HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 1

NATIONAL RESEARCH COUNCIL

MONDAY, APRIL 30, 1956

WEDNESDAY, MAY 2, 1956

Statement by Dr. E. W. R. Steacie, President, National Research Council.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956

73986—1

SPECIAL COMMITTEE ON RESEARCH

Chairman: G. J. McIlraith, Esq.

and Messrs.

Bourget	*Hahn	Power (*St. John's West*)
Brooks	Hardie	Richardson
Byrne	Harrison	Stewart (*Winnipeg North*)
Coldwell	Hosking	Stuart (*Charlotte*)
Dickey	Leduc (*Verdun*)	Weaver—(20).
Forgie	MacLean	
Green	Murphy (*Lambton West*)	

(Quorum 11)

J. E. O'Connor,
Clerk of the Committee.

*Replaced by Mr. Low on Tuesday, May 1, 1956.

ORDERS OF REFERENCE

WEDNESDAY, April 18, 1956.

Resolved,—That a Special Committee be appointed to examine into the role of government in the field of nonmilitary research in Canada, including:

(*a*) operations in the field of atomic energy,
(*b*) operations of the National Research Council.

That the committee be empowered to sit during the sittings of the House and to print such papers and evidence from day to day as may be ordered by the committee and to report from time to time; and that notwithstanding Standing Order 67 the Committee shall consist of twenty members.

FRIDAY, April 20, 1956.

Ordered,—That pursuant to the resolution of the House passed Wednesday, April 18, the Special Committee on Research consist of Messrs. Bourget, Brooks, Byrne, Coldwell, Dickey, Forgie, Green, Hahn, Hardie, Harrison, Hosking, Leduc (*Verdun*), MacLean, McIlraith, Murphy (*Lambton West*), Power (*St. John's West*), Richardson, Stewart (*Winnipeg North*), Stuart (*Charlotte*) and Weaver.

TUESDAY, May 1, 1956.

Ordered,—That the name of Mr. Low be substituted for that of Mr. Hahn on the said Committee.

Attest.

LEON J. RAYMOND,
Clerk of the House.

73986—1½

MINUTES OF PROCEEDINGS

MONDAY, April 30, 1956.

The Special Committee on Research met at 11.00 a.m. this day for organization purposes.

Members present: Messrs. Coldwell, Dickey, Green, Hahn, Hardie, Harrison, MacLean, McIlraith, Power (*St. John's West*), Stewart (*Winnipeg North*), Stuart (*Charlotte*), and Weaver.—(12)

On motion of Mr. Weaver, seconded by Mr. Green, Mr. McIlraith was elected Chairman.

Mr. McIlraith took the Chair and expressed his appreciation at having been elected Chairman. At the same time he referred to the importance of the Committee's task and particularly to its potential influence on the long-term development of a balanced program of research.

The Chairman then read the Committee's Order of Reference and asked for an expression of opinion regarding a schedule for future meetings. It was the opinion of the Committee that work could be expedited by meeting three times per week, and that Mondays and Fridays appear to be the most suitable days at present.

It was suggested by the Chairman that, as officers of the Atomic Energy Control Board are not available for appearance before the Committee at this time, the Committee proceed with its examination into the activities of the National Research Council. He also referred to the possibility of members of the Committee visiting N.R.C. installations on the Montreal Road and those of the Atomic Energy Control Board at Chalk River, Ontario.

On motion of Mr. Stuart (*Charlotte*), seconded by Mr. Coldwell,

Ordered—That a Sub-Committee on Agenda and Procedure by constituted and that the Chairman and four members to be chosen by him comprise the membership.

The Chairman designated the following members to serve with him on the Sub-Committee: Messrs. Dickey, Green, Stewart (*Winnipeg North*), and Weaver.

On motion of Mr. Power (*St. John's West*), seconded by Mr. Stuart (*Charlotte*),

Ordered—That, pursuant to its Order of Reference, the Committee print, from day to day, 750 copies in English and 250 in French of its Minutes of Proceedings and Evidence.

At 11.20 a.m., the Committee adjourned to the call of the Chair.

WEDNESDAY, May 3, 1956

The Special Committee on Research met at 3.00 p.m. this day. The Chairman, Mr. G. J. McIlraith, presided.

Members present: Messrs. Byrne, Coldwell, Dickey, Forgie, Green, Hardie, Harrison, Hosking, Leduc (*Verdun*), MacLean, McIlraith, Murphy (*Lambton West*), Richardson, Stewart (*Winnipeg North*), Stuart (*Charlotte*), Weaver.—(16)

In attendance: Dr. E. W. R. Steacie, President, National Research Council.

The Chairman called the meeting to order and introduced Dr. Steacie to members of the Committee.

At the Chairman's request, Dr. Steacie outlined his scientific and technical experience and qualifications. He then reviewed the organization and functions of the National Research Council and commented on its relations with industry.

On motion of Mr. Dickey, seconded by Mr. Coldwell,

Ordered: That a document presented by Dr. Steacie and entitled: "Associate Committees of the National Research Council—Function and Membership" be printed in the record.

The Chairman suggested that members of the Committee might be interested in asking questions of Dr. Steacie.

The following documents were filed with the Committee and copies distributed to members:

1. Thirty-eighth Annual Report of the National Research Council 1954-1955;
2. National Research Council of Canada—Organization and Activities—1956;
3. The National Research Council Review—1955.

Questioning of Dr. Steacie continuing, the Committee adjourned at 5.00 p.m. to meet again at 3.00 p.m. Friday, May 4, 1956.

J. E. O'Connor,
Clerk of the Committee.

EVIDENCE

2nd MAY, 1956
3 p.m.

The CHAIRMAN: Gentlemen, there appears to be a quorum present. Accordingly I now call the meeting to order. Perhaps I ought to report to the committee that since the organization meeting, the agenda sub-committee met and decided to proceed with the National Research Council evidence first, and to ask the chairman to arrange at some point during that evidence, a visit to the council buildings in the Ottawa area.

With your permission, I would prefer to leave the precise date of that visit open at the moment until we see how we are getting on with the preliminary evidence, and then at an appropriate point, we can fix a precise date, time, and the details of that visit.

We have here today as our first witness Dr. E. W. R. Steacie, the President of the Council. Dr. Steacie was appointed president in the year 1952. If you will recall our last meeting when the former committees were examining into the National Research Council, and the Atomic Energy activities, it was before the time he was chairman of the council. Oh that is not right with respect to the last Atomic Energy Committee.

Unless any member has some preliminary matter to raise, I now propose to call Dr. Steacie.

E. W. R. Steacie, O.B.E., Ph.D., D.Sc., LL.D., F.R.S.C., F.R.S., President of the National Research Council, called:

By the Chairman:

Q. Dr. Steacie, would you first place on the record your own exact titles and designation with the qualifying degrees, and then proceed to the matter of describing the whole organization of the council as it presently exists? —A. Well, I hold bachelor and master of science degrees as well as a doctor of philosophy degree, all from McGill. In addition to that I have done graduate work at the Universities of London, Frankfurt and Leipzig, and although they are not particular scientific qualifications, I hold nine honourary degrees as well.

My scientific experience was gained on the staff of the Department of Chemistry at McGill until six weeks before the war. I came to the National Research Council then as director of the division of chemistry.

During the middle of the war I vacated that job to become second in command of the joint Canadian-British Atomic Energy project in Montreal. I returned to the division of chemistry at the end of the war and became vice-president, scientific, of the Council, I think, in 1950, and president in 1952.

My own field is reaction mechanisms, and I have published seven books and about 200 papers.

By Mr. Coldwell:

Q. You followed Dr. C. J. Mackenzie?—A. Yes, I followed Dr. Mackenzie.

By the Chairman:

Q. Unless there are any questions of a personal nature, I now propose to ask Dr. Steacie to go right into the matter of the National Research Council's organization. Perhaps as a preliminary thereto we could have copies of the National Research Council's annual report for 1954-55 made available to all the hon. members as they wish, and we shall indicate in the minutes that they have been filed.—A. What I propose to do, Mr. Chairman, if it meets with the approval of the committee, is to try to confine my talk to the general organization and purpose of the council with the idea that the vice-president (administration) would probably be called later to discuss the estimates and the details of administration.

I think that as far as the National Research Council is concerned, one of the most important things about its organization is that it is not a government department but rather a private corporation incorporated under the Companies Act, and it reports to parliament therefore rather in the manner of a Crown Company.

There is a Privy Council committee on scientific and industrial research which consists of the Minister of Trade and Commerce as Chairman, and the ministers of those departments which have sizeable research organizations as members; in other words, the Ministers of Agriculture, Fisheries, Mines and Technical Surveys, National Defence, National Health and Welfare, and Northern Affairs and National Resources.

As President of the National Research Council I report to the chairman of the Privy Council committee, that is, to the Minister of Trade and Commerce, but I report to him not in his capacity as Minister of Trade and Commerce but as chairman of the Privy Council committee.

The actual governing body of the National Research Council under the minister is an honourary advisory council, and it is, I think, vital in the operations of the council. It consists of seventeen appointed members who are not government employees, together with the president, two vice-presidents—there is a vice-presidency vacant—who are public servants.

It has responsibility for the operation of the National Research Council's functions, and essentially the President is the executive officer carrying out the instructions of that council.

The council is far more than a mere advisory council, and I think it is more than a mere board of directors which decides occasional questions of policy. The council actually takes an active part in council affairs.

The present members of the council are I think a very distinguished group of Canadian scientists. The public servants who are members, apart from myself are Vice-President, Scientific, B. G. Ballard, O.B.E., B.Sc., F.I.R.E., F.A.I.E.E., and Vice-President, Administration, E. R. Birchard, O.B.E., B.A.Sc., D.Sc. The honourary members or appointed members are Professor A. N. Campbell, M.Sc., Ph.D., D.Sc., F.R.S.C., Professor of Chemistry, University of Manitoba, Winnipeg, Manitoba.

Mr. Gordon G. Cushing, Secretary-Treasurer, Trades and Labour Congress of Canada, 172 MacLaren Street, Ottawa. I am not quite sure of his revised title as of two or three days ago.

Mr. Stewart (*Winnipeg North*): It is vice-president of the Canadian Labour Congress.

The Witness: Yes, vice-president of the Canadian Labour Congress.

The Chairman: May we have permission to put the degrees of these men in the written record so that if there are any inaccuracies of that sort they can be picked up in the written record? We will be listing the seventeen names and it is possible that some of the scientific degrees and qualifications may not be accurately stated in the memorandum which we have. So with your permission I would like to be able to correct them in the transcript.

The WITNESS: With your permission I will omit the degrees as I go down the list.

The CHAIRMAN: No, you had better state the degrees and their occupations.

The WITNESS: Professor R. F. Farquharson, M.B.E., M.B., F.R.C.P. (London), Sir John and Lady Eaton, Professor of Medicine and Head of the Department of Medicine, University of Toronto, Toronto, Ontario.

Mr. H. Gaudefroy, S.B., I.C., Director, Ecole Polytechnique, Montreal, Quebec.

Mr. RICHARDSON: Right here on the face of this document is the list of these gentlemen. I wonder if the witness would be kind enough to indicate if there are any changes?

The WITNESS: There are some changes.

The CHAIRMAN: I think we ought to go throught the revised list, because the report you have, Mr. Richardson, is two years old.

The WITNESS: Abel Gauthier, L.Sc., M.A., Vice-Dean, Faculty of Science, University of Montreal, Montreal, Quebec.

G. E. Hall, A.F.C., E.D., M.S.A., M.D., Ph.D., D. ès Sc., LL.D., F.R.S.C., President and Vice-Chancellor of the University of Western Ontario, London, Ontario.

R. S. Jane, B.A.Sc., M.Sc., Ph.D., Executive Vice-President, Shawinigan Chemicals Limited, 600 Dorchester Street, W., Montreal, Quebec.

C. J. Mackenzie, my predecessor on the National Research Council, C.M.G., M.C., M.C.E., D.Eng., D.Sc., LL.D., D.C.L., F.R.S.C., F.R.S., President, Atomic Energy Control Board, Ottawa.

H. G. Thode, M.B.E., B.Sc., M.Sc., Ph.D., F.R.S.C., F.R.S., Principal, Hamilton College and Director of Research, McMaster University, Hamilton, Ontario.

David L. Thomson, M.A., Ph.D., LL.D., F.R.S.C., Vice-Principal, Dean of the Faculty of Graduate Studies and Research, and Chairman of the Department of Biochemistry, McGill University, Montreal, Quebec.

T. Thorvaldson, M.A., Ph.D., D.Sc., LL.D., F.R.S.C., Dean of Graduate Studies Emeritus, University of Saskatchewan, Saskatoon, Saskatchewan.

W. H. Watson, M.A., Ph.D., F.R.S.C., Professor and Head of the Department of Physics, University of Toronto, Toronto, Ontario.

Since that annual report was published there have been four members whose terms have expired and they have been replaced by I. McTaggart Cowan, B.A., Ph.D., F.R.S.C., Professor and Head of Department of Zoology, University of British Columbia; B. W. Sargent, M.B.E., M.A., Ph.D., F.R.S.C., Head of Department of Physics, Queen's University; R. B. Miller, M.A., Ph.D., Professor of Zoology, University of Alberta; J. H. L. Johnstone, M.B.E., O.B.E., M.Sc., Ph.D., Head of Department of Physics and Dean of Graduate Studies, Dalhousie University.

The honourary council meets in Ottawa at least three times a year. Its meetings last from four to five days. I may say that the members receive travelling expenses but no emolument, and if you include committee meetings I think that most of the members put in at least the equivalent of three full weeks a year. I think we owe a very great deal to them for the services they provide. On the other hand, I think that being on the council gives them a view of Canadian science as a whole and therefore it is not a one-way process. I think that the member on the council gets a very great deal out of his membership.

The council operates primarily through five committees, four of which, I think, are particularly important. Normally all members of the council attend all meetings of the committees and they have the right to vote whether or not they are members of the committee.

