Canada Ltd. two service contracts undertaken to determine the physical and chemical properties of chemical plant sewage.

### MAJOR FACILITIES

The centre main uses the university existing facilities.

### HUMAN RESOURCES

Most of the research undertaken by the Centre de Technologie de l'environnement (C.T.E.) was carried out by faculty members rather than by the centre directly. Only in cases where no faculty personnel is available, does the centre carry out the research itself. The exact number of human resource is not available.

### BUDGET

The total federal support was $300K over three years, with the ending in Oct. 1977.

| | | |
|---|---|---|
| **REVENUE** | | |
| Contracts (appropriations) | $ 39,731. | $ 90,000. |
| Grant (IT&C) | 100,000. | 100,000. |
| Total | $139,731. | $190,000. |
| **EXPENDITURE** | | |
| Research | | |
| Instrumentation | 2,537. | 10,000. |
| Supplies and materials | 12,332. | 8,000. |
| Contract services | 2,258. | 10,500. |
| Technical services | 743. | 10,000. |
| Salaries and benefits | 63,007. | 102.250. |
| Subtotal | 82,879. | 140,750. |
| Promotion and administration | 3,522. | 10,000. |
| University administrative expense | 9,211. | 17,253. |
| Total expenditures | 95,613. | 158,003. |
| EXCESS of revenue to expenditure | 44,118. | 31,997. |

## CENTRE OF ADVANCED TECHNOLOGY

Systems Building Centre
University of Toronto
35 St. George St.
Toronto, Ontario M5S 1A4
(416) 978-8653

General Manager: Professor M.W. Huggins

DOMAIN OF ACTIVITY

Variety of applied or mission-oriented research together with some basic research, sponsored by building materials industries, provincial departments and utilities.

Examples: Development of improved plaster cast for Smith and Nephen Ltd.

Assessing possibility making tubes of steel fabric cement to carry overhead transmission lines for Ontario Hydro.

Formulation of design criteria for polystyrene concrete for the Canadian market for B.A.S.F. Canada Ltd.

Testing the load bearing capacity of Durison walls for evaluation under the National Building Code of Canada.

Determining feasibility of applying glass reinforced tape membranes in cement mortar to decks of existing and new bridges to protect from calcium chloride damage for Ontario Ministry of Transportation and Communications.

MAJOR FACILITIES

The Centre uses existing university facilities.

HUMAN RESOURCES (1974)

No precise figures available.

BUDGET (1974)

Total grant from the federal government was $300K over 3 years. Since September 1974, the centre has been financially self-sufficient.

| | 1971-72 | 1972-73 | 1973-74 |
|---|---|---|---|
| Salaries | $45,680.50 | $63,128.64 | $82,458.24 |
| Supplies & Misc. | $10,750.75 | $12,340.27 | $12,785.61 |
| Equipment | $ 7,354.55 | $ 5,425.94 | - |
| Travel | $ 3,626.59 | $ 1,249.99 | $ 2,268.81 |
| Overhead | $20,223.72 | $23,428.52 | $29.837.16 |
| TOTAL | $87,636.11 | $105,573.26 | $126,516.79 |

Systems Analysis Control and Design Activity (SACDA)
University of Western Ontario
London, Ontario N6A 5R9

Director: J.R. Dickinson (1976)

DOMAIN OF ACTIVITY

To assist industry and other agencies in applying the methods of systems analysis, design and control in improving their operations.

Examples: Chinook chemicals methylamine plant expansion feasibility study and new process design, with the objective to raise production capacity by 50%.

Physical properties package for high pressure non-ideal systems. This is a computer package for predicting the behaviour of non-ideal chemical systems.

Finite element plotting program. This is a computer program developed for the Ontario Research Foundation.

Optimal use of a wilderness pack: a model was developed with a large set of non-linear algebraic equations for computer circulation.

Network partitioning project for Bell Northern Research. The objective of this project was to develop suitable algorithms for automating part (or all) of the partitioning task.

Lectures and courses: digital logic, control systems for electrical engineers, computing for engineers and other lectures were held at Sheridan Park, Ontario

MAJOR FACILITIES

SACDA uses university facilities and also SACDA owns computer terminals such as CDC 732 terminal to cyber 73, PDP-10, Tektronix 4013.

HUMAN RESOURCES (1975)

5 permanent professionals; 2 secretaries.

BUDGET (1977/78)

The total federal support for the centre was $875K for 5 years. The contract ended October 1978.

| | 1976-77 | 1977-78 |
|---|---|---|
| REVENUE | | |
| - Grant | $175,000 | $175,000 |
| - Project and Other | 143,841 | 156,000 |
| TOTAL REVENUE | $318,841 | $331,000 |
| EXPENSES | | |
| - Computer Services | $ 8,535 | $ 14,000 |
| - Computer Supplies | 3,098 | 5,000 |
| - Supplies | 5,848 | 6,000 |
| - Telephones | 1,814 | 3,000 |
| - Equipment Rental | 5,354 | 6,000 |
| - Office Rental | 3,547 | 4,000 |
| - Salaries | 119,457 | 135,000 |
| - Professional Services | 34,806 | 37,000 |
| - Staff Benefits | 14,574 | 15,000 |
| - Travel | 10,443 | 12,000 |
| - Printing and Promotion | 1,194 | 2,000 |
| - U.W.O. Admin. Charge | 12,933 | 12,000 |
| TOTAL EXPENSES | $221,603 | $251,000 |
| SURPLUS/ (DEFICIT) | $ 97,238 | $ 80,000 |
| BEGINNING RESERVE | $ 19,187 | $116,425 |
| ENDING RESERVE | $116,425 | $196,425 |

## CENTRE OF ADVANCED TECHNOLOGY

Biomedical Instrumentation Development Unit
University of Toronto
Toronto, Ontario M5S 1A4
(416) 878-6666

Director: J. Watson (1976)

### DOMAIN OF ACTIVITY

Biomedical Instrumentation Development Unit (BIDU) is dedicated to the progress and growth of the Canadian biomedical instrumentation industry.

Examples: Agreement with Oxford Manufacturing Co. to develop two prototype units for the semi-automatic identification of bacteria.

Negotiation for the licensing of the micropump was started in July 1976 with the Techno-Medic Inc.

A self-contained air monitor was developed for use by workers who are exposed to dust and certain toxic gases in their environment.

Prostehtic attachment system was develop on specific request by a surgeon.

A Doppler Ultrasound System capable of localizing and quantifying peripheral vascular disease is now in regular use in the Vascular Laboratory of the Toronto General Hospital.

Microprocessor Controlled Intensive Care Ventillator is in the development stage with BIDU.

Other projects; simple economical mass-spectrometer system for measuring the concentration of certain gases that are of significance in respiratory investigations. New procedure for improving, through automation, certain antibiotic susceptibility procedures.

### MAJOR FACILITIES

Although BIDU uses university of Toronto's space, the testing and laboratory equipments and supplies were purchased with BIDU's funds. ($43K in 1977).

### HUMAN RESOURCES (1977)

Full-time staff are: 2 professional engineers, 1 technologist and 1 research assistant, and 4 administrative and support staff on part-time contract.

### BUDGET (1978)

The total federal support is $875K for five years. The agreement will be terminated in February 1981.

| | | |
|---|---|---|
| Expenditure: | Salary | $94,445. |
| | Equipment | $18,162. |
| | Supplies | $24,776. |
| | Travel | $ 2,609. |
| | Lab. renovation | $ 624. |
| TOTAL Expenditure: | | $140,616. |
| Revenue* | | |
| Contract Fee: | | $165,000. |

* The total figure is not available.

## The Industrial Research Association Program

| Association | | Amount | Termination Date |
|---|---|---|---|
| Sulphor Development Institute of Canada | $ | 2,174,000 | June 30/81 |
| Canadian Welding* Development Institute | $ | 1,125,000 | July 31/80 |
| Canadian Gas Research Institute | $ | 875,000 | Dec. 31/79 |
| Centre for R&D in Masonry | $ | 900,000 | Mar. 31/84 |

Source - Dept. of Industry, Trade & Commerce, Office of Science and Technology "The Industrial Research Institute Program, The Centres of Advanced Technology Program, The Industrial Research Association Program", Annual Reports.

* Detailed in following page.

## INDUSTRIAL RESEARCH ASSOCIATION

Canadian Welding Development Institute
232 Merton St.,
Toronto, Ontario
M4S 1A1

Director: N.S. Eaton (1976)

### DOMAIN OF ACTIVITY

Welding technology and welding materials fabrication. Training welding specialists on new techniques and procedures.

Examples: Contract from the Government of British Columbia to develop a new curriculum for welding education in the college system.

In collaboration with Ontario Hydro, were asked to provide consulting services of relevance to the construction and operation of electrical generating plants, and also provide information of value to a wide range of industrial members in the structural fabricating industry.

The institute has undertaken considerable research and specialist investigation in support of the proposed Alaska Highway Pipeline Project.

On contract to American Gas Association, Ultrasonic inspection of pipeline girth welds.

In collaboration with the University of Waterloo the institute studied the stresses that occur in the root run of a pipe weld.

Organized a series of specialized seminars for professional engineers.

### MAJOR FACILITIES

Metallurgical examination, mechanical testing, welding and inspection equipment, laboratory.