The first committee is the Selection Committee which, from our point of view, takes the place of the civil service. Our employees are not civil servants, and the Selection Committee has authority over the hiring, promotion and superannuation of members of the staff; so that it acts as the equivalent of the Civil Service Commission. In view of the status of the people, I think that it has been responsible for keeping the standards up and it has certainly exercised itself very strongly in the direction of making sure that the standards of appointments are kept high.

Next is the Review Committee. It is not possible for an advisory council to dictate a scientific program. You must have the director of a laboratory in charge of his own program. The council control comes, therefore, by review, or in other words by examining the program in arrears. The Review Committee meets at usually two of the three regular meetings. The Review Committee spends from one to two days visiting a chosen division or divisions. That means that once every three years, roughly, the Review Committee gets around to all the units; and in addition to that there are subcommittees with outside people, plus a council or two who review each division each year.

The next two committees are rather related: they are the Scholarships Committee of the council and the Grants Committee or the Assisted Researches Committee. These two committees, subject to the amount of money voted, have complete control over the awarding of grants to universities for research and scholarships to graduate students at universities. We do not give scholarships at the undergraduate level. Our terms of reference are only research. So, the council through these committees, when you come to the university support side of the council's work, has executive control as well as policy control. I think that one of the reasons why we have been very successful in avoiding criticism and trouble in our awarding of grants and scholarships is that we put this squarely in the hands of a group of university people, and the full authority as to who gets a grant and how much and who gets a scholarship and who does not is placed in the hands of the council. The employees of the council come into this only in so far as they prepare documents for the use of these committees. They summarize applications and academic records and in general prepare the documents for the meetings.

The fifth council committee, which I do not think is of as great importance, is the Journals Committee which looks after the operation of the journals published by the council.

There are then a group of other rather minor committees.

I would like, at this point, to pay tribute to the members of the council. I think we have been very fortunate over a long period of years to have a group of people on the council who have taken this thing very seriously and have done a tremendous amount of hard work for us, and any success which we have had is due to their efforts.

The CHAIRMAN: I might perhaps interrupt at this point. With the committee's permission, we could, at a later meeting, rather fill out the evidence on this whole matter of scholarships and grants in aid to the universities. I would prefer, with the committee's permission, not to do it today but rather to do it later with Dr. Steacie and one or two of his personnel who are familiar with that subject

The WITNESS: I would like, if it is possible, Mr. Chairman, to call the head of our awards office in the administration division at that time. His full job is looking after the administration of these grants and scholarships and he has therefore a very wide knowledge of statistics involving things of that sort.

By Mr. Murphy (Lambton West):

Q. Advanced university students?—A. Yes. His job is really responsibility for the program of assistance to universities either through scholarships or through grants. As a matter of fact he is also administering a number of outside scholarships, the Nuffield Foundation work, and various other scholarships the administration of which we have been asked to look after by the private donors. I think that he has had a very great deal of experience.

On the detailed administration of the laboratory operations, I think that since you have planned, Mr. Chairman, to have the Vice-president (administration) and his second-in-command appear as witnesses, that there would be an advantage if we could have the examination of the detailed administration at that time.

The CHAIRMAN: Do you wish to indicate the division?

The WITNESS: The way we have administration organized is we have a Vice-president (administration), Dr. E. R. Birchard, and reporting to him we have general services, that is maintenance work, shop services and things of that sort. He is also responsible for patents and is president of Canadian Patents and Development Limited which is a crown company owned by the National Research Council.

On the standard administration side there is a division of administration, the director of which is Dr. Rosser who also reports to the vice-president in charge of administration.

The administration division is broken down into general services, which includes the normal administrative things, purchasing, personnel—which deals with the Selection Committee and with applicants for jobs— and awards which deals with the council's general scholarship program.

Naturally this division also has the responsibility of preparing estimates and things of that sort. However, I thought that I would just give a general summary of the work today and it would probably be more convenient to discuss estimates when the officers of the administration division are here, if that is agreeable.

The CHAIRMAN: Yes.

The WITNESS: Well, then, I have referred to the scholarships and grants, and I think since that is quite a big division that it would be an advantage if we could also discuss that as a separate item.

Then there are the laboratories. We have our laboratories organized into a number of scientific divisions, applied biology, pure and applied chemistry, pure and applied physics; and engineering divisions, mechanical engineering, radio and electrical engineering, and building research. We also have two regional laboratories— the Prairie Regional Laboratory in Saskatoon and the Atlantic Regional Laboratory in Halifax.

In addition we have a division of medical research which is rather anomalous in that we decided from the start that it was not practicable to operate a medical research organization divorced from teaching hospitals; so we have kept entirely out of the operation of medical research—we support it financially but do not actually carry it out. In this field we tend to support the basic medical sciences—biochemistry, physiology and bacteriology rather than clinical work. This theoretical division is actually just another arm of the scholarship and grants program; it is not an operating division in the normal sense.

All these divisions, basically, except for the prairie and Atlantic regional laboratories, are centred in Ottawa. There are, of course, odds and ends elsewhere. We operate an office in London, England and another in Washington; we have a couple of stations in the north, each staffed by one or two men, engaged in work in connection with building problems at Norman Wells and Aklavik. We have—or will shortly have—a building research station at St. John's, Newfoundland, which will be an exposure site to investigate the deterioration of masonry and questions of that sort, and which is only to be staffed on a part-time basis. We have two or three men at Scarboro, outside Toronto, in connection with some radar work, and we are installing a cosmic ray observation station on Sulphur mountain, Alberta. Then, for the next three years we will have a man or two at Resolute and a man or two at Baker lake in connection with the international geophysical year, engaged on observations in the north, but all these things involve only one or two men for relatively short periods, and by far the major part of the staff is in Ottawa.

The general purpose of the applied biology division is concerned not with agricultural science—that is the sphere of the Department of Agriculture—but with the use of biological materials. One of the main items with which the staff of the division have been concerned has been refrigeration. They have been responsible for major changes in the design of railroad refrigerator cars. They have also been occupied with questions of food preservation, storage and drying, and with fermentation processes—methods of producing by fermentation products other than alcohol. In general their concern is with what one might call biological secondary industry, as compared with, let us say, chemical secondary industry.

The pure chemistry division engages primarily in fundamental chemical work, and there are two reasons for this—to keep up the general scientific level and to retain staff whose work will be of interest in the wider field.

Pure chemistry and pure physics are in this category. They both operate through a very small skeleton staff plus post doctorate fellowship people who come to us from all the countries of the world for periods of one or two years. At any given time we have quite a collection of them. I think that at the present time we have something like 20 nationalities represented on a one or two year basis, and I believe this arrangement has been very useful in our scientific international relations.

By Mr. Coldwell:

Q. Is that in connection with our Colombo Plan?—A. .No, but we draw considerably from the Colombo Plan countries. I think at the present time we probably have some 30 people from Asian countries, a considerable number from the remainder of the Commonwealth and European countries and, of course, people from Canada and the United States.

The applied chemistry division is concerned with long-term chemical studies related to national resources, and an example of this was the tar sand development which turned out to be no tas interesting economically as it might have been because of the discovery of more oil in Alberta. This is the kind of thing which, I think, has to be undertaken by a non-commercial organization in existing circumstances. The division has also done quite a lot of investigation in the petroleum field in relation to lubricating oils and greases and in a number of what one might call more short-term technically important investigations—chemical engineering, a great deal of work on corrosion, textile research, polymers, quite a lot of work on some aspects of the synthetic rubber program and so forth.

The applied physics department deals with the branches of physics that affect industry. The most obvious are acoustics, electricity, optics, photogrammetry which is, photographic surveying, and radiology—in this case, primarily, in radiography of castings and things of that sort. They have standardized all the radioactive sources used for cancer treatment in Canada in the last one or two years, so they have some impact on the medical side, too. Also they are, by law, custodians of the fundamental standards of length, weight and so forth.

One example of their work which, I think, has been quite spectacular in the last year has been the application of acoustics to the paper industry. You would not expect the pulp and paper companies to have specialists in acoustics, but they found that noise due to rapidly running paper machines has been constituting a major hazard to health and we were asked to do something about it. Apparently not too much attention had been given to this question by people with the fundamental knowledge of acoustics, and the result of our efforts has been rather spectacular. In a comparatively short time a relatively inexpensive gadget has been designed which can be attached to a paper machine without changing its other characteristics and which reduces the noise level by a very large factor. It is in operation for test purposes at Gatineau Mills, and I think it will be generally adopted.

By Mr. Hosking:

Q. What was the effect of the noise on people, what did it do to the people?—A. I think you would find that in the paper industry all elderly paper makers are very deaf. It has been a very difficult problem. It is very difficult to wear so-called ear defenders, or things like ear muffs. They are uncomfortable and so forth. One of the difficulties is that the old-time skilled operator can tell by the sound of the machine if it is going on the blink, and if you cover up his ears he is in difficulty. This gadget is attached to the machine at the point where the air is blowing through holes, and by simply letting down the air gently, and in stages, it brings it down to the level where the sound is no longer dangerous from the health point of view.

By Mr. Murphy (Lambton West):

Q. Which mill is that?—A. I think at the present time there are several, but I know there is one on a trial operation at the International Paper Company at Gatineau Mills.

By Mr. Stewart (Winnipeg North):

Q. Is this machine patented by the company?—A. There is an application pending, actually, although it is a case where nobody is too interested in the patents. It is a question of installing the gadget. There are not so many paper machines, and you are not going to make very much money out of it. But, I think it is of very great value, though not in money.

Although this machine is at Sussex street in a different building, I think it would be possible to stage a demonstration when you visit the laboratories, if the members of the committee were interested, because it is a very spectacular thing. The machine is not very big and I think we could move it out to the Montreal road laboratories to demonstrate it if you are interested.

The CHAIRMAN: Is the committee interested?

The WITNESS: I think it has given us one indication of the place where the council can be useful. You do not expect a paper company to hire a physicist; they generally have a number of chemists. I think you will find continually in most industries there are problems which are not along the lines of those dealt with by the general type of technical people that industry can be expected to have. We notice that we are getting into investigations for some of the paper industries on other mechanical problems including the flow of materials and hydraulics. In other words, I think physics is invading the paper industry. It was invaded first by chemistry, and now I think physics is beginning to invade it; and I think there is an opportunity for us to get in in the early stages, and stimulate its development.

The Mechanical engineering Division is primarily aeronautics. This is a matter of history, in that aeronautical facilities existed at the beginning of the war in our mechanical engineering division, and no place else in Canada. So that during the war we were a research arm of the air force. The division expanded very rapidly during the war, and at the end of the war we were left with aeronautical facilities and personnel. When the Defence Research Board was set up they decided not to go into aeronautics, and asked us to continue to carry on aeronautical research.

Although our main function is a civilian one, that has been done since, to some extent, there is a change coming about, however, in that a new large wind tunnel is being built at Uplands. When that is well under way, probably in about a year, the Uplands part of our aeronautical research will be transferred to the Defence Research Board, including the new wind tunnel. We will continue to operate the aeronautical facilities at Montreal road. In other words, we are getting into a stage where we are stepping up, and the more direct engineering aspects of aeronautics for the services will go to the Defence Research Board, while the more fundamental research in aerodynamics and things of that sort will stay with us. It is a long-term development. The immediate step is the Uplands site being transferred to the Defence Research Board within a period of approximately a year.

At the present time we are engaged in aerodynamics; that is airframe work, structural problems in aeronautics, engines, fuels, lubricants and instruments. We have at the Uplands airport a flight research laboratory which does actual flying tests.

However, the division is also concerned with mechanical engineering in general. It has always done quite a lot of work in the way of model testing for the navy and for other ship builders.

The one development that has come along very largely, recently, has been hydraulic models. We have always done some model work in connection with power development. I refer to the operation of large scale models as experimental gadgets so as to determine the results connected with the flow of water, and so forth.

We have recently got into three things: one was the Ripple Rock investigation. We did some model work on it in connection with recommendations regarding the methods of removal.

Then we got into a very large program—part of it has also been done by the Ontario Hydro—on the St. Lawrence seaway. It involves the construction of scale models of sections of the seaway, and then investigating the effect of changing conditions, excavation, putting in barriers and so forth.

More recently we have built a model of the Port aux Basques harbour. So that these hydraulic models are, I think, becoming quite a major thing; and I feel sure that this field is one which will continue over quite a long period. I think it is getting more and more the custom in hydraulic power developments and things of that sort to look at large-scale models.

If the committee wished, we would certainly plan a visit to the Montreal road. I think the seaway is something that would interest you.

The radio and electrical engineering division started during the war, really as one man in the physics division, and ended up being the Canadian scientific backing for the Canadian radar effort. It was a very considerable one.

At the end of the war there was a transition more and more to electronics work of interest to the services, being part of the Defence Research Board operations, while we went over to the civilian work. But at the request of the Defence Research Board, because of the amount of effort we had put into it, and the amount of skill that had been acquired, we continued to do radar development. At the time of the Korean war these increased largely, and it still is quite large.

At the present time I think the division is doing something between 50 and 60 per cent of its work for the services, and the other 40 per cent is civilian work. The civilian work includes radar aids to navigation, things like radar lighthouses; automatic methods of turnings on fog horns; small scale radar beacons, and a variety of things of this sort. The division has also got into quite a lot of odds and ends in the electronics field including some along medical lines.

One recent thing that is becoming quite prominent is work in connection with high voltage transmission. There is the tendency for voltage in the transmission lines to go higher and higher as power is transmitted over longer distances.

The building research division really got going since the last committee on the Research Council. It was just in the process of formation at the time of the last meeting.

The CHAIRMAN: That is correct.

The WITNESS: Since that time the building has been completed, and the division has been recruited. It has been recruited slowly over a period, and is getting towards full size.

It is concerned with problems of heating, building materials, mechanical properties of soil, which is very important for foundations, particularly for buildings in the north.

It acts as a research wing of Central Mortgage and Housing Corporation, and one of the major accomplishments in the last two years has been the completion of the new national building code. Building regulations are a matter for the municipality and there are great variations, or there were, across the country. The idea of the building code was to try to draw up a model code which any municipality could adopt if it wished. It has no legal significance unless it is adopted by a municipality. This code was compiled with a great deal of effort. It involved something in the neighbourhood of 1,000 or more people on a variety of committees. They were brought in from industry—by industry I mean either the manufacturers of building materials or the contractors who would use them—and they sat with the municipaliites and other people responsible for regulations and so on. Committees sat on every conceivable subject occupied with building regulations and gradually beat out a set of virtually unanimous regulations as a recommendation. Since that time the code has been adopted—it is being adopted steadily—by more and more municipalities and I think it has been a very useful document.

We are just entering on a new field. This is at the request of the Federation of Mayors of municipalities and of the Firefighters and Fire marshals Associations. To start, we set up a committee to look into the question as to whether one should also develop a similar code, merely as a recommended document, which could be adopted on the subject of fire hazards. In view of the happenings last winter, there is no question about the seriousness of the problem. The underwriters have, of course, done a great deal of work on this. On the other hand, it seems to us that it is something which requires all the effort we can put into it. We are getting into fire research also on quite a large scale. I think this national fire code may turn out to be a very important document if and when it is beaten through. Even if it never materializes, I think it will raise enough questions which will require investigation, so the committee should be a very useful one.

In regard to the regional laboratories, there is one in Saskatoon which was established in 1948 for the utilization of farm products and so on. They are in an agricultural region but they are not attempting to compete with the

Department of Agriculture. Again this is more or less the secondary industry of agricultural products, that is, fermentation, chemical process and engineering development. They have done a lot of work on explosions in grain elevators and on matters of general interest to the prairie provinces.

The Atlantic Regional Laboratory was, incidentally, called the Maritime Regional Laboratory, but in deference to Newfoundland it is now being changed to the Atlantic Regional Laboratory, as it includes the four provinces. It has been concerned with a variety of small problems and three major ones. One problem has been the utilization of seaweed, another has been the question of the deterioration of masonry, which is rather bad in the Atlantic provinces. A number of metallurgical problems which affect the steel making industry and so on and which are of some interest to the Maritime steel industry have been dealt with. That generally is the sort of problem which is handled. The Atlantic Regional Laboratory is on the Dalhousie campus in Halifax.

At this point, it might be worth coming to the general question of the relations of the council with industry. There are four ways in which, basically, we deal with industry. The first is that we may do work in the laboratories which is of interest to the industry. This is of course the major operation. That work arises in various ways. It may arise as the result of an idea of someone in the laboratory, in other words, we may get into the development of a process on the basis of an idea which arises with us that it appears that such a process is worth investigating. This is true particularly in what might be called long term development of national resources.

The second way in which we can get into work for industry is by a cooperative arrangement, whereby an industry comes to us and contracts with us to do, over a long period, work which is of interest to them. In other words, it is what is normally called sponsored research. If this problem seems to us to be of interest, we may take it on; and it may be, if it is a specific company problem which it seems to us is worth doing but which the company wants for its own use, that we may enter into a contract with them whereby they pay the entire cost, including overheads and everything else, and the result belongs to them. It may be done cooperatively with several industries contributing, in which case the results are open to the industry. It may be that the industry raises the problem but it seems to us that it is of public interest that it should be done and in such a case we insist that the results be open to the public, in which case we will do it without charge.

Generally speaking, the problem may arise in the industry or with us. However, I think that simplifies the situation a little too much, as you not only get into a case where the problem arises, but you get into the field of work. In other words, very often you do not tackle a specific problem as the basic start in the field: you feel that this field is of interest and therefore you get into the field and you begin to do things in that field. This leads you to problems, which you then investigate.

Similarly, the industry may try to influence us to go into a certain field on the ground that there is not enough known about that field.

This work is done either on our own initiative in consultation with industry or at the request of industry. It varies and a great deal depends on the size of the industry, the type of the problem and so forth.

In certain cases companies which have active research laboratories of their own, may ask us to undertake work for them in a field which is a bit off the normal run. A second way in which we have contact with industries or try to assist industry is by consultation.

It is almost impossible to say how many visits take place each way. At one time we kept a spot check for a very short time. It is not at all unusual to have, in ones and twos, to see various people and in various sections, as many as 100 visits a day. I think the average certainly would run about 50 or 60, coming in ones and twos to see various individuals in various fields. This is apart from the question of tours just to have a general look at the place.

As far as inquiries are concerned, I do not know what the number would be, of inquiries which are answered. In general, one tries to decentralize. I think the only way you can handle technical work is in this way. What we want to do is to see our people who are specialists in that field get into direct contact with their opposite numbers in industry and then the technical correspondence goes direct and things are settled more or less on a personal basis. On the more formal side, we have a technical information service. It answers about 5,000 inquiries a year. This was set up for the sake of small industry primarily, with field representatives to visit small industries in their districts. Once we had it operating and provincial research organizations began to come into the field, we felt it was better for the local work to be handled locally. We have entered into contracts on that basis. We maintain headquarters organization which will answer the questions but we have entered into contracts with some of the provinces to operate the local field services. That is true in the case of British Columbia, Alberta, Saskatchewan, Ontario and Nova Scotia. We are operating the field representatives in other districts ourselves. This I think has been very useful to smaller industries.

Then finally, and I think it is something which looms quite large and is a rather unique Canadian development, there is a so-called associate committee structure. In some countries, Great Britain for example, research organizations have been quite prominent. You have a group of industries getting together in some field and establishing a research organization. But this has not been too prominent in this country for several reasons; one is that industrial research is only beginning to get under way in this country on any scale in industry. Another is that Canadian companies are often associates or subsidiaries of foreign companies and they have contacts across the line and therefore prefer that to contact with their competitors. At the same time it is very desirable to get co-operation. So what has been built up is a set of these so-called associate committees.

They involve representatives from the National Research Council, the federal government research organizations, provincial organizations, universities and industry, and they have been handled on a strict working basis. When there seems to be a job for one to do, then a committee is set up to do that job, and when the job disappears, the committee is wound up. We have had some 40 or 50, and at the present moment there are 28 in existence. These have approximaely 600 members, and they come from a wide cross-section of industry. A good example is the so-called prairie regional committee.

In the prairie provinces, grain, for example, is an extremely important question. So you have the National Research Council with some responsibility —not directly for agriculture—but it is supporting research in universities on agriculture.

The Board of Grain Commissioners for Canada is responsible for quality control, and the western universities, the prairie universities, have agricultural departments, and you also have the federal Department of Agriculture. So we have this prairie regional committee which includes representatives from these bodies. Perhaps I might just go through the membership; the chairman is Dr. A. G. McCalla who is Dean of the Faculty of Agriculture, University of Alberta; then there is Dr. A. N. Campbell, Professor of Chemistry, University of Manitoba; the director of our own plant biology division, Dr. W. H. Cook; Dr. N. H. Grace, Director Research Council of Alberta; Dr. V. E. Graham, Dean of the College of Agriculture, University of Saskatchewan; Dr. T. Johnson, Officer-in-Charge of the Laboratory of Plant Pathology, Department of Agriculture, Winnipeg; Dr. T. Thorvaldson, Co-ordinator of Research, Saskatchewan Research Council, Chemistry Department, University of Saskatchewan; and Dr. G. A. Ledingham, Director of the Prairie Regional Laboratory, National Research Council, Saskatoon.

Under this committee has been established a whole set of committees on grain research with sub-committees on various brands of wheat, oil, seeds, barley, and winter wheat; and in every case they have brought in these organizations plus representatives of the milling industry and other industries responsible for and concerned with grain.

I think this indicates a very remarkable co-operative set-up, and I do not think there is any country in the world in which research aimed at a given field of agriculture is as thoroughly co-ordinated and as thoroughly familiar to everyone in the field as is done through this prairie regional committee. I think also, to a large extent, this is true of these other committees.

We have 599 outstanding people sitting on these committees who are effectively giving us their specialized advice. I must say that in some cases we only act as a mechanism. Quite often these committees are set up in a field with which the council has nothing to do; but industry or some other department of the provincial government has requested us to set up such a committee.

The CHAIRMAN: If I might interrupt at this point: as I understand your evidence, Dr. Steacie, you have used as an example one of the 28 associate committees working in the field of co-ordination of scientific activities. My recollection of the last parliamentary committee is that on this subject there was a tremendous amount of interest on the part of the members, but we did not quite get the basic information before us for discussion: that is, we did not get a list of the committees currently sitting and how their membership was made up. Therefore I would like to have some guidance from this committee as to whether it wishes to have printed in the record the names of each of the 28 sub-committees with the personnel of each of the 28 sub-committees.

Personally I think it ought to be done if we are going to examine into the field of co-ordination of research in this country and to examine into the field of possible overlapping and so on. I would like to hear the committee members on that point.

Mr. MURPHY (*Lambton West*): Would that include the objects which each committee would have under survey?

The CHAIRMAN: Yes.

Mr. MURPHY (*Lambton West*): I think that is very important!

The WITNESS: What we have done in this brief—and we did not want to make it too lengthy—what we have done for example is this. Take the associate committee on the national building code. "Its activities are directed along three lines; first, development of codes of building practice for Canada; second, promotion of uniform building legislation in Canada; and third, research work necessary to these ends."

By Mr. Murphy (Lambton West):

Q. Would that evidence include the co-operation between the National Research Council and others? Would other bodies be related, such as provincial bodies?—A. Yes.

Q. All across the country?—A. Yes.

The CHAIRMAN: Yes.

Mr. MURPHY (*Lambton West*): I think it should be in the evidence then.

Mr. DICKEY: Mr. Chairman, I move that it be printed.

Mr. COLDWELL: I second the motion.

The CHAIRMAN: It has been moved by Mr. Dickey and seconded by Mr. Coldwell that this material be printed. All those in favour of the motion? Contrary minded, if any? I declare the motion carried.

The list of committees with the brief statement of the functions of each committee and the personnel of each committee will be printed in the record. That will give a proper basis for an examination of this subject by committee members. This material will be printed directly in the evidence at this point.

ASSOCIATE COMMITTEES OF THE NATIONAL RESEARCH COUNCIL, FUNCTION AND MEMBERSHIP

Associate Committee on Applied Psychology

Members

Dr. N. W. Morton, Chairman,
Defence Research Board,
Ottawa, Ontario.

Dr. J. M. Blackburn,
Head, Department of Psychology,
Queen's University,
Kingston, Ontario.

Dr. G. A. Ferguson,
Professor of Psychology,
McGill University,
Montreal, P.Q.

Rev. Father Noel Mailloux,
Director, Dept. of Psychology,
University of Montreal,
Montreal, P.Q.

Dr. R. B. Malmo,
Allan Memorial Institute of Psychiatry,
McGill University,
Montreal, P.Q.

Dr. A. H. Shephard,
Professor of Psychology,
University of Toronto,
Toronto, Ontario.

Dr. J. P. Zubek,
Head, Department of Psychology,
University of Manitoba,
Winnipeg, Man.

Mr. J. F. Dawe, Secretary,
Civil Service Commission,
Ottawa, Ontario.

The Committee is concerned with the experimental aspects of psychology, i.e., where it is becoming close to biology. It originated during the war in connection with personnel selection problems.

Associate Committee on Research on Aquatic Biology

Members

Dr. T. W. M. Cameron, Chairman,
Director,
Institute of Parasitology,
Macdonald College, Que.

Dr. Y. Desmarais,
Department of Biology,
Laval University,
Quebec, P.Q.

Dr. F. E. J. Fry,
Department of Zoology,
University of Toronto,
Toronto, Ontario.

Dr. J. L. Hart,
Director,
Atlantic Biological Station,
Fisheries Research Board of Canada,
St. Andrews, N.B.

Dr. F. R. Hayes,
Department of Zoology,
Dalhousie University,
Halifax, N.S.

Dr. W. S. Hoar,
Department of Zoology,
University of British Columbia,
Vancouver, B.C.

Dr. J. L. Kask,
Chairman,
Fisheries Research Board of Canada,
Ottawa, Ontario.

Dr. R. B. Miller,
Department of Zoology,
University of Alberta,
Edmonton, Alta.

73986—2½

Associate Committee on Research on Aquatic Biology—Conc.

Dr. W. E. Ricker,
Pacific Biological Station,
Fisheries Research Board of Canada,
Nanaimo, B.C.

Mr. H. Williamson, Secretary,
Division of Applied Biology,
National Research Council,
Ottawa, Ontario.

Ex officio members:

Dr. C. W. Argue,
Dean,
Faculty of Science,
University of New Brunswick,
Fredericton, N.B.

Dr. W. H. Cook,
Director,
Division of Applied Biology,
National Research Council,
Ottawa, Ontario.

This Committee was established in 1938 to act as an advisory group to the National Research Council on all matters pertaining to aquatic biology and in particular to recommend to Council how funds in aid of research might be allocated to best advantage in this field.

Associate Committee on Corrosion Research and Prevention

Members

Dr. H. D. Smith, Chairman,
Nova Scotia Research Foundation,
P.O. Box 1027,
Halifax, Nova Scotia.

Mr. K. N. Barnard,
Naval Research Establishment,
Dartmouth, Nova Scotia.

Mr. J. W. Brock,
Development Manager,
Paint and Varnish Division,
Canadian Industries Limited,
Montreal, P.Q.

Dr. M. Cohen,
Division of Applied Chemistry,
National Research Council,
Ottawa, Ontario.

Mr. E. T. Hurley,
Controller of Tests and Materials Research,
Dept. of Res. and Development, C.N.R.,
1801 Le Ber Street,
Montreal, P.Q.

Mr. R. J. Law,
International Nickel Co. of Canada,
25 King Street West,
Toronto, Ontario.

Dr. R. R. Rogers,
Mineral Dressing and Metallurgy Division,
Dept. of Mines and Tech. Surveys,
569 Booth St.,
Ottawa, Ontario.

Professor F. A. Forward,
Department of Mining and Metallurgy,
University of British Columbia,
Vancouver 8, British Columbia.

Mr. E. V. Gibbons,
Division of Building Research,
National Research Council,
Ottawa, Ontario.

Dr. H. P. Godard,
Aluminium Laboratories Limited,
P.O. Box 84,
Kingston, Ontario.

Dr. R. Guest,
Department of Chemistry,
Ontario Research Foundation,
Toronto, Ontario.