### HUMAN RESOURCES (1978)

Professional: 8 Support: 10

### BUDGET (1978)

The grant from the federal government was $875,000 over 5 years. Since July 1978, the institute has been financially self-sufficient.

| REVENUE SOURCE | 1974 | 1975 | 1976 | 1977 | 1978 |
|---|---|---|---|---|---|
| Government Grant Earned | $175,000 | $175,000 | $175,000 | $175,000 | $175,000 |
| Industry Grant | $122,049 | $ 20,288 | $171,402 | $ 82,659 | $ 69,538 |
| Membership Fees | - | $ 24,650 | $ 52,049 | $ 86,633 | $107,567 |
| Course Fees Received | $ 81,487 | $111,408 | $107,017 | $ 83,069 | $ 96,892 |
| Seminar Registration Fees | $ 869 | $ 30,079 | $ 51,082 | $ 30,053 | $ 46,963 |
| Technical Contract Fees | - | $ 10,613 | $ 83,861 | $ 97,652 | $210,348 |
| Interest | $ 9,568 | $ 17,185 | $ 21,176 | $ 21,523 | $ 26,113 |
| TOTAL REVENUE - ACTUAL | $388,073 | $389.223 | $661,587 | $576,589 | $732,421 |
| EXPENDITURES (ACTUAL) | $175,627 | $420,405 | $652,669 | $521,484 | $591,595 |
| SURPLUS | $213,347 | ($ 31,182) | $ 8,918 | $ 55,105 | $140,826 |

## UNITED STATES SELECTED PROGRAMS TO STIMULATE TECHNOLOGY TRANSFER

| MECHANISM | EXAMPLES | COMMENTS |
|---|---|---|
| 1) Direct corporate funding of University Research Projects | Harvard(Monsanto Biological and medical research program (1975) | This arrangement represents a long-term (12 years) high level committment ($23 million) to support basic research. It is hoped that it will result in improved interactions that favour technology transfer. However, it is too soon to judge on the relative success. |
| 2) Cooperative Research Programs | Presently NSF sponsors cooperative research programs at Carnegie-Mellon, North Carolina State University and MIT | This program is designed to stimulate technology transfer for specific industries. It has been most successful in large industries where a few firms control the market. |
| 3) University/Industry Research Consortia | - Department of Defence in the development of military technology<br>- Clemson University experiment/Dept. of Commerce research on fabric flammability<br>- Gulf Universities Research Consortium | A group of experts in the field defines the key research needs, selects proposals from both university and industry. The consortia are most productive when they are directed towards the achievement of a specific goal. As yet, it is too soon to comment on the relative success in stimulating technology transfer. |
| 4) Joint Industry/University Laboratory | Fluid Dynamics and Energetics Laboratory of New York | Because of the basic differences between universities and for-profit organizations it has been extremely difficult to promote this type of activity. |

| MECHANISM | EXAMPLES | COMMENTS |
|---|---|---|
| 5) Technology Licensing and Technological Brokers | New England Energy Development System (NEEDS) developed by MITRE Corporation funded by NSF (a component of NSF's Cooperative Research Program | An organization is established to coordinate university research with the needs of industry. In the case of the MITRE experiment, an attempt was made to "facilitate the flow of technology between the New England electric utilities and those universities/non-profit research groups capable of performing research needed by the utilities". Again, it is too early to evaluate the relative success of this mechanism. |
| 6) Extension Services | Energy Advisory Service for Taxes (EAST) organized by Taxes A&M University | The University develops an extension centre designed to provide contacts and expertise on particular issues. In general, this approach appears to be most appropriate for fragmented industries where the cost of obtaining information about new developments is high. |
| 7) University Industrial Associates | Successful Industrial Associates programs are operating at MIT, Stanford and California Institute of Technology | Member companies contribute an annual fee between $15,000 and $25,000. In return, they exchange research results in fields they are actively pursuing and receive intensive briefings in unfamiliar areas. Only a few of the nations most prestigious institutions have been able to achieve the appropriate number of corporate members needed to defray costs of running the program. |
| 8) Industrial Parks near universities | - Stanford Industrial Park<br>- Research Triangle Park (University of North California) | Since this requires strong political and financial commitments by universities and governments only a limited number of universities have been successful. |

| MECHANISM | EXAMPLES | COMMENTS |
|---|---|---|
| 9) Innovation Centres Experiment | Presently there are three innovation centres supported by NSF at the University of Oregon, MIT and Carnegie-Mellon University | The program is designed to provide support for inventors and teach the necessary skills to move a new product from the laboratory to the market place. At present, it is too soon to evaluate the overall success of this program but preliminary evidence appears encouraging. |
| 10) University Business Development Centres | University Business Development Centres (UBDC's) established by the Small Business Administration | These programs have had little direct effect on university research links with industry since the institutions carry out little on-going research. However, they may stimulate technology transfer indirectly by helping establish new firms that may then acquire technology from universities. |
| 11) Federally Funded Research and Development Centres (FFRDC's) | - Applied Physics Laboratory (John Hopkins University)<br>- Lincoln Laboratory (MIT)<br>- National Astronomy and Ionsophere Centre (Cornell University) | There are approximately 21 FFRDC's located on university campuses. These institutes are financed exclusively or primarily by the Federal Government to perform R&D in relatively specific areas, or in some instances to provide facilities at universities for research and associated training purposes. The Centres usually have a direct and long-term relationship with their funding agency, making it possible for them to maintain instrumentation, facilities, and operational support beyond the capabilities of single educational or research institutions. These institutes primarily conduct basic research of the Nation's total basic research expenditures in 1975, FFRDC's administered by universities and colleges accounted for 7 percent of the total which amounted to about $300 million (current). |

APPENDIX IV

# INNOVATION CENTRES IN UNITED STATES

## MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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| OBJECTIVE: | To encourage students with ideas to develop them into products with potential in the real marketplace and, thereby, to increase the supply and the quality of technical entrepreneurs through a supplementary education program. The Centre is also conducting formal research on the innovation process. |
| STRUCTURE: | The Centre is organized as a division within the School of Engineering with support from the Sloan School of Management. |
| PROGRAM: | Two programs are provided:<br>- Innovation Education Program - An inter-disciplinary program that provides two major parallel activities: a) a set of elective courses; b) a series of laboratory, workshop, office, and field activities relating to the generation of concepts, their subsequent evaluation and their development to a marketable stage.<br>- Innovation Co-Op - An organization similar to a small R&D company wherein actual development and commercialization of inventions takes place. It provides a clinical environment in which students, with supervision and guidance, can undertake prototype development, experimental fabrication, patent application, market analysis, and promotion of new products, processes, and services. |
| ENROLMENT: | 1974 58 students 18 faculty<br>1975 150 students 23 faculty |
| REVENUE: | Royalties on innovations developed in centre and industry project fees. ($33,000 from outside sources in 1974). |
| ACTIVITIES: | As of May 1976, 23 Co-op projects were listed, 9 funded with project funds, 10 with industrial funds, and 4 were unfunded. |
| EXAMPLES OF PRODUCTS: | Bicycle framesets, electronic games, current limiters, high efficiency bow, precious metal forgery detection system, small molecule detector, wide band electronic guitar. |

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SOURCE: R.M. Burger, RANN Utilization Experience, Report to the National Science Foundation, Case Study No. 33, Research Triangle Institute, pages 33-39.

EXPERIMENTAL CENTRE FOR THE ADVANCEMENT OF INVENTION AND INNOVATION

University of Oregon

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|---|---|
| OBJECTIVE: | To promote, encourage and stimulate technology transfer -- specifically from the inventor to the innovator to society. The Centre carries out education, public service, and research missions in support of this objective. |
| STRUCTURE: | The Centre is an entity within the College of Business Administration of the University of Oregon and is subject to normal University policies. The Western Inventors Council provides support to and participates in the Centre programs. Liaisons have been established with other universities and with public and private installations, agencies, and firms. |
| PROGRAM: | The Centre identifies its thrusts in three distinct activity areas: education, public service, and research. In education, a curriculum of nine courses is offered covering the full spectrum of entrepreneurship and innovation. At present, the thrust of public service is the evaluation of a large number of inventions that are brought to the Centre and the moving of worthy ideas to the marketplace. Finally, research is in two parts: the first relating to the Centre and the invention evaluation process, and the second consisting of faculty conducted, Centre funded research. |
| ENROLMENT: | 1974 301 students 8 faculty<br>1975 325 students 10 faculty |
| REVENUE: | Fee of $25 required for each evaluation, but revenue is assigned to Western Inventors Council and is being accumulated in a trust. No revenue has yet been realized from the marketing of ideas and the NSF funding is the sole financial support for Centre operations. |
| ACTIVITIES: | A very large number of ideas has been received and over 500 have been evaluated. During the year ending June 30, 1975 alone, over 70 patents were issued on these ideas; and some 8 product efforts have been initiated. |
| EXAMPLES OF PRODUCTS: | Plumbing fixture to allow setting of bath temperature, wood burning stove, three-wheeled car, wine rack. |

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SOURCE: R. M. Burger, Ibid., pp 33-41, Case Study No. 33