Dr. F. E. W. Wetmore,
Department of Chemistry,
University of Toronto,
Toronto, Ontario.

Dr. W. C. Winegard,
Asst. Professor of Metallurgical Engineering,
University of Toronto,
Toronto, Ontario.

Dr. C. Winkler,
Department of Chemistry,
McGill University,
Montreal, P.Q.

Associate Committee on Corrosion Research and Prevention—Conc.

Mr. J. W. Young,
Imperial Oil Limited,
300 Ninth Avenue, West,
Calgary, Alberta.

Mr. D. A. Webster, Secretary,
Division of Administration,
National Research Council,
Ottawa, Ontario.

The function of this Committee is to coordinate research and testing methods.

Canadian Committee on Culture Collections of Micro-Organisms

Members

Dr. N. E. Gibbons, Chairman,
Division of Applied Biology,
National Research Council,
Ottawa, Ontario.

Dr. J. W. Groves,
Division of Botany and Plant Pathology,
Department of Agriculture,
Ottawa, Ontario.

Dr. A. G. Lochhead,
Division of Bacteriology and Dairy Research,
Department of Agriculture,
Ottawa, Ontario.

Prof. E. G. D. Murray,
Research Professor,
University of Western Ontario,
London, Ontario.

Dr. M. Saint-Martin,
Hotel Dieu Hospital,
Montreal, P.Q.

Dr. S. M. Martin, Secretary,
Division of Applied Biology,
National Research Council,
Ottawa, Ontario.

This is part of a Commonwealth cooperative scheme to maintain and exchange culture collections.

Associate Committee on Dental Research

Members

Dr. J. B. Macdonald, Chairman,
Division of Dental Research,
University of Toronto,
Toronto, Ontario.

Dr. E .W. R. Steacie, ex officio,
President,
National Research Council,
Ottawa, Ontario.

Representing the dental profession:

Dr. J. S. Bagnall,
Faculty of Dentistry,
Dalhousie University,
Halifax, N.S.

Dr. C. D. Husband,
Suite 110,
Metro Block,
Red Deer, Alta.

Dr. J.-P. Lussier,
Faculty of Dental Surgery,
University of Montreal,
Montreal, P.Q.

Dr. R. H. McDougall,
1505 Hampshire Road,
Victoria, B.C.

Dr. A. G. Racey,
Department of Oral Pathology,
McGill University,
Montreal, P.Q.

Dr. C. H. M. Williams,
Faculty of Dentistry,
University of Toronto,
Toronto, Ontario.

Representing the Royal Canadian Dental Corps, Department of National Defence:

Brig. E. M. Wansbrough, ex officio,
Director General of Dental Services,
Royal Canadian Dental Corps,
Department of National Defence,
Ottawa, Ontario.

Representing the Division of Dental Health, Department of National Health and Welfare:

Dr. H. K. Brown, ex officio,
Chief, Dental Health Division,
Department of National Health and Welfare,
Ottawa, Ontario.

Representing Dental Research, Department of Veterans Affairs:

Dr. L. A. Kilburn, ex officio,
Director of Dental Research,
Department of Veterans Affairs,
Ottawa, Ontario.

Representing the Basic and Medical Sciences:

Dr. J. G. Aldous,
Dept. of Pharmacology,
Dalhousie University,
Halifax, N.S.

Dr. H. J. Barrie,
Dept. of Pathology,
Faculty of Medicine,
University of Toronto,
Toronto, Ontario.

Dr. D. H. Copp,
Dept. of Physiology,
University of British Columbia,
Vancouver, B.C.

Dr. A. W. Ham,
Dept. of Anatomy,
Faculty of Medicine,
University of Toronto,
Toronto, Ontario.

Dr. J. M. R. Beveridge,
Dept. of Biochemistry,
Queen's University,
Kingston, Ontario.

Dr. A. C. Burton,
Dept. of Biophysics,
University of Western Ontario,
London, Ontario.

Dr. E. Pagé,
Dept. of Nutrition,
Medical School,
Laval University,
Quebec, P.Q.

Dr. J. B. Marshall, Secretary,
Awards Officer,
National Research Council,
Ottawa, Ontario.

The Associate Committee on Dental Research was established in 1945 to stimulate research in or related to the field of dentistry in Canada.

To achieve this objective, a large proportion of the annual appropriation of the Committee is spent on grants in aid of research carried out in Canadian universities under the direction of qualified research scientists. During the nine-year period since its inception, the Committee has sponsored a total of 57 research projects, some of them for several years.

For the fiscal year 1954-55, grants to a total of over $23,000 were made in support of 14 projects under way in six Canadian universities. The subjects of these projects were varied, ranging from an anatomical study of the hitherto untraced vascular pattern of human dental pulp, to the measurement of electro-potentials of dental alloys, and a fundamental investigation of the entry of phosphate, carbonate and calcium into teeth; problems related to dental caries, periodontal disease and malocclusion were also studied.

Two Fellowships valued at $3,000 each were awarded for the year to graduates of Canadian dental schools, to enable them to continue their research training.

Canadian Committee on Fats and Oils

Members

Dr. G. A. Adams, Chairman,
Division of Applied Biology,
National Research Laboratories,
Ottawa, Ontario.

Mr. G. Fearnley,
International Paints (Canada) Ltd.,
Montreal, P.Q.

Canadian Committee on Fats and Oils—Conc.

Dr. R. H. Common,
Department of Chemistry,
Macdonald College, P.Q.

Dr. E. W. Crampton,
Department of Nutrition,
Macdonald College, P.Q.

Dr. C. Y. Hopkins,
Division of Pure Chemistry,
National Research Laboratories,
Ottawa, Ontario.

Mr. J. Hulse,
Food Section,
Defence Research Medical Laboratories,
Toronto, Ontario.

Dr. H. J. Lips, Secretary,
Division of Applied Biology,
National Research Laboratories,
Ottawa, Ontario.

Dr. R. U. Lemieux,
Department of Chemistry,
University of Ottawa,
Ottawa, Ontario.

Dr. W. D. McFarlane,
Canadian Breweries Ltd.,
Toronto, Ontario.

Mr. H. W. Lemon,
Department of Biochemistry,
Ontario Research Foundation,
Toronto, Ontario.

Dr. W. G. McGregor,
Cereal Division,
Central Experimental Farm,
Ottawa, Ontario.

Mr. W. F. McLean,
General Superintendent's Office,
Canada Packers Limited,
Toronto, Ontario.

Dr. R. P. A. Sims,
Chemistry Division,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. O. C. Young,
Fisheries Research Board of Canada,
Ottawa, Ontario.

This Committee was established by Council in March, 1952. Since then it has held four meetings and has arranged two conferences on Fats and Oils.

The Committee's terms of reference permit it to undertake research in the field of triglyceride fats and oils and to serve in a liaison capacity between the Council and other organizations concerned with research in the assigned and related fields.

Canadian Committee on Food Preservation

Members

Dr. W. H. Cook, Chairman (and Chairman, Subcommittee on Engineering),
Director, Division of Applied Biology,
National Research Laboratories,
Ottawa, Ontario.

Dr. J. Hulse,
Defence Research Medical Labs.,
P.O. Box 62, Postal Station K,
Toronto 12, Ontario.

Dr. N. M. Carter,
Director,
Pacific Fisheries Experimental Station,
Vancouver, B.C.

Mr. M. B. Davis (Chairman, Sub-Committee on Fruits and Vegetables),
Dominion Horticulturist,
Experimental Farm Service,
Ottawa, Ontario.

Dr. B. A. Eagles,
Professor of Dairying,
University of British Columbia,
Vancouver, B.C.

Dr. N. E. Gibbons (Chairman, Subcommittee on Meat and Animal Products),
Division of Applied Biology,
National Research Laboratories,
Ottawa, Ontario.

Dr. M. Jean,
Department of Biochemistry,
Laval University,
Montreal, P.Q.

Canadian Committee on Food Preservation—Conc.

Mr. S. C. Barry,
Associate Director of Production Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. S. A. Beatty,
Director, Atlantic Fisheries Research Station,
Halifax, N.S.

Dr. R. K. Larmour,
Director of Research,
Maple Leaf Milling Co.,
Toronto, Ontario.

Dr. K. W. Neatby,
Director, Science Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. A. D. Robinson,
Professor of Biochemistry,
University of Manitoba,
Winnipeg, Man.

Dr. E. G. Young,
Professor of Biochemistry,
Dalhousie University,
Halifax, N.S.

Mr. O. C. Young,
Scientific Assistant to the Chairman,
Fisheries Research Bd. of Canada,
West Block, Ottawa, Ontario.

Dr. Dyson Rose, Secretary,
Division of Applied Biology,
National Research Laboratories,
Ottawa, Ontario.

Subcommittee on Engineering

Dr. W. H. Cook, Chairman,
Director, Division of Applied Biology,
National Research Laboratories,
Ottawa, Ontario.

Mr. W. H. Bailey,
Research Department,
Canadian National Railways,
Montreal, P.Q.

Mr. P. E. Brougham,
Chief Supervisor, Perishable Traffic,
Canadian Pacific Railway Co.,
Montreal, P.Q.

Mr. H. J. Hart,
Mechanical Department,
Canadian National Railways,
Montreal, P.Q.

Mr. D. E. Jones,
Air-Conditioning Engineer,
Canadian Pacific Railway Co.,
Montreal, P.Q.

Mr. G. B. Miller,
Marketing Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. W. R. Phillips,
Division of Horticulture,
Experimental Farms Service,
Central Experimental Farm,
Ottawa, Ontario.

Mr. G. Stevens,
Assistant Engineer,
Car Equipment,
C.P.R.,
Montreal, P.Q.

Mr. J. L. Townshend,
General Supervisor,
Perishable Traffic,
Canadian National Railways,
Montreal, P.Q.

Mr. C. P. Lentz, Secretary,
Division of Applied Biology,
National Research Laboratories,
Ottawa, Ontario.

Subcommittee on Fruits and Vegetables

Mr. M. B. Davis, Chairman,
Dominion Horticulturist,
Experimental Farms Service,
Central Experimental Farm,
Ottawa, Ontario.

Dr. J. H. Craigie,
Dominion Botanist,
Science Service,
Central Experimental Farm,
Ottawa, Ontario.

Mr. F. E. Atkinson,
Dominion Experimental Station,
Experimental Farms Service,
Summerland, B.C.

Mr. E. G. Paige,
Chief, Fruit and Vegetable Inspection,
Marketing Service,
Department of Agriculture,
Ottawa, Ontario.

Subcommittee on Fruits and Vegetables—Conc.

Dr. Jean David,
Department of Horticulture,
Macdonald College, P.Q.

Mr. A. J. Ducker,
Defence Research Medical Labs.,
R.C.A.F. Station, Toronto,
1107 Avenue Road,
Toronto, Ontario.

Mr. C. A. Eaves,
Dominion Experimental Station,
Experimental Farms Service,
Kentville, N.S.

Mr. F. J. Francis,
Horticulture Department,
Ontario Agricultural College,
Guelph, Ontario.

Mr. A. W. Franklin,
Department of Horticulture,
Ontario Agricultural College,
Guelph, Ontario.

Mr. G. S. Harper,
Experimental Farms Service,
Central Experimental Farm,
Ottawa, Ontario.

Mr. G. W. Hope,
Dominion Experimental Station,
Experimental Farms Service,
Kentville, N.S.

Dr. F. B. Johnson,
Division of Chemistry,
Experimental Farms Service,
Central Experimental Farm,
Ottawa, Ontario.

Miss L. C. Pepper,
Consumer Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. F. J. Perry,
Fruit and Vegetable Division,
Marketing Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. P. A. Poapst,
Division of Horticulture,
Experimental Farms Service,
Central Experimental Farm,
Ottawa, Ontario.

Dr. L. I. Pugsley,
Laboratory of Hygiene,
Department of National Health and Welfare,
Ottawa, Ontario.

Mr. R. E. Robinson,
Chief, Fruit and Vegetable Inspection,
Marketing Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. A. L. Shewfelt,
Dominion Experimental Station,
Experimental Farms Service,
Morden, Man.

Dr. C. C. Strachan,
Dominion Experimental Station,
Experimental Farms Service,
Summerland, B.C.

Dr. A. H. Jones,
Science Service,
Central Experimental Farm,
Ottawa, Ontario.

Dr. A. G. Lochhead,
Dominion Agricultural Bacteriologist,
Science Service,
Central Experimental Farm,
Ottawa, Ontario.

Director,
B.C. Industrial and Scientific Research Council,
Vancouver, B.C.

Mr. W. R. Phillips, Secretary,
Division of Horticulture,
Experimental Farms Service,
Central Experimental Farm,
Ottawa, Ontario.

Mr. G. Strachan,
Dominion Experimental Farm,
Lethbridge, Alta.

Mr. D. B. Taylor,
Ontario Research Foundation,
Queen's Park,
Toronto, Ontario.

Dr. J. H. L. Truscott,
Horticulture Experiment Station,
Vineland, Ontario.

Dr. J. C. Woodward,
Division of Chemistry,
Science Service,
Central Experimental Farm,
Ottawa, Ontario.

Subcommittee on Meat and Animal Products

Dr. N. E. Gibbons, Chairman,
Division of Applied Biology,
National Research Labs.,
Ottawa, Ontario.

Mr. F. F. Baird,
Assistant to the Director,
Marketing Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. E. D. Bonnyman,
Poultry Products Inspection,
Marketing Service,
Department of Agriculture,
Ottawa, Ontario.

Director,
B.C. Industrial and Scientific Research Council,
Vancouver, B.C.

Mr. E. S. Manning,
Secretary,
Industrial and Development Council,
Canadian Meat Packers,
Toronto, Ontario.

Prof. W. A. Maw,
Department of Poultry Husbandry,
Macdonald College, P.Q.

Dr. G. B. Miller,
Marketing Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. W. C. Cameron,
Dairy Products Division,
Marketing Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. H. S. Gutteridge,
Poultry Division,
Experimental Farms Service,
Ottawa, Ontario.

Mr. E. B. Fraser,
Division of Animal Husbandry,
Experimental Farms Service,
Central Experimental Farm,
Ottawa, Ontario.

Dr. C. K. Johns,
Dairy Bacteriology Section,
Science Service,
Central Experimental Farm,
Ottawa, Ontario.

Dr. A. G. Lochhead,
Dominion Agricultural Bacteriologist,
Science Service,
Central Experimental Farm,
Ottawa, Ontario.

Mr. C. G. Hickman,
Division of Animal Husbandry,
Experimental Farms Service,
Central Experimental Farm,
Ottawa, Ontario.

Mr. G. N. Ruhnke,
Director of Research,
Department of Agriculture,
Ontario Agricultural College,
Guelph, Ontario.

Dr. F. S. Thatcher,
Food and Drug Division,
35 John Street,
Ottawa, Ontario.

Dr. J. C. Woodward,
Division of Chemistry,
Science Service,
Central Experimental Farm,
Ottawa, Ontario.

Miss Helen Brown, Secretary,
Division of Applied Biology,
National Research Laboratories,
Ottawa, Ontario.

This Committee provides a means for exchanging information and co-ordinating Canadian research activities in the field of food preservation. The investigations reported at meetings of this Committee and its three sub-committees consist largely of work directed or supported by the several services of the Department of Agriculture, the Fisheries Research Board of Canada, and the National Research Council. Other organizations represented include the Defence Research Board, the Department of National Health and Welfare, several universities and colleges, and various commercial firms.

The Committee has issued five volumes of collected papers (1 to 284) and has received 20 papers for inclusion in Volume 6. These volumes are distributed throughout the world to seventy-two organizations interested in food technology.

Associate Committee on Forest Fire Protection

Members

Mr. T. E. Mackey, Chairman,
Chief,
Division of Forest Protection,
Dept. of Lands and Forests,
Toronto 5, Ontario.

National Research Council Representatives:

Mr. C. H. Bayley,
Division of Applied Chemistry,
National Research Council,
Ottawa, Ontario.

Mr. G. W. Shorter,
Division of Building Research,
National Research Council,
Ottawa, Ontario.

National Parks Branch Representative:

Mr. D. J. Learmonth,
National Parks Branch,
Northern Affairs and National Resources Department,
Ottawa, Ontario.

Provincial Representatives:

Mr. C. Cahill,
Supervisor of Forestry,
Dept. of Mines and Resources,
St. John's, Newfoundland.

Mr. F. R. Hayward,
Secretary,
Newfoundland Forest Protection Assoc.,
Grand Falls, Newfoundland.

Mr. J. F. Gaudet,
Provincial Forester,
Dept. of Industrial and Natural Resources,
Charlottetown, P.E.I.

Mr. R. H. Burgess,
Provincial Forester,
Dept. of Lands and Forests,
Halifax, N.S.

Mr. G. L. Miller,
Chief Forester,
Dept. of Lands and Mines,
Fredericton, N.B.

Mr. Henri Kieffer,
Chief,
Forest Protection Service,
Dept. of Lands and Forests,
Quebec, Que.

Mr. A. W. Braine,
Chief of Forest Protection,
Dept. of Mines and Natural Resources,
Winnipeg, Man.

Mr. F. Warburton,
Supervisor of Forest Fire Control,
Dept. of Natural Resources,
Regina, Sask.

Mr. E. S. Huestis,
Directory of Forestry,
Dept. of Lands and Mines,
Edmonton, Alta.

Mr. I. T. Cameron,
Chief, Forest Protection,
Dept. of Lands and Forests,
Victoria, B.C.

Forest Protective Association Representatives:

Mr. G. A. Kingston,
Manager, Lower Ottawa Forest Protective Assoc., Ltd.,
P.O. Box 252,
Hull, Que.

Mr. H. M. Small,
Ottawa River Forest Protective Association,
53 Queen Street,
Ottawa, Ontario.

Mr. J. D. Brulé,
Manager, Southern St. Lawrence Forest Protective Assoc.,
Val Brilliant, Que.

Forest Industries Representatives:

Mr. L. R. Andrews,
British Columbia Lumber Manufacturers Association,
302 Forest Industries Bldg.,
550 Burrard Street,
Vancouver 1, B.C.

Mr. C. R. Mills,
Manager, Ontario Forest Industries Assoc.,
159 Bay Street,
Toronto, Ontario.

Mr. Edgar Porter,
Manager, Quebec Forest Industries Association,
65 Ste. Anne Street,
Quebec, Que.

Associate Committee on Forest Fire Protection—Conc.

Joint Secretaries:
Mr. J. C. Macleod,
Fire Protection Section,
Forestry Branch,
Dept. of Northern Affairs and National Resources,
Ottawa, Ontario.

Mr. D. A. Webster,
Division of Administration,
National Research Council,
Ottawa, Ontario.

The Associate Committee on Forest Fire Protection was formed by the National Research Council in March, 1952. This Committee was created to organize and guide fire research studies in Canada and particularly to promote cooperation among the Provincial Governments in conducting long-term research in this field.

Associate Committee on Geodesy and Geophysics

Members

Dr. C. S. Beals, Chairman,
Dominion Astronomer,
Dominion Observatory,
Dept. of Mines and Technical Surveys,
Ottawa, Ontario.

Dr. L. Gilchrist, Honorary Member
Department of Physics,
University of Toronto,
Toronto, Ontario.

Mr. A. H. Miller, Honorary Member,
326 Fairmont Avenue,
Ottawa, Ontario.

Mr. C. H. Ney, Honorary Member,
Asst. Dominion Geodesist,
Dept. of Mines and Technical Surveys,
Ottawa, Ontario.

Mr. N. J. Ogilvie, Honorary Member,
96 Carling Avenue,
Ottawa, Ontario.

Dr. J. E. Blanchard,
Nova Scotia Research Foundation,
P.O. Box 1027,
Halifax, N.S.

Dr. B. W. Currie,
Professor of Physics,
University of Saskatchewan,
Saskatoon, Sask.

Mr. F. T. Davies,
Defence Research Telec. Est.,
Defence Research Board,
Shirley Bay, Ottawa, Ontario.

Dr. B. T. Denis,
Chief, Division of Mineral Deposits,
Quebec Department of Mines,
Quebec, P.Q.

Dr. M. J. S. Innes,
Gravity Division,
Dominion Observatory,
Ottawa, Ontario.

Professor J. A. Jacobs,
Department of Physics,
University of Toronto,
Toronto, Ontario.

Dr. D. A. Keys,
Chairman, Project Co-ordinating Committee,
Atomic Energy of Canada Ltd.,
Chalk River, Ontario.

Mr. J. E. Lilly,
Geodetic Survey of Canada,
Dept. of Mines and Technical Surveys,
Ottawa, Ontario.

Mr. R. G. Madill,
Chief, Terrestrial Magnetism Division,
Dominion Observatory,
Dept. of Mines and Technical Surveys,
Ottawa, Ontario.

Dr. A. D. Misener,
Head of Physics Department,
University of Western Ontario,
London, Ontario.

Dr. L. W. Morley,
Chief, Geophysics Section,
Dept. of Mines and Technical Surveys,
Ottawa, Ontario.

Dr. T. D. Northwood,
Division of Building Research,
National Research Council,
Ottawa, Ontario.

Associate Committee on Geodesy and Geophysics—Conc.

Dr. G. D. Garland, Editor,
Department of Physics,
University of Alberta,
Edmonton, Alberta.

Dr. H. B. Hachey,
Chief Oceanographer,
Joint Committee on Oceanography,
Fisheries Research Board of Canada,
St. Andrews, N.B.

Dr. G. Hanson,
Chief Geologist,
Dept. of Mines and Technical Surveys,
Ottawa, Ontario.

Dr. J. H. Hodgson,
Chief, Division of Seismology,
Dominion Observatory,
Dept. of Mines and Technical Surveys,
Ottawa, Ontario.

Dr. H. G. I. Watson,
Department of Physics,
McGill University,
Montreal, Que.

Dr. P. L. Willmore,
Dominion Observatory,
Dept. of Mines and Technical Surveys,
Ottawa, Ontario.

Dr. G. L. Pickard,
Department of Physics,
University of British Columbia,
Vancouver, B.C.

Dr. D. C. Rose,
Division of Physics,
National Research Council,
Ottawa, Ontario.

Mr. J. E. R. Ross,
Dominion Geodesist,
Department of Mines and Technical Surveys,
Ottawa, Ontario.

Mr. A. Thomson,
Controller, Air Services,
Meteorological Division,
Department of Transport,
315 Bloor Street West,
Toronto 5, Ontario.

Dr. J. T. Wilson,
Professor of Geophysics,
University of Toronto,
Toronto, Ontario.

Mr. D. A. Webster, Secretary,
Division of Administration,
National Research Council,
Ottawa, Ontario.

The Associate Committee on Geodesy and Geophysics serves to co-ordinate geophysical research in Canada, and also functions as the National Committee for Canada of the International Union of Geodesy and Geophysics.

The Committee accomplishes its task of co-ordinating research by including in its membership representatives of the main research groups working in geophysics in Canada. Various special fields of geophysics are dealt with by sections set up under the chairmanship of members of the Committee. Membership of the sections includes, in addition to some members of the main Committee, others who are working in the special field dealt with by the sections.

Associate Committee on High Polymer Research

Members

Dr. S. Bywater, Chairman,
National Research Council,
Ottawa, Ontario.

Dr. E. J. Buckler,
Research and Development Div.,
Polymer Corporation Limited,
Sarnia, Ontario.

Dr. L. H. Cragg,
Department of Chemistry,
McMaster University,
Hamilton, Ontario.

Dr. A. T. Hutcheon,
Department of Chemistry,
McMaster University,
Hamilton, Ontario.

Dr. D. G. Ivey,
Department of Physics,
University of Toronto,
Toronto, Ontario.

Dr. M. H. Jones,
Ontario Research Foundation,
Toronto, Ontario.

Associate Committee on High Polymer Research—Conc.

Dr. S. G. Mason,
Pulp and Paper Research Institute,
Montreal, Que.

Dr. L. A. McLeod,
Research and Development Div.,
Polymer Corporation Limited,
Sarnia, Ontario.

Dr. H. Sheffer,
Defence Research Board,
Ottawa, Ontario.

Prof. M. Rinfret,
University of Montreal,
Montreal, Que.

Dr. C. Sivertz,
University of Western Ontario,
London, Ontario.

Dr. H. L. Williams,
Research and Development Div.,
Polymer Corporation Limited,
Sarnia, Ontario.

Dr. C. A. Winkler,
McGill University,
Montreal, Que.

Mr. R. J. Adams, Secretary,
Research and Development Div.,
Polymer Corporation Limited,
Sarnia, Ontario.

The Committee provides a forum for discussion of problems in the important field of polymers.

Associate Committee on the National Aviation Museum

Members

General A. G. L. McNaughton,
Chairman,
International Joint Commission,
Ottawa, Ontario.

Dr. J. J. Green, Vice-Chairman,
Defence Research Board,
Ottawa, Ontario.

Mr. G. C. Hurren,
Royal Canadian Flying Clubs Association,
Journal Building,
Ottawa 4, Ontario.

Mr. L. Lamontagne,
Department of Northern Affairs and National Resources,
Ottawa, Ontario.

Mr. J. R. K. Main,
Department of Transport,
Ottawa, Ontario.

Mr. J. H. Parkin,
Director, Division of Mechanical Engineering,
National Research Council,
Ottawa, Ontario.

AVM J. L. Plant,
Royal Canadian Air Force,
Ottawa, Ontario.

Mr. G. M. Ross,
General Manager,
Air Cadet League of Canada,
Ottawa, Ontario.

Mr. A. G. Sims,
Canadair Limited,
P.O. Box 6087,
Montreal, Que.

Mr. J. M. Manson, Secretary,
Liaison Office,
National Research Council,
Ottawa, Ontario.

During 1954 a number of interested people met to discuss means of preserving items of interest in the growth and development of aviation in Canada. At this meeting it was felt that a National Aviation Museum would be a most effective means of attaining the desired results. It was agreed that steps should be taken to start collecting this material, even before the establishment of a museum, since any delay in starting to collect the items might result in irreparable loss. It was further suggested that, in view of its activity in the field of aviation, the National Research Council should be asked to consider setting up an Associate Committee to take the necessary steps to acquire and safeguard documents, specimens, and other materials of interest in the history of Canadian aviation.

The National Research Council, at its meeting of 12 November 1954, decided that a Committee should be established. The membership of the Committee, as given above, is representative of the organizations in Canada most actively interested in the subject. At the year's end, organization of the Committee had just been completed.

Associate Committee on the National Building Code

Members

Mr. R. F. Legget, Chairman,
Director,
Division of Building Research,
National Research Council,
Ottawa, Ontario.

Maj. L. R. Andrews,
Executive Vice-President,
B.C. Lumber Manufacturers Assoc.,
550 Burrard St.,
Vancouver, B.C.

Mr. D. C. Beam,
Chief Engineer,
Canadian Institute of Steel Construction,
124 Bloor St. W.,
Toronto, Ontario.

Prof. John Bland,
Director,
School of Architecture,
McGill University,
Montreal, Que.

Mr. Raymond Brunet,
c/o E. Brunet and Son,
Contractors,
9 Dumas Street,
Hull, Que.

Mr. Joseph Connolly,
115 Snowdon Ave.,
Toronto, Ont.

Mr. E. A. Cross,
Consulting Engineer,
991 Bay St.,
Toronto, Ontario.

Mr. E. A. Driedger,
Law Branch,
Department of Justice,
Ottawa, Ontario.

Mr. R. G. Johnson,
President,
Defence Construction Limited,
No. 4 Temporary Building,
Ottawa, Ontario.

Col. W. R. McCaffrey*,
General Manager,
Canadian Standards Association,
Ottawa, Ontario.

Mr. J. Y. McCarter,
McCarter and Nairn,
1930 Marine Building,
355 Burrard St.,
Vancouver, B.C.

Mr. G. S. Mooney,
Executive Director,
Canadian Federation of Mayors and Municipalities,
Montreal, Que.

Mr. A. J. C. Paine,
Architect,
Sun Life Building,
Montreal, Que.