## CENTRE FOR ENTREPRENEURIAL DEVELOPMENT

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Development of a Laboratory Experiment in Technology Transfer Via Entrepreneurship

Carnegie-Mellon University

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| OBJECTIVE: | To encourage and develop entrepreneurial activities and innovation through education, research, and support of new ventures. |
| STRUCTURE: | The Centre is a separately chartered tax exempt corporation with the University as residual beneficiary. The Board of Directors consists of the Executive Director and three CMU deans. Three components of the University -- Carnegie Institute of Technology, the Graduate School of Industrial Administration, and the School of Urban and Public Affairs, provide the academic base on which the Centre was created. |
| PROGRAM: | The Centre provides courses in the engineering and management disciplines, including a Master of Engineering degree in design. However, its primary focus is on entrepreneurial activities. For these, it directly participates in the development of new businesses, arranges community service seminars, stimulates related academic activities, and is a resource centre. It provides capital, where no commercial capital is available, and interfaces strongly with the small businesses that it spawns. |
| ENROLMENT: | 1974 — 41 students — 18 faculty<br>1975 — 90 students — 20 faculty |
| REVENUE: | Efforts are made to obtain venture capital for small businesses. No revenue to date. |
| ACTIVITIES: | Three small businesses with 43 employees have been created. Others are in various development stages, and additional product ideas such as the oximeter are being considered. |
| EXAMPLES OF PRODUCTS: | Small businesses: Compu-Guard, Inc., The Pittsburgh New Sun, People's Cab Company, International Lamp Corporation, and Bactex, Inc. |

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SOURCE: R.M. Burger, <u>Ibid</u>., pp 33-37, Case Study No. 33

# FACTORS INFLUENCING THE UTILIZATION OF THE INNOVATION CENTRES EXPERIMENT

The experimental nature of the program--emphasis is on testing hypotheses on the education of entrepreneurs and on innovation, although in each centre, this is interpreted differently;

the well-defined experiment duration--knowing that NSF support of the centres terminates in five years places emphasis on creation of future income and causes some to view the centres as transient perturbations in the educational structure;

the multi-objective structure--the hierarchy of objectives creates options in approaches and products and permits commendable program flexibility. At the same time, the measures of performance are not well-defined and it becomes easier to "march to the sound of the drums" rather than follow a reasoned experiment protocol;

the calibre of the directors--through selection of strong Centre Directors, a strong measure of enthusiasm, competence, and zeal permeates the centres and bodes well for their success;

the importance of the subject--innovation and entrepreneurship are in the national spotlight, thus the Innovation Centres Experiment benefits from a large receptive audience, but must bear the burden of detailed scrutiny;

the quality of the work--each of the centres can enumerate significant accomplishment and an apparent concordance of support from those served. The early victories have aided greatly in attracting recruits to the centres;

the resistance to change--as innovations in the education process countering established academic patterns, the centres meet with resistance just as does any interdisciplinary program in a disciplined structure;

the block funding--the initial commitment to full funding of the programs has been important in allowing the centres to obtain institutional status and in avoiding the resource dissipation associated with renewal processes and the accompanying uncertainties;

the program management--although minor irritation was voiced relative to the documentation required for the experiment evaluation, no significant faults were attributed to NSF management in response to inquiries on this subject. All evidence points to an effective, flexible, and constructive approach to centre supervision by NSF;

the liberal patent policy--the agreements permitting the centres to develop through patents and other means, income that supports present and future operations, are a significant factor in the experiment design and are apparently an innovation in government policy that could have far-reaching effects;

the nature of venture capital--in the business world, venture implies levels of risks and rewards that are beyond the resources of the Innovation Centres Experiment. Thus it appears that the ventures being undertaken must be considered as small-scale laboratory experiments, and recognition must be given in the research to the factors involved in full-scale ventures.

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SOURCE: R.M. Burger, RANN Utilization Experience, Ibid., pp 33-31 and 33-32

thompson foss inc.
P.O. BOX 397 STATION A OTTAWA, CANADA K1N 8V4

# Barriers to the University-Industry Interface:

# The Case of Engineering and Applied Science.

10th JUNE 1978.

Philip M. Thompson, M.A., P. Eng
Telephone (613) 233 0674
Residence (613) 233 1812

Barriers to the University-Industry Interface:

The Case of Engineering and Applied Science.

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P.M.Thompson.

## Executive Summary.

In many countries, industry makes good use of the research results of the universities. This does not happen in Canada, because of attitudes both in industry and universities. Much of Canadian industry is branch-plant oriented and has little direct use for any technological research output, whereas most university research is aimed more at the production of scientific papers than being of direct value to industry. The situation has grown worse over the last 15 years because of attitudes within universities towards entrepreneurship, competing pressures for professors' time, the criteria by which professors are judged within faculties of engineering and N.R.C. granting policies.

The prime cause for these problems is either lack of clear research objectives in universities, or diverging objectives between universities and industry. Thus the first step towards their correction is the development of a tier system, first of industrial objectives, then of research objectives to support them. All sectors of the engineering (and applied science)

community must be involved in the process of developing them.

Once the objectives are determined the technology reinforcement of Canadian industry must be assisted by appropriate purchasing policies of Government departments. Research fund granting must be determined by utility to industry and success in meeting predetermined research objectives, rather than by the present system of peer evaluation.

University engineering faculties must become more atuned to the needs of entrepreneurship and this direction could be assisted by professional accreditation authorities. An organizational structure similar to that of medical schools would ensure that student engineers were taught by professors who understood the demands of the private sector. Financial pressures resulting from an inevitable decline in student enrolment could be used as a positive factor in bringing this about.

If industrial and research objectives are properly developed, then supported in government, industry and the universities, the technology base of Canadian industry must benefit as will Canada's economic position in the world.

## Barriers to the University-Industry Interface: The Case of Engineering and Applied Science.

P. M. Thompson.

Canada has a well developed university system, in which almost every professor, in faculties of engineering and applied science and 50% of their graduate students spend some of their time in research. Canadian industry represents a potential market for this research. However, little of this research output finds its way into Canadian industry and an expensive and potentially useful national resource is ignored. The purpose of this report is to identify barriers existing between universities and the private sector and to propose measures to improve the communication of research information between the two. The improvement in this communication requires, first a research output that is useful to industry and second, an industry that is capable of using the results of this research.

The barriers consist of a complex combination of attitudes and have been reflected in legislation which reinforces the barriers. At the working level, these attitudes have resulted in opposing objectives in universities and the private sector. The university professors' main research objective is to publish and this leads him into research areas of little use to Canadian industry.

Many of these attitudes are reinforced by the policies of granting agencies. For example the peer evaluation system used by N.R.C. demands a high publication rate. Also the policy of not allowing grants to pay the salary of the recipient reinforces the idea that government research money should not be used to stimulate profit making.

The report will first review the situation as it exists today in universities, the private sector and in a variety of other bodies, the roles of which influence the relationship between the first two. It will be shown that the key to the situation is in the different objectives in the two areas and how the various bodies identified can share in its improvement. What is needed is a National plan in which objectives are first identified, then implemented through the policies of the research fund granting agencies. (At the same time, the appropriate parts of the private sector should be encouraged by policies of other branches of government, but that is outside the scope of this report.)

Role Players:

Engineers interact as members, (or employees), of a variety of organizations which can be classified under four general headings.

1. Private sector (a) Industry
   (b) Consultants.

2. University.
3. Government. (a) Federal
   (b) Provincial.
4. Societies (a) National (and international)
   (b) Provincial.

Of the above 1a. Industry and 1b. Consultants represent opposite ends of the spectrum encompassed by the private sector. 3a. the Federal Government includes all its agencies, including Crown corporations. Engineers include applied scientists and represent the design and supervisory aspect of technology.

Private Sector:

Canada, as an industrial nation, must compete directly with the U.S. and in many cases, it has not been very successful. There are two major difficulties, the smaller home market and the relatively higher labour costs in Canada. However, both of the above warrant further examination. Many U.S. technology based industries thrive on a local market base, not very different from that found in parts of Canada. The high labour costs in Canada relate to unskilled and semi-skilled workers. The labour costs in Canada for highly skilled technologists and engineers are competitive. Thus, we must look for other reasons for the shortage of technology based industry.

Although it is clear that the major beneficiary of a research programme is the person who does it, industry can benefit if it is in a position to use the results. The main difficulty is that much Canadian industry has a branch plant relationship with companies in other countries. Often an independent native industry also has a branch plant philosophy. This kind of industry has little interest in research or development and exists by manufacturing other countries designs for a protected Canadian market. Here, it is less risky and perhaps cheaper to pay design royalties than to develop ones own products. However, there are a few large Canadian companies who do their own research and development and who export some of their products. (Northern Telecom has recently caused the U.S. industry to take notice as they expand into the U.S.A.) Also, there is an increasing number of small technology based Canadian companies who can greatly benefit from research and development.

These small companies have much to gain from cooperation with universities. Their growth frequently depends upon the availability of new staff already familiar with their technology and they, in turn represent a market for new Masters and PhD graduates. These companies often find a Canadian protected market as much of a disadvantage as the "branch-plant"" companies find it an advantage.