Mr. J. G. Schaeffer,
Director, Division of Sanitation,
Department of Public Health,
Regina, Sask.

Mr. W. J. Scott, O.B.E., Q.C.,
Fire Marshal,
210 Huron St.,
Toronto, Ontario.

Mr. P. S. Secord,
Vice-President,
Central Mortgage and Housing Corporation,
Ottawa, Ontario.

Mr. C. A. E. Fowler,
C. A. Fowler and Co.,
Engineers and Architects,
Capitol Building,
Halifax, N.S.

Col. J. H. Jenkins, Chief,
Forest Products Laboratories Division,
Department of Northern Affairs and National Resources,
Ottawa, Ontario.

Mr. G. Lorne Wiggs,
Wiggs, Walford, Frost & Lindsay,
Consulting Engineers,
4350 Sherbrooke St. W.,
Westmount, Que.

* Deceased, 1954.

Associate Committe on the National Building Code—Conc.

Mr. R. S. Ferguson, Secretary,
Division of Building Research,
National Research Council,
Ottawa, Ontario.

Mr. Stewart G. Frost,
Associate Secretary,
Division of Building Research,
National Research Council,
Ottawa, Ontario.

The activities of the Associate Committee on the National Building Code are directed along three lines: first, development of codes of building practice for Canada; second, promotion of uniform building legislation in Canada; third, research work necessary to these ends.

When starting its work in 1948, the Associate Committee decided that it could best accomplish these tasks by revising the existing National Building Code of Canada and by promoting its use throughout Canada.

Associate Committee on Navigation Facilities on the West Coast

Members

Dr. E. W. R. Steacie, Chairman,
President,
National Research Council,
Ottawa, Ontario.

Mr. Maurice Archer,
Vice-Chairman,
National Harbours Board,
Ottawa, Ontario.

Dr. E. R. Birchard,
Vice-President (Administration),
National Research Council,
Ottawa, Ontario.

Mr. F. G. Goodspeed,
Assistant Chief Engineer,
(Retired),
Department of Public Works,
Ottawa, Ontario.

Dr. H. C. Gunning,
Dean of Applied Science,
University of British Columbia,
Vancouver, B.C.

Mr. J. H. Parkin,
Director,
Division of Mechanical Engineering,
National Research Council,
Ottawa, Ontario.

Mr. Norman Wilson,
Assistant Director of Marine Services,
Department of Transport,
Ottawa, Ontario.

Dr. J. B. Marshall, Secretary,
Awards Officer,
National Research Council,
Ottawa, Ontario.

The Associate Committee on Navigation Facilities on the West Coast was established in April, 1953, to facilitate the administration of expenditures anticipated for the engineering investigations required under the terms of reference assigned to an Interdepartmental Committee on Engineering studies of Vancouver Harbour, and other possible improvements to navigation on the Pacific Coast. During 1954-55 the Committee met three times.

Joint Committee on Oceanography

Co-operating Organizations:

National Research Council
Royal Canadian Navy
Hydrographic Service
Defence Research Board
Fisheries Research Board

Members

Dr. F. H. Sanders, Chairman,
Scientific Adviser to C.N.S.
Department of National Defence,
Ottawa, Ontario.

Dr. J. L. Kask,
Chairman,
Fisheries Research Board of Canada,
Ottawa, Ontario.

Fisheries Research Board—*Conc.*

Dr. G. S. Field,
Chief Scientist,
Defence Research Board,
Ottawa, Ontario.

Dr. T. D. Northwood,
Division of Building Research,
National Research Council,
Ottawa, Ontario,

Mr. F. C. G. Smith,
Dominion Hydrographer,
Canadian Hydrographic Service,
Ottawa, Ontario.

Advisers

Dr. J. H. L. Johnstone,
Chairman,
Department of Physics,
Dalhousie University,
Halifax, N.S.

Dr. W. L. Ford, Director,
Scientific Services (Navy),
Department of National Defence,
Ottawa, Ontario.

Dr. W. A. Clemens,
Director,
Institute of Fisheries,
University of British Columbia,
Vancouver, B.C.

Dr. W. W. H. Needler,
Director,
Pacific Biological Station,
Nanaimo, B.C.

Dr. J. L. Hart,
Director,
Atlantic Biological Station,
St. Andrews, N.B.

Dr. W. A. Templeman,
Director,
Newfoundland Fisheries Research Station,
St. John's, Newfoundland.

Dr. H. B. Hachey, Secretary,
Chief Oceanographer,
Fisheries Research Board of Canada,
St. Andrews, N.B.

The Canadian Joint Committee on Oceanography came into existence on 1 April 1946, after two preliminary conferences had explored the need for continuing research on oceanography in the postwar period. The Joint Committee defines policy and controls, through its Chief Oceanographer, the oceanographic investigations carried out by the Atlantic and Pacific Oceanographic Groups located at St. Andrews, N.B. and Nanaimo, B.C. Responsibilities are roughly divided among the member organizations as follows: The Fisheries Research Board furnishes office and laboratory facilities and scientific staff; the Royal Canadidan Navy provides two oceanographic research vessels, as well as facilities on a modern ice breaker for investigations in Arctic waters; the Canadian Hydrographic Service, with several ships, cooperates in taking oceanographic observations; the Naval Laboratories of the Defence Research Board cooperate in various projects with the Oceanographic Groups; and the Defence Research Board and the National Research Council expend considerable effort and funds in furthering the subject of oceanography in Canada.

Joint Committee on the Institute of Parasitology

Members

Dr. D. L. Thomson, Chairman,
Dean of Graduate Studies and Research,
McGill University,
Montreal, Que.

Dr. C. W. Argue,
Dean of Science,
University of New Brunswick,
Fredericton, N.B.

Joint Committee on the Institute of Parasitology—Conc.

Dr. W. H. Brittain,
Vice-Principal,
Macdonald College, Que.

Dr. W. H. Cook,
Director, Division of Applied Biology,
National Research Council,
Ottawa, Ontario.

Dr. E. G. D. Murray,
Head, Department of Bacteriology and Immunology,
McGill University,
Montreal, Que.

Mr. H. Williamson, Secretary,
Assistant to the Director,
Division of Applied Biology,
National Research Council,
Ottawa, Ontario.

Technical Subcommittee

This consists of the Committee members together with:

Mr. J. Gibbard,
Chief, Laboratory of Hygiene,
Department of National Health and Welfare,
Ottawa, Ontario.

Dr. C. A. Mitchell,
Chief, Animal Diseases Research Institute,
Department of Agriculture,
Hull, Que.

The Committee is responsible for the general policy of the Institute, and makes recommendations to the bodies responsible for the operation of the Institute, viz. McGill University and the National Research Council.

Associate Committee on Photographic Research

Members

W/C J. A. E. Schwartz, Chairman,
D/AMTS(D),
Department of National Defence,
Ottawa, Ontario.

Mr. R. D. Davidson,
Army Surveys Establishment,
R.C.E. Militia Stores,
The Driveway,
Ottawa, Ontario.

S/L N. G. Drolet,
DASS/ASP,
Air Force Headquarters,
Ottawa, Ontario.

Mr. P. D. Carman,
Division of Applied Physics,
National Research Council,
Ottawa, Ontario.

Mr. S. G. Gamble,
Topographical Survey,
Department of Mines and Technical Surveys,
No. 8 Building,
Ottawa, Ontario.

Professor K. B. Jackson,
Department of Applied Physics,
University of Toronto,
Toronto, Ontario.

S/L M. W. McLelland,
CAOPS/DASS/S4,
Air Force Headquarters,
Ottawa, Ontario.

Mr. H. E. Seeley,
Forestry Branch,
Department of Resources and Development,
Ottawa, Ontario.

Dr. H. Brown, Secretary,
Division of Applied Physics,
National Research Council,
Ottawa, Ontario.

The Committee coordinates research on photography, especially among the various government agencies. Its interest is in aerial photography, not normal commercial photography.

Prairie Regional Committee

With which are included reports of the Associate Committees on Grain Research, Plant Diseases, Plant Breeding, and Animal Nutrition, and a report on Miscellaneous Grants for Agricultural and Biological Research.

Co-operating Organizations:

National Research Council
Board of Grain Commissioners for Canada
University of Manitoba
Department of Agriculture
University of Alberta
University of Saskatchewan.

Members

Dr. A. G. McCalla, Chairman,
Dean,
Faculty of Agriculture,
University of Alberta,
Edmonton, Alta.

Dr. A. N. Campbell,
Professor of Chemistry,
University of Manitoba,
Winnipeg, Man.

Dr. W. H. Cook,
Director,
Division of Applied Biology,
National Research Council,
Ottawa, Ontario.

Dr. N. H. Grace,
Director,
Research Council of Alberta,
Edmonton, Alta.

Dr. V. E. Graham,
Dean,
College of Agriculture,
University of Saskatchewan,
Saskatoon, Sask.

Dr. T. Johnson,
Officer-in-charge,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Dr. T. Tharvaldson,
Co-ordinator of Research,
Saskatchewan Research Council,
Chemistry Department,
University of Saskatchewan,
Saskatoon, Sask.

Dr. G. A. Ledingham, Secretary,
Director,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

The Prairie Regional Committee, established in 1949 as a Standing Committee of the National Research Council, is composed of the three prairie members of Council and three additional members appointed by Council. The Committee's functions are: (1) to review the work of the Prairie Regional Laboratory, (2) to review the work of the Associate Committee on Grain Research, Plant Breeding, Plant Diseases, and Animal Nutrition, and (3) to consider and make recommendations concerning applications for assisted research grants in the field covered by the above Committees and in the general field of biological and agricultural research in the prairie region.

Associate Committee on Grain Research

Co-operating Organizations:

National Research Council
Board of Grain Commissioners for Canada
University of Manitoba
Department of Agriculture
University of Alberta
University of Saskatchewan.

Members

Dr. A. G. McCalla, Chairman,
Dean,
Faculty of Agriculture,
University of Alberta,
Edmonton, Alta.

Dr. J. A. Anderson,
Chief Chemist,
Board of Grain Commissioners for Canada,
Grain Research Laboratory,
Winnipeg, Man.

Associate Committee on Grain Research—Conc.

Mr. M. J. Conacher,
Board of Grain Commissioners for Canada,
Winnipeg, Man.

Dr. W. H. Cook,
Director,
Division of Applied Biology,
National Research Council,
Ottawa, Ontario.

Dr. B. M. Craig,
Biochemist,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

Dr. D. G. Hamilton,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. T. J. Harrison,
Director,
Barley Improvement Institute,
Winnipeg, Man.

Dr. R. K. Larmour,
Director of Research,
Maple Leaf Milling Co.,
Toronto, Ont.

Dr. W. D. McFarlane,
Director of Research,
Canadian Breweries Ltd. and Victory Mills Ltd.,
307 Fleet St. E.,
Toronto 2, Ont.

Dr. W. O. S. Meredith,
Chemist,
Board of Grain Commissioners for Canada,
Grain Research Laboratory,
Winnipeg, Man.

Dr. A. D. Robinson,
Professor of Chemistry,
University of Manitoba,
Winnipeg, Man.

Dr. C. C. Walden,
B.C. Research Council,
Vancouver, B.C.

Mr. A. G. O. Whiteside,
Senior Cerealist,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. J. C. Woodward,
Chief,
Division of Chemistry,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. H. R. Sallans, Secretary,
Biochemist,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

Ex-officio Members

President,
National Research Council,
Ottawa, Ontario.
(Dr. E. W. R. Steacie).

Chief Commissioner,
Board of Grain Commissioners for Canada,
Winnipeg, Man.
(Mr. D. G. McKenzie).

Chief Grain Inspector,
Board of Grain Commissioners for Canada,
Winnipeg, Man.
(Mr. A. F. Dollery).

Chief Chemist,
Board of Grain Commissioners for Canada,
Grain Research Laboratory,
Winnipeg, Man.
(Dr. J. A. Anderson).

Subcommittee on Hard Red Spring and Durum Wheats

Dr. J. A. Anderson, Chairman,
Chief Chemist,
Board of Grain Commissioners for Canada,
Grain Research Laboratory,
Winnipeg, Man.

Mr. A. W. Alcock,
Chief Chemist,
Purity Flour Mills Ltd.,
Winnipeg, Man.

Subcommittee on Hard Red Spring and Durum Wheats—Conc.

Dr. I. Hlynka,
Board of Grain Commissioners for Canada,
Grain Research Laboratory,
Winnipeg, Man.

Dr. R. K. Larmour,
Director of Research,
Maple Leaf Milling Co.,
Toronto, Ontario.

Dr. A. G. McCalla,
Dean,
Faculty of Agriculture,
University of Alberta,
Edmonton, Alta.

Dr. C. C. Walden,
B.C. Research Council,
Vancouver, B.C.

Dr. G. N. Irvine,
Chemist,
Board of Grain Commissioners for Canada,
Grain Research Laboratory,
Winnipeg, Man.

Mr. A. G. O. Whiteside,
Senior Cerealist,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. T. R. Aitken, Secretary,
Chemist,
Board of Grain Commissioners for Canada,
Grain Research Laboratory,
Winnipeg, Man.

Subcommittee on Oil Seeds

Dr. J. C. Woodward, Chairman,
Chief,
Division of Chemistry,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. B. M. Craig,
Biochemist,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

Mr. D. K. Cunningham,
Assistant Chemist,
Board of Grain Commissioners for Canada,
Grain Research Laboratory,
Winnipeg, Man.

Dr. N. H. Grace,
Director,
Research Council of Alberta,
Edmonton, Alberta.

Mr. A. D. Miller,
Manager,
Vegetable Oil Plant,
Sask. Co-op. Producers Ltd.,
Saskatoon, Sask.

Dr. W. G. McGregor,
Senior Cerealist,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. H. R. Sallans,
Biochemist,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

Dr. T. M. Stevenson,
Chief,
Forage Plants Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. S. Zalik,
Assistant Professor of Plant Physiology and Biochemistry,
University of Alberta,
Edmonton, Alberta.

Mr. R. B. Carson, Secretary,
Chemistry Division,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Subcommittee on Malting Barley

Dr. W. O. S. Meredith, Chairman,
Chemist,
Board of Grain Commissioners for Canada,
Grain Research Laboratory,
Winnipeg, Man.

Mr. P. J. Dax,
Chief Chemist,
Canada Malting Co.,
Montreal, Que.

Subcommittee on Malting Barley—Conc.

Mr. D. S. Kaufman,
Superintendent,
Dominion Malting Co.,
Winnipeg, Man.

Dr. A. G. McCalla,
Dean,
Faculty of Agriculture,
University of Alberta,
Edmonton, Alberta.

Mr. W. E. Stoddart,
Victory Mills Ltd.,
285 Fleet St. E.,
Toronto, Ont.

Mr. V. M. Bendelow, Secretary,
Chemist,
Barley Improvement Institute,
Winnipeg, Man.

Special Subcommittee on
Soft Wheat and Western Winter Wheat

Dr. A. G. McCalla, Chairman,
Dean,
Faculty of Agriculture,
University of Alberta,
Edmonton, Alberta.

Mr. A. W. Alcock,
Chief Chemist,
Purity Flour Mills Ltd.,
Winnipeg, Man.

Dr. R. K. Larmour,
Director of Research,
Maple Leaf Milling Co.,
Toronto, Ontario.

Mr. W. H. Waddell,
Assistant Professor,
Field Husbandry Dept.,
Ontario Agricultural College,
Guelph, Ontario.

Mr. A. G. O. Whiteside, Secretary,
Senior Cerealist,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Associate Committee on Plant Breeding

Co-operating Organizations:

National Research Council
Board of Grain Commissioners for Canada
University of Manitoba
Department of Agriculture
University of Alberta
University of Saskatchewan

Members

Dr. R. F. Peterson, Chairman,
Officer-in-Charge,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Dr. M. N. Grant,
Head,
Laboratory of Cereal Breeding,
Department of Agriculture,
Lethbridge, Alta.

Dr. J. B. Harrington,
Professor and Head,
Department of Field Husbandry,
University of Saskatchewan,
Saskatoon, Sask.

Mr. W. H. Johnston,
Experimental Station,
Department of Agriculture,
Brandon, Man.

Dr. Ruby I. Larson,
Field Crop Insect Laboratory,
Department of Agriculture,
Lethbridge, Alta.

Prof. E. A. Lods,
Associate Professor of Agronomy,
Macdonald College, Que.

Mr. D. S. McBean,
Assistant Cerealist,
Experimental Farm,
Department of Agriculture,
Swift Current, Sask.

Dr. L. H. Shebeski,
Professor of Plant Science,
University of Manitoba,
Winnipeg, Man.

Dr. J. Unrau,
Professor of Plant Science,
University of Alberta,
Edmonton, Alta.

Associate Committee on Plant Breeding—Conc.

Dr. J. R. Weir,
Dean,
College of Agriculture,
University of Manitoba,
Winnipeg, Man.

Dr. L. R. Wetter,
Biochemist,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

Dr. W. J. White,
Officer-in-charge,
Forage Crops Laboratory,
Department of Agriculture,
Saskatoon, Sask.

Dr. B. C. Jenkins, Secretary,
Research Professor,
Department of Plant Science,
University of Manitoba,
Winnipeg, Man.

Ex-officio Members

President,
National Research Council,
Ottawa, Ontario.
(Dr. E. W. R. Steacie).

Director,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.
(Dr. E. S. Hopkins).

Chief,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.
(Dr. C. H. Goulden).

Subcommittee on Common and Durum Wheats

Mr. A. B. Campbell, Chairman,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Dr. M. N. Grant,
Head,
Laboratory of Cereal Breeding,
Department of Agriculture,
Lethbridge, Alta.

Mr. A. A. Guitard,
Experimental Station,
Department of Agriculture,
Beaverlodge, Alta.

Mr. E. A. Hurd,
Experimental Sub-Station,
Department of Agriculture,
Regina, Sask.

Dr. J. B. Harrington,
Professor and Head,
Department of Field Husbandry,
University of Saskatchewan,
Saskatoon, Sask.

Mr. D. S. McBean,
Assistant Cerealist,
Experimental Station,
Department of Agriculture,
Swift Current, Sask.

Mr. A. D. McFadden,
Experimental Station,
Department of Agriculture,
Lacombe, Alta.

Mr. H. McKenzie,
Laboratory of Cereal Breeding,
Department of Agriculture,
Lethbridge, Alta.

Mr. A. B. Masson,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Dr. R. F. Peterson,
Officer-in-Charge,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Dr. J. Unrau,
Professor of Plant Science,
University of Alberta,
Edmonton, Alta.

Miss A. M. Wall,
Experimental Station,
Department of Agriculture,
Lethbridge, Alta.

Subcommittee on Oats

Mr. J. N. Welsh, Chairman,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Mr. H. Ballantyne,
Experimental Station,
Department of Agriculture,
Melfort, Sask.

Mr. R. A. Derick,
Senior Cerealist,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. D. K. Taylor,
Experimental Station,
Department of Agriculture,
Agassiz, B.C.

Dr. D. M. Huntley,
Professor and Head,
Department of Field Husbandry,
Ontario Agricultural College,
Guelph, Ont.

Mr. A. G. Kusch,
Assistant Superintendent,
Experimental Station,
Department of Agriculture,
Scott, Sask.

Dr. J. M. Naylor,
Assistant Professor of Field Husbandry,
University of Saskatchewan,
Saskatoon, Sask.

Subcommittee on Barley

Dr. D. G. Hamilton, Chairman,
Cereal Division,
Experimental Farms Service,
Department of Agriculure,
Ottawa, Ontario.

Mr. R. G. Anderson,
Assistant Professor of Field Husbandry,
University of Saskatchewan,
Saskatoon, Sask.

Dr. L. P. V. Johnson,
Prof. of Genetics and Plant Breeding,
University of Alberta,
Edmonton, Alta.

Mr. W. H. Johnston,
Experimental Station,
Department of Agriculture,
Brandon, Man.

Mr. K. W. Buchannon,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Dr. S. B. Helgason,
Assistant Professor of Plant Science,
University of Manitoba,
Winnipeg, Man.

Mr. H. R. Klinck,
Department of Agronomy,
Macdonald College, Que.

Mr. S. A. Wells,
Experimental Station,
Department of Agriculture,
Lethbridge, Alta.

Subcommittee on Flax and Safflower

Dr. W. G. McGregor, Chairman,
Senior Cerealist,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. W. J. Breakey,
Experimental Station,
Department of Agriculture,
Morden, Man.

Dr. A. E. Hannah,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Dr. B. C. Jenkins,
Research Professor,
Department of Plant Science,
University of Manitoba,
Winnipeg, Man.

Mr. A. L. D. Martin,
Experimental Farm,
Department of Agriculture,
Indian Head, Sask.

Mr. W. E. Smith,
Assistant Professor of Field Crops,
University of Alberta,
Edmonton, Alta.

Subcommittee on Winter Wheat and Rye

Mr. J. E. Andrews, Chairman,
Laboratory of Cereal Breeding,
Department of Agriculture,
Lethbridge, Alta.

Dr. B. C. Jenkins,
Research Professor,
Department of Plant Science,
University of Manitoba,
Winnipeg, Man.

Mr. D. S. McBean,
Assistant Cerealist,
Experimental Station,
Department of Agriculture,
Swift Current, Sask.

Mr. A. D. McFadden,
Experimental Station,
Department of Agriculture,
Lacombe, Alta.

Dr. J. Unrau,
Professor of Plant Science,
University of Alberta,
Edmonton, Alta.

Mr. W. H. Waddell,
Assistant Professor,
Field Husbandry Department,
Ontario Agricultural College,
Guelph, Ontario.

Mr. A. G. O. Whiteside,
Senior Cerealist,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Subcommittee on Plant Introductions and Sources of Breeding Material

Mr. J. G. C. Fraser, Chairman,
Senior Cerealist,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. R. A. Derick,
Senior Cerealist,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. J. B. Harrington,
Professor and Head,
Department of Field Husbandry,
University of Saskatchewan,
Saskatoon, Sask.

Dr. R. F. Peterson,
Officer-in-Charge,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Subcommittee on Plant Breeding Equipment

Dr. C. H. Goulden, Chairman,
Chief,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. R. H. Cunningham,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Mr. H. J. Kemp,
Experimental Station,
Department of Agriculture,
Saanichton, B.C.

Mr. A. G. Kusch,
Assistant Superintendent,
Experimental Station,
Department of Agriculture,
Scott, Sask.

Mr. W. E. Smith,
Assistant Professor of Field Crops,
University of Alberta,
Edmonton, Alta.

Subcommittee on Cytogenetic Research in Cereals and Related Grasses

Dr. Ruby I. Larson, Chairman,
Field Crop Insect Laboratory,
Department of Agriculture,
Lethbridge, Alta.

Dr. T. J. Arnason,
Professor of Biology,
University of Saskatchewan,
Saskatoon, Sask.

Subcommittee on Cytogenetic Research in Cereals and Related Grasses—Conc.

Dr. B. C. Jenkins,
Research Professor,
Department of Plant Science,
University of Manitoba,
Winnipeg, Man.

Mr. J. W. Morrison,
Cereal Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. C. O. Person,
Department of Plant Science,
University of Alberta,
Edmonton, Alta.

Dr. R. F. Peterson,
Officer-in-Charge,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Dr. D. R. Knott,
Assistant Professor of Field Husbandry (Research),
University of Saskatchewan,
Saskatoon, Sask.

Dr. A. Love,
Associate Professor of Botany,
University of Manitoba,
Winnipeg, Man.

Mr. R. C. McGinnis,
Laboratory of Cereal Breeding,
Department of Agriculture,
Winnipeg, Man.

Dr. L. H. Shebeski,
Professor of Plant Science,
University of Manitoba,
Winnipeg, Man.

Dr. J. Unrau,
Professor of Plant Science,
University of Alberta,
Edmonton, Alta.

Mr. W. H. Waddell,
Assistant Professor,
Field Husbandry Department,
Ontario Agricultural College,
Guelph, Ont.

Associate Committee on Plant Diseases

Co-operating Organizations:

National Research Council
Board of Grain Commissioners for Canada
University of Manitoba
Department of Agriculture
University of Alberta
University of Saskatchewan
McGill University

Members

Dr. T. Johnson, Chairman,
Officer-in-Charge,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Dr. W. C. Broadfoot, Director,
Science Service Laboratories,
Department of Agriculture,
Lethbridge, Alta.

Dr. W. J. Cherewick,
Plant Pathologist,
Lab. of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Dr. M. W. Cormack,
Officer-in-Charge,
Laboratory of Plant Pathology,
Department of Agriculture,
Lethbridge, Alta.

Dr. F. J. Greaney,
Director,
Line Elevators Farm Service,
Winnipeg, Man.

Dr. A. W. Henry,
Professor of Plant Pathology,
University of Alberta,
Edmonton, Alta.

Dr. G. A. Ledingham,
Director,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

Dr. J. D. Newton,
Professor of Soils,
University of Alberta,
Edmonton, Alta.

Associate Committee on Plant Diseases—Conc.

Dr. R. C. Russell,
Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Saskatoon, Sask.

Dr. G. B. Sanford,
Officer-in-Charge,
Laboratory of Plant Pathology,
Department of Agriculture,
Edmonton, Alta.

Dr. M. Shaw,
Professor of Plant Physiology,
University of Saskatchewan,
Saskatoon, Sask.

Dr. A. J. Skolko,
Division of Botany and Plant Pathology,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Prof. T. C. Vanterpool,
Professor of Plant Pathology,
University of Saskatchewan,
Saskatoon, Sask.

Dr. A. C. Blackwood, Secretary,
Bacteriologist,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

Ex-officio members

President,
National Research Council,
Ottawa, Ontario.
(Dr. E. W. R. Steacie).

Director,
Science Service,
Department of Agriculture,
Ottawa, Ontario.
(Dr. K. W. Neatby).

Chief,
Division of Botany and Plant Pathology,
Science Service,
Department of Agriculture,
Ottawa, Ontario.
(Dr. W. F. Hanna).

Subcommittee on Antibiotics

Dr. W. A. F. Hagborg, Chairman,
Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Dr. A. C. Blackwood,
Bacteriologist,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

Dr. S. Chinn,
Laboratory of Plant Pathology,
Department of Agriculture,
Saskatoon, Sask.

Dr. A. W. Henry,
Professor of Plant Pathology,
University of Alberta,
Edmonton, Alta.

Dr. A. G. Lochhead,
Chief,
Division of Bacteriology and Dairy Research,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. A. J. Skolko,
Division of Botany and Plant Pathology,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. L. E. Tyner,
Senior Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Edmonton, Alta.

Subcommittee on Varieties and Disease Reaction

Dr. T. Johnson, Chairman,
Officer-in-Charge,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Dr. W. Popp,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Subcommittee on Varieties and Disease Reaction—Conc.

Dr. W. E. Sackston,
Associate Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Dr. W. A. F. Hagborg,
Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Dr. P. M. Simmonds,
Officer-in-Charge,
Laboratory of Plant Pathology,
Department of Agriculture,
Saskatoon, Sask.

Dr. J. T. Slykhuis,
Cereal Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Lethbridge, Alta.

Subcommittee on Soil Microbiology

Dr. N. James, Chairman,
Professor of Microbiology,
University of Manitoba,
Winnipeg, Man.

Dr. A. C. Blackwood,
Bacteriologist,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

Dr. S. Chinn,
Laboratory of Plant Pathology,
Department of Agriculture,
Saskatoon, Sask.

Mr. F. D. Cook,
Experimental Station,
Department of Agriculture,
Swift Current, Sask.

Dr. A. G. Lochhead,
Chief,
Division of Bacteriology and Dairy Research,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. J. D. Newton,
Professor of Soils,
University of Alberta,
Edmonton, Alta.

Subcommittee on Smuts

Dr. R. C. Russell, Chairman,
Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Saskatoon, Sask.

Dr. A. W. Henry,
Professor of Plant Pathology,
University of Alberta,
Edmonton, Alta.

Mr. J. S. Horricks,
Laboratory of Plant Pathology,
Department of Agriculture,
Lethbridge, Alta.