A large part of the engineering in Canada today is done by consultants who provide specialized services both inside and outside the country. A design for say a new arena will have an engineering component which will be sub-contracted to a company of engineering consultants. Then this company will, in turn, sub-contract heating, electrical, foundations etc. to other engineering consultants. This body of engineering expertise is well thought of abroad and it is employed in the near and far East and other developing parts of the World. Canadian integrated circuits consultants are employed by major manufacturers in the U.S., Europe and Japan, marine systems consultants are employed in Singapore, Hong Kong etc., and they all add prestige to Canadian technology. These companies do not play a large role in research and development as it is understood for the purpose of statistics, but they represent a significant research and development resource.

(These consultants will be referred to in some of the proposals made below. They must not be confused with a variety of engineering and management consulting companies, which provide such services as "body shopping", assisting in management decisions etc. Although these latter services are useful, they have little to do with engineering research and development).

Universities:

Most Canadian universities have defined the functions of professors as the following three: 1) Teaching 2) Research 3) Administration. Also, performance of research is frequently a requirement of a graduate degree. In this case, the student acts as a research assistant to a professor and develops his research skills. Usually a common set of rules and guidelines applies to all faculties, so that a professor of engineering operates within the same framework as a professor of philosophy. This structure leads to some difficulties for the engineering professor who wishes to do research relevant to the needs of industry. In order to explain these difficulties, the three elements of his "job description" should be treated separately.

1) Teaching: This is usually taken as being the function for which a professor is paid. In a small university, his course load can be high. If he takes his courses seriously, a professor of engineering spends a lot of his time on the preparation and up dating of his courses in addition to his lecture room and laboratory functions. Most professors teach at both the undergraduate and graduate levels in similar general areas of specialization. The desire for a well-rounded programme results in a broad spread of expertise and this can result in no two professors being in the same field with little incentive to cooperate in research matters.

2) Research: Although a professor earns his salary primarily as a teacher, he earns his "brownie points" mainly by research. Here, he will be expected to "strive for academic excellence". In small universities excellence is difficult to assess, because usually the professor himself is the only person in his institution able to judge his work. The yardsticks, used by others tend to be 1) Number of papers published. 2) Value of grants in support of research. Any bond with entrepreneurship is of negative value, because profit making tends to be regarded as not compatible with academic excellence. Certainly, using a research grant to assist in a venture, which leads to a profit for the professor would be treated as unethical. It should be noted that the "peer committee", which judges

his applications for research grants tends to be in a similar position to other members of his department, when it comes to being able to assess his work and they rely strongly on a paper count. A professor is thus encouraged to use his limited research time to generate academic papers.

It is generally the case, in engineering subjects, that the areas in which it is easiest to publish are not those which are most applicable to Canadian industry. Thus, the pressures from university administration and the N.R.C. granting system have tended to inhibit research applicable to industry. This is illustrated by the case of the N.R.C. grant to Dr. K. C. Smith, Chairman of the Department of Electrical Engineering at the University of Toronto.

Dr. Smith is a university researcher, with an excellent reputation and many years experience. He is particularly interested in carrying out research relevant to industrial needs and has long supported ventures which might give Canadian industry an edge over competition from outside the country. Recently, his research has been particularly productive of ideas that could lead to useful entrepreneurial ventures. Also he has a creditable publication record for this kind of work. He was informed of his grant for the new year (about $22,000) by a letter which indicated clearly, that although his grant would be sufficient for the work envisaged, the committee wished to see a significant increase in the number of his publications. To put this in perspective, it should be realized that there are several professors in Dr. Smith's department who received over $30,000, all in fairly mathematical fields, where the publication rate is high.

It is not difficult to guess what would have already happened to the N.R.C. grant of a professor who did not have Dr. Smith's reputation or position. The lesson is clear. To survive in university research, ones real objective must be to publish as many academic papers as possible, rather than to concern oneself with the usefulness of the work to Canadian industry.

3) Administration: This fills an increasing proportion of a professors time and competes with the time available for his research. Three main activities fall under this heading: 1) Student matters. 2) External organizations. 3) University committees. The first of these, student matters, represents an extension of his teaching function and any well-motivated professor will spend a lot of his time in this direction. In addition to consultation on academic matters, there are many aspects of a student's degree programme that can best be dealt with by professors, on a one to one basis.

Most university administrations are conscious of the need for professors to play a role in society outside the university. They see this in terms of activity as members of committees of non-profit organizations, such as community associations, professional bodies, learned societies etc. Also they tend to feel that a full-time professor should not make a significant amount of money outside his university. They have no objection to his earning money from publication royalties and tolerate a small amount of consulting, but they view with distrust any significant contribution to a profit making venture. Although the above comments apply to most universities, there are some engineering faculties which do encourage consulting and entrepreneurial activities.

There has been a recent tendency for the proliferation of the committee structure at all levels in universities. Most professors find themselves on several (often unwillingly) and committee work takes up a fair amount of time that might otherwise be used for research. Many excellent researchers and teachers have learned the dangers of not giving sufficient attention to the polital aspect of university life by finding a "knife in their back" when they least expected it.

When all the pressures on engineering professors are considered, it is not surprising that they tend to specialize in the areas which yield academic papers in favour of those of practical value to industry. Indeed, it is very much to the credit of some application oriented professors that they do choose to do research that is of value to industry.

Government:

There are many branches of government which influence research and development, both in universities and industry. Each has its own terms of reference and operates independently. Although there is considerable effort to prevent conflict, there are many examples of the actions of one agency defeating those of another. Canada is unique amongst Western industrial countries in the way defence funds are spent and most Defence equipment dollars go abroad. Also the Department of Finance seems to do little to help the Department of Industry Trade and Commerce in its aims to encourage new Canadian ventures. There are opportunities for departments to cooperate on their instrumentation needs. In many cases Transport and National Defence have requirements which overlap, but Canadian industry is not able to benefit because of conflicting funding policies or time scales. (The author regrets that it is not possible to quote examples without revealing information which one or more departments may regard as secure).

If Canadian industry is to be able to exploit these requirements, neither the DSS formula for favouring Canadian products, nor tax write-off schemes will be sufficient. We must follow the lead of other industrial nations. That is, we must identify needs sufficiently in advance for suitable products to be developed. Then the funds required for the development must be made available. Once a company had a product it would have the responsibility of competing, with it, in the marketplace.

If there were a system of research and development objectives, it would assist Government departments in identifying requirements for products that could be met within this structure. General departmental policies (to support the growth of Canadian industry) could then be made specific and Canada would develop industry that could make use of university output. The development of these policies is outside the scope of this report, but is clearly a subject that warrants further study.

Engineering Socities:

The main purpose of these societies is to provide a forum for the exchange of information between engineers in related specialities. This is done by technical meetings and national journals. Professors and practicing engineers certainly meet through these organizations and they both contribute to the same journals. However, many practicing engineers complain that, in an attempt to achieve "technical excellence" the papers are becoming unreadable and of little use to them. Thus a potential aid to effective university-industry communication is lost. (A notable exception to this is the Canadian Geotechnical Journal, which provides information well used by practicing engineers).

In both the national and provincial engineering organizations, mechanisms exist which can facilitate the flow of technical information between university researchers and industrial users. This will be developed later in this report.

Provincial Engineering Bodies:

Each province has a body which licences engineers to practice. These bodies accredit university engineering programmes and can have a significant influence on what an undergraduate engineer is taught. In recent years, this accreditation process has assumed greater inportance than in the past, but is has not been used to ensure that graduates will be prepared for an entrepreneurial or small company environment.

The A.P.E.O. has instituted an Engineers in Education Division to serve engineering professors within the structure of the provincial association. However it is doubtful that it will do anything to promote a flow of information, on engineering matters, between professors and practicing engineers. Indeed it is more likely to do the opposite.

Objectives:

It is possible for the various elements of Government, industry and the universities to cooperate. The country, which has, in recent years, been most successful in combining the resources of industry, government and universities is Japan. It would be neither possible nor desirable for Canada to follow the Japanese approach, because it is based on a paternalistic society, with a very different history from Canadian society. However, there are features of the Japanese approach that we would do well to copy. The success of the Japanese is a result of their attention to objectives. They concentrate the effort of a complete industry, with university and government support, towards a well defined long term objective. There are numerous examples of such cooperative efforts by the Japanese. Cameras, watches and consumer electronics are but three. It would neither be possible for Canada to adopt similar objectives nor a similar method of identifying them as Japan, but Canada could adapt the principle to its situation and its own political philosophies.

The change that would be effected is one of approach.

Consider, for example, a present situation. If it is agreed that a group of professors in a Canadian university relate their work, they choose a "common field" such as digital systems or communications. Although each of these areas is regarded as a speciality it is possible for six professors to be working in six different sub-areas of say communications and to each understand so little of the others work that they are unable to communicate. In contrast, if they had a common research objective, each would be able to communicate in terms of that objective, (and aid the others' research while working in a different field).

Several tiers of objectives must be developed. For example, in civil engineering, it could be argued that whilst Canadian companies now compete successfully in Canada, it would be useful to explore areas which would improve their competitive edge abroad. This would become a prime research objective and a set of sub-objectives would be developed to support it.

The principle of research by defined objectives would result in better communication not only between university staff, but also between them and industry where the concept of objectives is readily understood. Furthermore it could be mechanism by means of which sufficient effort could be brought to bear on matters of National importance.

The development of these common objectives takes a high priority. Because the objectives must be meaningful to the private sector, government and the universities, they must all cooperate in their development. The best forum for this appears to be in national technical societies. Once economic and policy matters are settled, the prime responsibility for the selection of engineering research objectives should be on the shoulders of the engineering end-user, usually the Canadian-based component of the private sector. A possible format for this would be a group of several leading members of suitable companies and senior consultants all answering to a committee within a national technical society. (There is a problem here in the electrical area, which is dominated by the U.S. based IEEE).

There is no reason why the same committees should not develop both long term objectives and sub-structures of shorter term objectives to sustain them. The committees should all be given the same basic terms of reference in the form of the objective "Develop a set of realistic long term and short term research objectives in which universities, government and the private sector can cooperate in improving the competitive position of Canada as an industrial nation". Here, long term could be taken meaning 10 to years and short term 2 to 9 years. It is clear that both the long and short term objectives would need to be reviewed frequently in the light of events which had not been predicted when the initial objectives were set. For example, if energy demanding objectives had been set in the early 60's, they would need to be re-evaluated later in the light of the energy crisis. However, it would be important to avoid the sudden termination of projects, such as has happened in Canada's aviation industry, with the resulting loss of expertise.

The way in which the selection of objectives might work is illustrated by an example from electronics. This is chosen because it represents a very different area from the previous example from civil engineering. A recent discussion paper "The Canadian Electronics Industry", published by the Department of Industry Trade and Commerce, concludes "------the outlook for Canada's electronics industry is not encouraging", and " ---- there is no necessary reason that electronics products should be made in Canada"., but "The key to the future is the business climate, augmented by other initiatives such as consolidation of the industry structure and FURTHER DEVELOPMENT OF ITS STRENGTHS ON A SELECTIVE AND SPECIALIZED BASIS" (The capitals are mine). Canada's particular strengths lie in the technology areas related to its size ie. communications, transportation etc. The above mentioned discussion paper agrees with the author in the contention that Canada needs an electronics industry as a key component of its other industry. Perhaps an appropriate long term objective would be to develop an electronics industry in a variety of specialized technology dependent areas. These would include communications, instrumentation and transportation based electronics. The shorter term objectives would identify specific tasks in specific areas.

New Directions for Universities.

There must be significant changes in engineering faculties of universities if useful objective-oriented research results are to be exchanged with industry. The undergraduate programme must be tuned to the needs of the private sector and an environment must be developed, within which professors are encouraged both to communicate with each other on research matters and to communicate with industry. Changes in the undergraduate programme can be achieved through changes in accreditation policy of the provincial engineering bodies. Changes in research programmes can be achieved by changing conditions for funding. Further opportunities which can be used to achieve the desired ends arise from an inevitable decline in student enrolment and provincial governments' need to save money. All these factors interact and suggestions will be made on how advantage can be taken of the present situation.

Consider the example of an engineering faculty in a small university which serves some well defined population area. It is probable that, at the time of writing, the student population is just adequate to support the staff required to offer a well balanced programme covering the traditional areas expected from a university degree programme. Faced with a decreasing enrolment* and decreasing funds, the faculty can either reduce its staff and hence its breadth, or partially support its staff in another way. The first of these alternatives will result in a lower quality education given by the less mobile professors. The alternative is a faculty of professors who give a limited and well defined part of their time to the engineering school and another well defined part of their time to an

* Although engineering enrolment is temporarily rising, at the expense of other faculties, the predicted continuing decline in the student population will make itself felt in engineering.

engineering practice. This latter part of their time could be partly or totally concerned with research. Under this arrangement, only their time spent in the engineering school would be booked to education and their remaining time would be supported by research or consulting money.

Although this kind of structure is new for an engineering faculty, it has been used by medical faculties for many years. It has prepared medical students well for medical practice and there is no reason why it would not work equally well for engineers. Such a change would require consultation between the Federal and Provincial Governments. The engineering school component would involve the Provincial Governments only, while the research component would involve the Federal Government, Provincial Governments and the private sector working together. Research operating grants would need to cover part of the principal workers salary in addition to assistants' salaries. Also these grants would need to cover many research costs that are now covered by educational money.

Within a structure, such as suggested, professors would have a stronger commitment to specific research programmes than under the present system. As a consultant, a professor would be in direct competition with consultants in the private sector. As such, he would be instrumental in introducing new ideas and techniques into the profession and carrying practical engineering knowledge back to "engineers in training".

Clearly, his research environment would be improved if it were based upon a specific research facility, which would bring him together with other researchers who wanted to work within the same area. This could also be favoured by the granting system. (The author, who would find himself in competition for business with these professors, would welcome the system).

There are many other ideas of considerable merit which have been proposed or implemented. K.C.Smith of the University of Toronto proposes Technology Resource Centres. At the University of Windsor there is the Industrial Institute, with several achievements to its credit. The University of Waterloo operates an Inventors Assistance Programme. There are consulting companies, in the private sector, with university professors on their staffs. There are also private consulting companies operated by and for university professors, some with the active encouragement of university administrations. There is much to be learned from all these organizations and this could well be the subject of a further study.

A Granting Policy:

The ideas presented in this report will not be generally adopted by universities until there is some incentive. An incentive to which universities respond quickly is the granting of research funds. A strategy towards this end is now set forth. (The following suggestions must be recognized as being in a preliminary state only and requiring further study before being considered as the basis for a policy.)

1) Announce the policy of objective oriented research: It is important to gain support for an

objective oriented approach from as broad a segment of the engineering community as possible. This means the approach should be understood, because, even with the best of intentions, the aims of the new policy could be defeated by the actions of the engineering community. The policy might well be introduced to the engineering community as part of phase 2 below.

2) Develop objectives: The committees responsible for this will require a lot of highly paid assistance. This might consist of consultants, or senior staff from industry, who would visit companies which might apply the results of research and also university researchers. In the process of this, they would explain the idea of industrial and research objectives and perform a public relations role, in addition to gathering information.

This process is equivalent to that performed by secior executives in the private sector whenever an important contractural agreement is made. It is recognized that it costs money to spend money wisely and that to attempt to reduce this expenditure is false economy.

(In the process of obtaining background information for this report, the author visited a wide range of authorities, not all of whom would be expected to be sympathetic to his ideas. The list included, amongst others, the following.

University of Windsor, Vice Pres. Administration.
Dean Engineering.

| | |
|---|---|
| University of Toronto: | Chairman Electrical Engineering and others. |
| Sinclair Radio: | Several senior staff. |
| Mosaid Inc: | President. |
| W. Trow Associates: | General Manager. |

All of them, without exception, were sympathetic and gave a lot of time to discussing the ideas set down in this report. The author feels that this is an illustration that the engineering community will be cooperative if the time and trouble is taken to present the ideas of objective oriented university research to them properly).

3) Solicit research proposals: Forms will be sent to universities and research staff much as is done now. However new forms will be designed to ask questions appropriate to the new policy. Differences in the new forms will reflect the following:

a) Researchers will be treated as members of coordinated groups, with a single proposal from a group. The qualifications of individual researchers will be attached.

b) In order to develop facilities, around which a group will cooperate, emphasis will be given to the purchase of equipment, the availability of related facilities etc.

c) The group will be asked to explain how it organizes itself and how its structure interacts with related engineering organizations outside the university.

d) The objectives of the research must be stated and these should be related to the previously determined overall objectives.

e) Research reports will be reviewed in the light of how well the work meets the stated objectives, in addition to more general criteria.

4) Review proposals: The reviewing process will be different from the current system. The mass of applications from separate professors will be replaced by a smaller number of group proposals. The proposals will be reviewed by the practicing engineers who were instrumental in generating the original objectives, with assistance only from academics. The reviewers will be encouraged to visit prospective candidates for research grants to assess their suitability for the programmes proposed.

5) Research reports: The same practicing engineers, who approved the research grants in the first place, will review research reports. They could be assisted by the report of a peer group committee who would assess the academic content of the research, but the prime criterion will be performance in meeting previously stated objectives.

6) Research grants: The main objective of the granting committee will be to obtain the maximum contribution towards the published objectives for the funds under its control. This may involve larger budgets for some groups, particularly where there are equipment costs to create or upgrade a facility. Some universities will suffer as a result and there will be

much criticism of the "fairness" of the system. As university engineers become more objective-oriented, the bona-fide demands for research funds will increase and ways should be found of responding. It is possible that companies assisted by this research may be called upon to contribute. This would certainly have the desired effect of placing the control of university research and a stake in the results, in the same hands. Many alternatives are possible and this subject requires further study.

7) Conditions attached to funds: It has already been indicated that these objective oriented grants will differ in many ways from current research grants and it is important to attach restrictions to ensure that the money actually is spent on the research for which it was granted. For example, it is the practice in many universities to pay graduate students, from research grants, before they are ready to make a research contribution. Research groups should be required to adopt criteria for the admission of students to the pay-roll to ensure that they are qualified to perform the research for which they are employed.

The Introduction of a New Policy.

Although the advantages of an objective-oriented granting system are clear, its too rapid introduction would harm many excellent engineering faculties. It is not realistic to expect professors whose modus operandi is adapted to the present system to change to the new system immediately. An attempt to force this would result in the fragmentation of the old system before the new one can properly take its place. Furthermore, there should always be room for the independent researcher to explore new directions, so some elements of the old system must be retained.

It is the writer's opinion that it will prove feasible to attach a significant proportion of the currently available research funds to specific objectives, in the first few years. If these objectives are well chosen and the granting procedures carefully implemented, the success of the objective-oriented system will attract sufficient new funds to permit its expansion to new objectives.

Conclusions:

It has been shown that the barriers to the university-industry interface, in science and engineering result from either the lack of well defined objectives or diverging objectives. For this reason the first step towards the removal of the barriers is the development of common objectives. To be appropriate for the university-industry interface, the objectives must be developed at a National level and must be supported by several tiers of objectives at the disciplinary level.

The implementation of the objectives can be realized through the appropriate university research fund granting policy and appropriate policies for industry and government. Some initial ideas for university research fund granting have been proposed, but although the problems relating to industry and government have been touched upon, these generally fall outside the scope of this report and warrant further studies. Two specific changes are suggested within the university faculties of engineering. It is proposed that they adopt a relationship with the engineering profession similar to that between medical faculties and the medical profession. Also they should increase their bonds with entrepreneurship and this could be supported better by the undergraduate programme than is currently the case. This report and the recommendations that follow imply increased control by the engineering community over matters which many consider to be entirely the responsibility of universities. However any improvement in communication, in the real sense, involves the application of and the response to, pressures. The present barriers to the university-industry interface have grown partly as a result of a lack of this real communication and they will be broken down, only if people outside universities become involved in this way.

Once the basic political decisions have been made, the development of the tier structure of objectives and the programmes to support their implementation will require the cooperation of the whole engineering community. However, the benefits of following such a course will be felt by the whole nation.

Recommendations:

1. Barriers to the university-industry interface can be removed by developing a tier system of common objectives, leading to specific research objectives.

Recommendation 1a:

That a system of objectives for Canadian industry be developed and that a tier system of research objectives be developed to support it.

Recommendation 1b:

That the present system of Federal research funding be replaced by one based upon research objectives and that the rules by means of which the funds are applied be strengthened to ensure that the funds are employed towards the stated objectives.

2. The development of the tier system of objectives will require the participation of the whole engineering and applied science community organized by appropriate disciplines. The national scientific and technical societies have evolved along such lines and it is appropriate to enlist their aid in developing the objectives. However there is a limit to the amount of work volunteers can be asked to do. Thus they will need to be supported by a number of highly paid senior staff who will help in gathering information, forming policy and explaining the aims of the policies to universities and industry.

Recommendation 2a:

That national technical societies be invited to form committees to assist in the coordination of the development of the system of industrial and research objectives.

Recommendation 2b:

That a portion of the funds allocated for research grants be used to fund the process, by which the remainder of the funds are spent wisely. These funds should be applied to the retention of the highly qualified senior industrial staff and consultants required to support the committees which develop the objectives.

3. There are barriers to the university-industry interface resulting from attitudes and the organizational structure within faculties of engineering and applied science. There are problems resulting from lack of a clear division of professional responsibilities, because provincial operating bodgets are allocated primarily for teaching. Bonds with entrepreneurship are discouraged. Undergraduate programmes do little to prepare students for small business. It is desirable to institute an organizational structure in which practicing engineers play a significant role in teaching engineers and where the costs of research are more clearly separated from the costs of teaching.

Recommendation 3a:

That the Federal Government enter into discussion with the provincial governments on matters concerning the organization and funding of engineering faculties in universities, with the following aims.

a) Engineering schools are encouraged to adopt a structure similar to that of medical schools, where teachers' salaries are partly based upon their professional practice.

b) Research costs are separately funded.

Recommendation 3b.

That the provincial engineering bodies, which licence engineers to practice, be encouraged to strengthen their accreditation procedures to the end that graduate engineers will be more atuned to the needs of small business than is presently the case.

4. In order for industry to be able to use the results of university research, it must have the opportunity to participate in the design and manufacture of technology-based products.

Recommendation 4:

That the Government departments, which purchase quantities of technology-based equipment, (eg. National Defence, Transport and Energy Mines and Resources), be invited to cooperate in planning for the technology reinforcement of Canadian industry.

This recommendation will involve the identification of requirements sufficiently in advance for Canadian industry to prepare to meet them. It will also require development funds to be made available so that Canadian companies are able to reach a point at which they will be competitive when equipment is ordered.

APPENDIX VI

# A

# Report on Technology Transfer Mechanisms in Four Countries in Europe

Frank J. Doyle
Technology Branch
December 1977

## CONTENTS

## Executive Summary and Conclusions

A series of interviews with officials in Britain, Denmark and West Germany took place in November to exchange ideas about various technology transfer mechanisms and obtain factual information about the effectiveness of Industrial Research Associations as technology transfer agencies. A second topic reviewed was the need for a generalized "face to face" delivery service of the Technical Information Service (TIS) type to provide technological and managerial assistance to small manufacturers. Although Belgium was not visited, information on recent government initiatives there was obtained from an official at the conference on technology transfer.

It was felt by all officials that the existing network of sectorally oriented technical centres forms the essential backbone of that part of the technological infrastructure which serves industry in Europe. It was pointed out, however, that these centres are better at dealing with medium sized and large firms than with the smaller ones partly because the small firms usually do not employ an engineer and are often not capable of defining and articulating their problems. All four countries have introduced new programs within the past year or two to provide free on-site consultancy services to small manufacturers of the type provided by TIS.

The visits strengthened the conviction of the Technology Branch that an integrated two-level infrastructure is required - consisting of one level with sectorally oriented centres which deal directly with medium sized and larger firms and act as centres of expertise, plus a second level made up of an expanded TIS which provides factory floor consultancy service to small manufacturers and draws upon the sectoral centres when specialized expertise is needed.

The body of this report also describes a conference which was attended, an interview with a researcher from the Science Policy Research Unit at Sussex and a visit to the Furniture Industry Research Association in Britain.

Summary of A Report On

A Trip To Investigate European Technology Transfer Measures

The Technology Branch has developed proposals for initiatives to assist small manufacturing firms in Canada to improve their productivity as part of the Department's small business thrust. (1)

In brief these proposals suggest measures to improve the technological infrastructure so that it will be more effective in delivering technical information and advice and advice on management to Canadian manufacturers, particularly to smaller firms by:

1. Expanding the existing Technical Information Service (TIS) over a period of five years to about 140 or 150 field officers (presently 40) in order to provide an adequate level of the critical face to face, on-site advice that small manufacturers need on how to improve the production function and the general management of the firm.

2. Encouraging the development by industry of a number of sectoral productivity centres to assist specific industries become more competitive by offering information, advice and assistance on technological matters and on other functions which have an improtant bearing on productivity in a particular industry.

3. Structuring the above services so that they are strongly motivated to work in unison.

Most European countries have had sectorally oriented research associations (RA) for many years. While the proposed productivity centres are somewhat different than RA's in that they would not perform research, they are also similar in that many of the RA's do devote a good deal of their time to helping firms improve productivity by technology transfer and advising on improved management practices.

Three European countries were visited and a discussion held with an official of a fourth country at the technological transfer conference in order to obtain the views of knowledgeable officials on the effectiveness of the RA's there in assisting industry keep abreast of technological change. Great Britain has 42 RA's, Belgium 20, Denmark 22 and West Germany 79. These Centres communicate with firms in their industrial sector by regular publications, special bulletins, schedule personal visits, organized meetings and seminars and by personal visit in response to a request from a firm. Officials in all three countries visited felt that the RA's form an indispensible element in the infrastructure but that they are more effective in dealing with medium sized and large firms, particularly those employing professional engineers or scientists, than with smaller firms. The typical small manufacturer, who does not employ an engineer, does not react to written technical information and is not able to identify and articulate his technological or managerial problems. Both Britain and Germany have introduced new programs in 1977 to provide face to face, shop floor assistance to manufacturers and Belgium began a program in 1976. In Britain the Manufacturing Advisory Service (MAS), introduced in September, offers

(1) Initiatives to Assist Small Manufacturing Firms Improve their Productivity Through Technology-Technology Branch, Department of Industry, Trade and Commerce, December 1977.

free advisory service by specialists for up to 15 man days, a 50% subsidy for the next 15 man days and charged for service thereafter. MAS initiates scheduled visits to manufacturers and suggests an internal review of its manufacturing process, followed by advice on problems by consultants. In Germany, two experimental programs were launched in 1977 which offer free on-site advice and assistance to small firms. In Belgium the Technological Guidance program, established in 1976, now provides small firms in nine different manufacturing sectors with free technological advice and assistance and is expanding rapidly. Denmark has offered this kind of free help to its small firms for a number of years but recently has intensified and localized its "face to face" technical services by opening a number of local offices in the outlying regions of the country. A more detailed description of these recent initiatives in Europe is in the following report.

The main point is that all four countries are moving toward the kind of technological delivery system proposed for Canada - one which would consist of two levels of assistance. The first level would be characterized by the following:

- Free, general shop-floor technical and managerial advice would be offered to small firms in their own factories.

- The agency offering this service would initiate the contact, help the small businessman to define his problems and to arrive at appropriate solutions.

- This agency would draw upon sectoral centres with their specialized expertise in an industry when required. It has been estimated that 80% of the technical problems of small firms can be handled by expert industrial engineers who are generalists.

The second level of the technological delivery system would consist of sectorally oriented centres (RA's in Europe) which would deal directly with large industries and those medium sized and small firms which had reached the require level of sophistication to define and articulate their problems and then to seek assistance.

In Canada, we now have an excellent general advisory service in TIS, although TIS, with 40 field officers cannot adequately serve 27,500 small manufacturing firms and needs to be enlarged.

There is only one centre in Canada which is similar to the productivity centres proposed by the Technology Branch and actions to encourage industry to establish more of these in appropriate sectors is needed in order to create a good delivery system in Canada. It is recommended that these measures be given a high priority in the Department.

The following pages list the officials who were interviewed and summarize the discussions and conclusions reached for each country.

## Great Britain

Interviews were arranged with the following officials by Mr. J. Koop, Science Counsellor:

Mr. A. Ladd, R&D Requirements Division, Department of Industry

Mr. D.M.J. Gwinnell, Assistant Secretary, Small Firms Division, Department of Industry

Dr. L. Bovey, R&D Requirements Division, Department of Industry

Lord Shannon, Chairman, Committee of Directors of the Research Associations

### Existing Technology Transfer Delivery Mechanisms

#### Library-Information Services

A number of organizations dispense scientific and technological information in Britain. An example is the Technology Reports Centre which publishes R&D abstracts and also offers a service called Techlink for the dissemination of new technological information in selected fields (similar to NRC's profile service). Another significant contributor is the Science Reference Library which handle 80,000 enquiries per year.

#### The Industrial Research Association (RA's)

The majority of the 42 RA's in Britain work with a specific industry such as the furniture industry, the shoe industry, the textile industry, etc. They range in size from very small, such as the Cutlery and Allied Trades RA with a staff of fourteen, to large centres with up to 500 employees. The functions tend to vary widely as well, with many of the smaller RA's performing little R&D but emphasizing instead technology transfer, marketing and other productivity related activities. It has been estimated that about 40-50% of the activities of a typical RA are devoted to the transfer of existing technical, managerial and marketing knowledge to their clients. In general it is agreed that these are considerably more effective in communicating with medium sized firms (over 100 employees) and large firms than with smaller manufacturers.

#### The Industrial Liaison Centres

These centres were established with government support about 1963 with the objective of providing assistance to small manufacturers through liaison officers located at local colleges of technology. In 1973 government support was withdrawn but in a number of cases the activity and staff has remained at the colleges.

#### The Council for Small Industries in Rural Areas (COSIRA)

COSIRA and a similar organization in Scotland provide on site advice and assistance to small firms with fewer than 20 skilled workers operating in towns with a population of 10,000 or less in England and 15,000 or less in Scotland. More than 150 field officers, backed by specialist advisers, provide these services.

## Recent Initiatives

### Small Business Information Centres

Ten experimental information centres have recently been established. The service is free and is designed to offer a "sign-post" service to all small firms. The centres, manned by three people, either answer directly a personal or telephone query or find out where the small business should go to get an answer.

### The Manufacturing Advisory Service (MAS)

The MAS commenced in September, 1977. It is in many ways similar to the Technical Information Service (TIS) in Canada. Like TIS its objective is to increase manufacturing efficiency through the improved utilization of production technologies and methods. The first fifteen days work by MAS experts is provided free of charge, the next fifteen is charged for at half rate and further work is fully charged for. Unlike TIS it is restricted to medium sized firms employing between 100 and 1000 people in certain restricted sectors of the manufacturing industry. These restrictions limit its application to about 6000 firms in Britain today. The other similarity to TIS is that "cold" calls are made upon firms by the MAS experts following an introductory letter. The response has been excellent to date with an 85% favourable response rate and with over 50% of the firms agreeing immediately to develop a project. As a point of interest a somewhat similar scheme (The Product Engineering Advisory Service (PEAS)) which was tried for a short time a decade ago in Britain had a 16% response rate. The major difference between the two plans was that PEAS charged for all of its services. Mr. Ladd stated that the objective of MAS was to convince British companies that outside technical advice and assistance can improve productivity demonstrating its value.

### Summary

Britain possesses a fairly well developed, sectorally oriented, technological delivery system in the form of its 42 RA's. At the very small, rural level it offers face to face general advice through COSIRA and at the level of the medium sized manufacturing firm (100 to 1000 employees) direct, person to person advice and assistance is now provided by MAS. However, the fact that advice and assistance is not available to small, non-rural manufacturing firms with fewer than 100 employees would seem to be a serious gap in the British technological delivery system, particularly when it is realized that the sectoral research associations do not provide much technical assistance to firms of this size. In addition, this is the size category of the firm which has a great deal of difficulty in incorporating written technical information into their production processes and therefore badly needs the kind of face to face, factory floor assistance now being provided to medium sized firms and to very small rural manufacturers.

## DENMARK

Mr. K. Klintoe, Director of the Danish Technical Organization (DTO) was interviewed. Mr. Klintoe has been involved for more than twenty years in technological policy development and program administration and was able to succinctly summarize all of those programs now operating in the country.

### Information Dissemination

The Danish Technical Library operates a technical documentation service available to business. It can be accessed in person or by computer. It provides information upon request and has the ability to search out data based upon key work profiles.

### The Danish Academy of Technical Sciences

The Danish Academy of Technical Sciences is a non-profit organization responsible for 22 separate, applied research centres which work in specialized technological or industrial fields. These centres, in many ways similar to British Industrial Research Associations, derive about 15% of their revenue from the government and employ about 800 people who deal directly with manufacturers of all sizes which utilize the technologies they are expert in. In addition, there are two major technological institutes, which together employee about 600 professionals and consist of about 70 separate technological divisions. While there is some duplication between the 22 applied research centres and the divisions in the technological institutes, there is a distinct difference in the emphasis between the applied research of the centres and the more basic research conducted by the institutes.

### The Danish Technical Organization (DTO)

The DTO defines "technical information" as marketing, management and technological information. Its twelve field officers call upon small, medium and large manufacturers which employee at least one engineer. Its officers are industrial engineers who are trained in management and marketing. If a problem requires specialized knowledge of an industry or a technology it draws upon the more than 800 national and international "centres of knowledge" it has identified.

DTO offers the following services to its clients:

1. A free contact program. The DTO staff schedule uninvited calls to stimulate interest in the utilization of information. Following an interview and an analysis of the basic needs of the firm, relevant information (technical, managerial, marketing in nature) is sent to the firm. Free advice on where to obtain information is also given by telephone.

2. A charged for "client-based program" often stems from the free visits. A program might include the provision of information, analysis of the information, the arrangement of training sessions, studies and recommendations and advice to improve the flow of information in the firm. DTO has identified 800 national and international "centres of knowledge" (these include the centres and institutes described earlier).

Technological Institutes (TI) and (JTI)

TI and JTI are similar organizations which focus on providing technical services to small and medium business. They provide industrial R&D, advisory services, training, testing and information. A small fee is usually (but not always) charged and 54% of their income comes from a government subsidy. They both make schedule calls to business rather than wait for an inquiry. A recent experiment consists of extending their services by creating five local centres in the more remote regions of Denmark. Each of these centres is manned by a business generalist, an engineer, a technician and a clerk. No fee is charged for services from these local offices by TI. TI and JTI are quite large, having a combined staff of 900, of which 650 are technicians or engineers. They had a budget of more than $20 million in 1975. When the size of Denmark is considered (population 5 million) this is indeed a major effort.

Summary

Denmark, with a population of five million, has hundreds of professionals and technicians making face to face calls to manufacturing firms to offer information, advice and assistance. In addition, 22 centres of applied technology and about 70 divisions in the two technological institutes offer technical assistance to industry, both directly and through the intermediary organization described above. In spite of this very extensive technological delivery system, the Danes are now experimenting with additional local offices to further improve the diffusion of technology to small and medium sized firms.

## West Germany

A meeting was arranged by Mr. C.H. Baker, Science Counsellor with the following officials:

Dr. Bernd Kramer, Head, Technology Transfer, Ministry of Research & Technology

Herr Gruber, Head, Bilateral Relations for North American, Ministry of Research and Technology

Herr Muller-Helle, Bilateral Relations for North America, Canada Desk, Ministry of Research and Technology

## Existing Technology Transfer Mechanisms

### Library/Information Services

A large number of organizations too numerous to list provide information services in West Germany. Computer access, user profile services and technical library services are all available. In addition, a number of organizations including The Institut fur Dehumentationsweser (IDW) and the Zentralstelle Fur Maschunelle Dakumentation (ZMD), associated with the Max Planck Society, are responsible for performing research on documentation, developing new measures and planning for sectoral information services.

### Research Centres in West Germany

West Germany has a vast, well organized network of institutions which perform basic, applied and industrial research. The Max Planck Society is the parent organization for a network of over 50 centres and twenty institutes which perform basic and applied research. The total staff exceeds 8,000 with more than 4,000 scientists. Close links are maintained with university researchers who also conduct basic research. About 90% of the funds for the society come from public sources with the federal and state governments sharing equally. In addition, 79 industrial research associations exist, one for each significant industrial sector in Germany. These are more effective in transferring technology to large companies than to small and medium companies - in fact it was the opinion of Dr. Kramer that the RA's are not effective mechanisms for the transfer of technology to small and medium sized manufacturing firms and that other measures were needed to provide "demand pull" for technology transfer from smaller firms. As a result a number of new initiatives are now being developed to provide them with technical information, advice and assistance.

## Recent Initiatives

### R&D Encouragement

Beginning in January 1978, a 15% tax free bonus will be paid on all investment related to R&D capital costs up to a maximum of $250,000 per company. The bonus will also be available for "immaterial" investments in patents, know how and licenses in connection with research and innovation. This later aspect of the measure provides a tax free bonus for technology transfer costs.

## Technical Assistance for Small Firms

$3 million in 1978 and $5 million in 1979 will be used to subsidize contract research undertaken on behalf of small business. The subsidies will cover 30% of costs up to a total of $60,000 per year per company and the objective is to enhance the ability of small companies to adapt to technological change and to promote better technology transfer between research establishments and small firms. This plan is very similar to the SID proposal being developed here, which would utilize the resources of the Provincial Research Associations.

## New Technology Transfer Measures for Small Manufacturing Firms

Two slightly different means of delivering technological advice and assistance directly to small firms are currently being experimented with. The first involves three projects administered by a non-profit organization called Rationalizierungs-Kuratorum der Deutschen Wirtschaft (RKW). The first project consists of a series of conferences and seminars, the second the organized dissemination of R&D results to small firms and the third provides face to face consultancy services of all types. The consultancy includes an analysis of technologically weak areas, a review of other business problems and payment up to 75% of the cost of an expert, outside consultant for two to three weeks. RKW is now making regular calls on small businesses with two man teams made up of a business expert and an industrial engineer.

A second, simultaneous experiment is being run by the German Chamber of Commerce. As every business in Germany is obliged by law to financially support the Chamber of Commerce the organization is quite different from its North American counterpart. The chamber, acting as an agent for the government, has a professional engineer who calls upon small firms and performs a free-of-charge analysis of all technical problems. The local office of the chamber also serves as an information outpost and will either answer questions directly or search for and find answers to the technical problems of small manufacturers.

These two pilot projects are intended to furnish experience with providing face to face technical information and assistance as well as general advice to small manufacturers so that optimal measures can eventually be developed to furnish this kind of assistance. It is interesting to note that the Canadian Technical Information Service (TIS) offers the same package of management and technical advice as the "consultancy" project of RKW.

## BELGIUM

Although time did not permit a visit to Belgium, a brief discussion was held with Dr. J. VanKeymeulen who gave a paper (1) at the Technology Transfer Conference describing new measures begun there in 1976 to "transfer available technology and information to smaller manufacturing companies which cannot afford an R&D lab or participation in collective projects". The measures are called The Technological Guidance measures. Their essential elements are:

- Free technical advice and assistance is provided smaller firms in designated sectors by qualified advisors. These advisors initiate contacts with small firms and, during an on-site meeting, help to analyse and solve technical and production problems.

- The advisors are provided with the necessary test and research facilities (usually through an existing industrial research association).

- The advisors are provided with access to a broad range of technological resources in universities and laboratories and research associations in Belgium.

This service is now offered to small firms in sectors and is being rapidly expanded.

The similarities between the Belgium Technological Guidance Measures, the West German consultative assistance initiatives, the Manufacturing Advisory Service in Britain, the intensive assistance offered small firms in Denmark and the tiny TIS service in Canada are striking.

The basic common features of all these programs are:

- They offer free of charge, factory floor advice and assistance to small manufacturing firms (Medium sized firms in the British case)

- They are financed by government.

- All of these agencies initiate calls to small manufacturers and help them identify problem areas.

- They all utilize qualified technical generalist (usually an experienced industrial engineer) who draws upon the specialized expertise of sectoral industrial research associations (except of course in Canada where these do not exist) as a basic source of technical information relating to a particular industry.

(1) See - Technological Guidance in Belgium, Dr. W. Degreuck and Dr. J.Van Keymeulen

## The Furniture Industry Research Association (FIRA)

In addition to the interviews with the aforementioned officials, a day was spent with FIRA in Stephenage, England. This RA was visited because the Technology Branch and the Textile and Consumer Products Branch are working with representatives of the furniture industry in Canada to establish a productivity centre for the industry and FIRA may well serve as a model for such an institute here.

FIRA is a medium sized RA, with a staff of 90, which provides a variety of services to its members including:

1. Development of technology for its industry, mainly in the field of specialized measuring instruments - a number of which have been produced.

2. A variety of technical services including technical inquiries, design, testing, advice on materials, etc.

3. A constant survey of technological developments which might be useful to the industry.

4. Marketing studies - both national and international.

5. A number of computerized accounting services including programs for standard costing, budgeting, etc.

6. Consulting services on managerial, production, technical and marketing matters.

The in-depth knowledge of the industry displayed by FIRA employees and the extent to which the organization had adapted its functions to serve the special needs of the industry is impressive. This functional variation relative to the requirements of a particular industry is one of the innate strengths of a sectorally oriented centre. The second major strength is the in-depth knowledge obtained of the markets, technologies and managerial problems of the industry. The one difficulty with a sectoral productivity centre is that it tends to gravitate towards serving the larger firms because they have knowledgeable employees who can articulate their problems and they tend to be more vociferous and demanding than smaller firms. A smaller firm frequently cannot precisely identify problems and often will not contact a research association or other potential source of help.

## The Science Policy Research Unit (SPRU) at the University of Sussex, England

SPRU, with a staff of 40 professionals is one of the largest and best policy research establishments in existence today. Doctors Christopher Freeman and Keith Pavitt, who have published numerous articles on technological policy and performed many major studies for OECD, EEC and the British Government are perhaps its best known practitioners.

A meeting with J.Paul Gardiner, a Canadian member of the SPRU group, who also participates in the policy research work taking place in Manchester University, was arranged by Mr. J. Koop, Science Counsellor in London. As Mr. Gardiner is currently working on a study of the Farm Machinery Industry, an industry which is being examined by the Technology Branch as a possible candidate for a sectoral productivity centre, this meeting was a timely one. Mr. Gardiner agreed to mail us copies of a number of useful statistics charts, and other analyses of the industry which have resulted from their work to date. Following this discussion of the Farm Machinery Industry, a useful exchange of views concerning technological policy development in general took place. Mr. Gardiner eventually plans to return to Canada and work in the policy development field and it was agreed that he would be sent a copy of the 1978 shopping list for the University Grant program in the hope that a mutually beneficial project can be identified.

## THE TECHNOLOGY TRANSFER CONFERENCE

Over 100 individuals representing governments, research associations, universities and private industry participated in the conference. The papers presented covered a wide spectrum of topics related (in a few cases somewhat distantly related) to the question of technology transfer. On the whole the quality of the papers was high and I left the conference feeling that both the discussions about Technology Transfer and the opportunity to interact with officials from other countries responsible for developing technology transfer policies and programs made the investment of time and money worthwhile. A list of the papers available from the conference follows.

In addition, a number of potentially useful contacts were made, for example with American officials from the National Science Foundation, the General Accounting Office (which for some reason is very active in developing initiatives to improve productivity through technology) and the U.S. Navy group concerned with technology transfer to industry.

## Papers Available from the Technology Transfer Conference

Applied Anthropological Methodology as a Contribution to Technology Transfer Programs

Centralized Versus Decentralized Management Structures in Technology Transfer

Innovation in Industry and Technology Transfer - Holland

Legal Restrictions on International Technology Transfer

Measuring Effectiveness in Technology Transfer

Mechanisms for Technology Transfer

Problems Relating to the Transfer of Technology in Portugal

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Technological Guidance in Belgium

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Technology Transfer in Belgium - An Industry Perspective

Technology Transfer in Canada - Jorge Miedzinski, Science Council

Technology Transfer in Japan

The Role of Government in Promoting Technological Innovation

The Role of Industrial Research Association in Technology Transfer in the United Kingdom

The Role of the European Industrial Research Association in Technology Transfer

## INDUSTRIAL INNOVATION CENTRES

On June 1, 1978, the Government announced its intentions to establish University-based Industrial Research and Innovation Centres to aid industry, particularly small businesses and private inventors, in the development of new products or technologies.

The Industrial Research and Innovation Centres were discussed at the Federal-Provincial Conference of Ministers on Industrial Research and Development. Ministers agreed that these Centres could foster the transfer of technological capabilities and results of university research to industry.

On March 15, 1979, the establishment of two industrial innovation centres, one at the University of Waterloo and the other at Ecole Polytechnique de Montréal was approved in principle. Subsequently, the Ecole Polytechnique and the University of Waterloo reached an agreement which met the approval of their respective provincial Ministers of Education.

Support in the amount of $400,000 for feasibility studies at these two universities was approved in August, 1979. The program is administered by the Department of Industry, Trade and Commerce.

Other groups have expressed interest in establishing such centres. However, no additional centres will be established until a full evaluation of the experience of these first two centres has taken place.

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