Dr. W. Popp,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Dr. L. E. Tyner,
Senior Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Edmonton, Alta.

Subcommittee on Seed Treatments

Mr. I. L. Conners, Chairman,
Division of Botany and Plant Pathology,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Dr. A. W. Henry,
Professor of Plant Pathology,
University of Alberta,
Edmonton, Alta.

Dr. J. E. Machacek,
Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Dr. R. C. Russell,
Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Saskatoon, Sask.

Subcommittee on Seed Treatments—Conc.

Mr. J. S. Horricks,
Laboratory of Plant Pathology,
Department of Agriculture,
Lethbridge, Alta.

Dr. L. E. Tyner,
Senior Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Edmonton, Alta.

Subcommittee on Root Diseases of Cereals

Mr. H. A. H. Wallace, Chairman,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Mr. R. J. Ledingham,
Associate Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Saskatoon, Sask.

Dr. B. J. Sallans,
Associate Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Saskatoon, Sask.

Dr. J. T. Slykhuis,
Cereal Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Lethbridge, Alta.

Dr. L. E. Tyner,
Senior Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Edmonton, Alta.

Professor T. C. Vanterpool,
Professor of Plant Pathology,
University of Saskatchewan,
Saskatoon, Sask.

Subcommittee on Diseases of Forage Crops

Dr. J. B. Lebeau, Chairman,
Associate Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Edmonton, Alta.

Dr. M. W. Cormack,
Officer-in-Charge,
Laboratory of Plant Pathology,
Department of Agriculture,
Lethbridge, Alta.

Mr. E. J. Hawn,
Science Service Laboratories,
Department of Agriculture,
Lethbridge, Alta.

Dr. H. W. Mead,
Associate Plant Pathologist,
Laboratory of Plant Pathology,
Department of Agriculture,
Saskatoon, Sask.

Mr. W. C. McDonald,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Subcommittee on Plant Physiology

Dr. M. Shaw, Chairman,
Professor of Plant Pathology,
University of Saskatchewan,
Saskatoon, Sask.

Dr. W. G. Corns,
Associate Professor of Crop Ecology,
University of Alberta,
Edmonton, Alta.

Dr. F. R. Forsyth,
Laboratory of Plant Pathology,
Department of Agriculture,
Winnipeg, Man.

Dr. P. K. Isaac,
Botany Department,
University of Manitoba,
Winnipeg, Man.

Dr. D. W. A. Roberts,
Laboratory of Plant Pathology,
Department of Agriculture,
Lethbridge, Alta.

Dr. D. J. Samborski,
Biology Department,
University of Saskatchewan,
Saskatoon, Sask.

Associate Committee on Animal Nutrition

Co-operating Organizations:

National Research Council
University of Alberta
University of Saskatchewan
Ontario Agricultural College
Department of Agriculture
University of Manitoba
Macdonald College, McGill University
University of British Columbia

Members

Dr. V. E. Graham, Chairman,
Dean,
Faculty of Agriculture,
University of Saskatchewan,
Saskatoon, Sask.

Dr. J. M. Bell,
Professor of Animal Husbandry,
University of Saskatchewan,
Saskatoon, Sask.

Dr. H. D. Branion,
Head,
Department of Nutrition,
Ontario Agricultural College,
Guelph, Ont.

Dr. E. W. Crampton,
Professor of Nutrition,
Macdonald College, Que.

Dr. A. R. G. Emslie,
Head,
Animal Chemistry Division,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. H. S. Gutteridge,
Chief,
Poultry Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Prof. G. C. Hodgson,
Associate Professor of
Poultry Husbandry,
University of Manitoba,
Winnipeg, Man.

Dr. R. H. Haskins, Secretary,
Mycologist,
Prairie Regional Laboratory,
National Research Council,
Saskatoon, Sask.

Dr. J. W. Hopkins,
Division of Applied Biology,
National Research Council,
Ottawa, Ontario.

Dr. L. W. McElroy,
Professor of Animal Husbandry,
University of Alberta,
Edmonton, Alta.

Prof. J. B. O'Neil,
Associate Professor of Poultry,
University of Saskatchewan,
Saskatoon, Sask.

Dr. A. R. Robblee,
Associate Professor of Poultry
Husbandry,
University of Alberta,
Edmonton, Alta.

Dr. F. Whiting,
Animal Nutritionist,
Experimental Station,
Department of Agriculture
Lethbridge, Alta.

Dr. A. J. Wood,
Department of Animal Husbandry,
University of British Columbia,
Vancouver, B.C.

Dr. J. C. Woodward,
Chief,
Division of Chemistry,
Science Service,
Department of Agriculture,
Ottawa, Ontario.

Ex-officio Members

President,
National Research Council,
Ottawa, Ontario.
(Dr. E. W. R. Steacie).

Director,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.
(Dr. E. S. Hopkins).

Director,
Science Service,
Department of Agriculture,
Ottawa, Ontario.
(Dr. K. W. Neatby).

Chief,
Animal Husbandry Division,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.
(Dr. K. Rasmussen).

Associate Committee on Publication and Abstracting Services

Members

Dr. H. H. Saunderson, Chairman,
President,
University of Manitoba,
Winnipeg, Man.

Dr. F. J. Alcock,
National Museum of Canada,
Ottawa, Ontario.

Miss M. S. Gill,
Librarian,
National Research Council,
Ottawa, Ontario.

Mr. Paul J. Henderson,
Consolidated Press Ltd.,
73 Richmond Street W.,
Toronto 1, Ontario.

Mr. L. W. J. Hurd,
General Secretary,
Agricultural Institute of Canada,
338 Somerset St. West,
Ottawa, Ontario.

Dr. W. Kaye Lamb,
Dominion Archivist,
National Archives of Canada,
Ottawa, Ontario.

Dr. H. E. MacDermot,
Editor, Canadian Medical Association Journal,
3640 University Street,
Montreal, Que.

Mr. L. F. MacRae,
Defence Research Board,
Ottawa, Ontario.

Dr. Leo Marion,
Director,
Division of Pure Chemistry,
National Research Council,
Ottawa, Ontario.

Dr. Garnet Page,
General Manager,
Chemical Institute of Canada,
18 Rideau Street,
Ottawa, Ontario.

Miss E. R. Carson,
Division of Building Research,
National Research Council,
Ottawa, Ontario.

Mr. R. Eric Crawford,
Maclean-Hunter Publishing Co. Ltd.,
481 University Ave.,
Toronto, Ont.

Dr. A. L. Pritchard,
Department of Fisheries,
Ottawa, Ontario.

Dr. D. C. Rose,
Division of Physics,
National Research Council,
Ottawa, Ontario.

Miss Madeleine Saulter,
Department of Mines and Technical Surveys,
Ottawa, Ontario.

Dr. H. Schwartz,
Forest Products Laboratory,
Department of Northern Affairs and National Resources,
Ottawa, Ontario.

Dr. L. C. Simard,
University of Montreal,
Montreal, Que.

Mr. J. N. Stephenson,
Editor, Pulp and Paper Magazine of Canada,
Gardenvale, Que.

Mr. H. L. Trueman,
Department of Agriculture,
Ottawa, Ontario.

Dr. L. Austin Wright,
Engineering Institute of Canada,
2050 Mansfield St.,
Montreal 2, Que.

Mr. O. C. Young,
Fisheries Research Board,
Ottawa, Ontario.

Mr. J. M. Manson, Secretary,
National Research Council,
Ottawa, Ontario.

The Royal Society Information Conference of 1948 and the UNESCO Conference on Science Abstracting of 1949 studied the problems arising from the rapid increase in the number of scientific articles published each year. The Abstracting Journals are the key to the situation and any means to improve their quality, coverage, and speed of publication will be useful.

The countries associated with UNESCO were asked to study these problems, and at the behest of the Department of External Affairs the National Research Council set up this Associate Committee to study what could be done in Canada to improve speed of publication of scientific and technical papers, to make them more easily available, and to assist abstracting journals in publishing abstracts from Canadian scientific periodicals.

Associate Committee on Radio Science

Members

Dr. D. W. R. McKinley, Chairman,
Radio and Electrical Engineering Division,
National Research Council,
Ottawa, Ontario.

Mr. B. G. Ballard,
Vice-President (Scientific),
National Research Council,
Ottawa, Ontario.

Dr. Pierre Bricout,
40 Golf Avenue,
Pte. Claire,
Montreal 33, Que.

Mr. A. E. Covington,
Radio and Electrical Engineering Division,
National Research Council,
Ottawa, Ontario.

Dr. B. W. Currie,
Physics Department,
University of Saskatchewan,
Saskatoon, Sask.

Mr. F. T. Davies,
Radio Physics Laboratory,
Defence Research Board,
Shirley Bay,
Ottawa, Ontario.

Professor R. C. Dearle,
Physics Department,
University of Western Ontario,
London, Ontario.

Dr. J. T. Henderson,
Physics Division,
National Research Council,
Ottawa, Ontario.

Dr. H. P. Koenig,
Physics Department,
Laval University,
Quebec, Que.

Dr. G. Sinclair,
Electrical Engineering Dept.,
University of Toronto,
Toronto, Ontario.

Dr. J. S. Marshall,
Physics Department,
McGill University,
Montreal, Que.

Dr. Peter M. Millman,
Radio and Electrical Engineering Division,
National Research Council,
Ottawa, Ontario.

Mr. James C. W. Scott,
Defence Research Telecommunications Establishment,
Radio Physics Laboratory,
Shirley Bay,
Ottawa, Ontario.

Professor G. A. Woonton,
Eaton Electronics Research Lab.,
McGill University,
Montreal, Que.

Mrs. J. M. Ann Marshall, Secretary,
Radio and Electrical Engineering Division,
National Research Council,
Ottawa, Ontario.

The Associate Committee on Radio Science was established in 1950 to further research in Canada in radio science and to act as the Canadian National Committee of Union Radio Scientifique Internationale (U.R.S.I.)

Associate Committee on St. Lawrence River Model Studies

Members

C. W. West, Chairman,
Member, St. Lawrence Seaway Authority.

Members ex-officio:

R. A. C. Henry,
Consulting Engineer.

General A. G. L. McNaughton,
Chairman, Canadian Section, International Joint Commission.

Members:

T. M. Patterson,
International Waterways Section, Department of Northern Affairs and National Resources.

Dr. Otto Holden,
Hydro-Electric Power Commission of Ontario.

Mr. R. Dupuis,
Quebec Hydro Electric Power Commission.

Mr. J. H. Parkin,
Director, Division of Mechanical Engineering,
National Research Council.

Mr. D. M. Ripley,
St. Lawrence Seaway Authority.

Mr. H. W. Lea,
St. Lawrence River Joint Board of Engineers—Canadian Section.

Mr. E. R. Peterson,
International Joint Commission.

Mr. E. S. Turner,
National Research Council, Secretary.

This Committee was set up at the request of the St. Lawrence Seaway Authority.

Three meetings of the Committee were held during the year. The design requirements of a model of the Prescott-Cardinal reach were decided upon and arrangements made for its construction and operation. A testing program for a model of the Cornwall Island reach was approved.

Associate Committee on Soil and Snow Mechanics

Members

Mr. R. F. Legget, Chairman,
Director,
Division of Building Research,
National Research Council,
Ottawa, Ontario.

Mr. G. J. Klein,
Division of Mechanical Engineering,
National Research Council,
Ottawa, Ontario.

Lt. Col. Scott Lynn,
Directorate of Engineer Development,
Department of National Defence,
Ottawa, Ontario.

Mr. J. O. Martineau,
Quebec Department of Roads,
Quebec, P.Q.

Dr. N. W. Radforth,
Professor of Botany,
Department of Biology,
McMaster University,
Hamilton, Ontario.

Dr. P. O. Ripley,
Experimental Farms Service,
Department of Agriculture,
Ottawa, Ontario.

Mr. G. W. Rowley,
Arctic Research Section,
Defence Research Board,
Department of National Defence,
Ottawa, Ontario.

W/C C. V. Trites,
Director of Construction, Engineering and Design,
Royal Canadian Air Force,
Ottawa, Ontario.

Associate Committee on Soil and Snow Mechanics—Conc.

Mr. Graham Potter,
Meteorological Division,
Department of Transport,
Toronto, Ontario.

Mr. J. Walter,
Ontario Department of Highways,
Parliament Buildings,
Toronto, Ontario.

Dr. J. T. Wilson,
Department of Geophysics,
University of Toronto,
Toronto, Ontario.

Dr. V. K. Prest,
Geological Survey of Canada,
Victoria Museum,
Ottawa, Ontario.

Mr. George Jacobsen,
President,
Tower Company Limited,
1509 Mackay Street,
Montreal, Que.

Dr. Svenn Orvig,
Director, Montreal Office,
Arctic Institute of North America,
3485 University Street,
Montreal, Que.

Col. R. L. Franklin,
Director,
Directorate of Vehicle Development,
Department of National Defence,
Ottawa, Ontario.

Mr. N. D. Lea,
Assistant to the Vice-President,
Foundation of Canada Engineering Corp., Ltd.,
200 Bloor Street, E.,
Toronto, Ontario.

Mr. R. Peterson,
Prairie Farm Rehabilitation Administration,
505 Canada Building,
Saskatoon, Sask.

Mr. J. L. Wickwire,
Chief Engineer,
Department of Highways,
Halifax, N.S.

Mr. W. J. Eden, Secretary,
Division of Building Research,
National Research Council,
Ottawa, Ontario.

The Associate Committee on Soil and Snow Mechanics was initiated in 1945 to study military track problems. After the war the Associate Committee became a co-ordinating body for research on various aspects of the terrain of Canada. The Committee's activities are now centred in four major fields: soil mechanics, snow and ice research, muskeg, and permafrost. Four subcommittees have been set up, each dealing with one of these particular fields. A fifth subcommittee, closely allied to the Soil Mechanics Subcommittee, deals with problems relating to Canadian landslides.

Associate Committee on Survey Research

Members

Mr. R. H. Field, Chairman,
Division of Physics,
National Research Council,
Ottawa, Ontario.

S/L L. R. Pattee,
Royal Canadian Air Force,
Department of National Defence,
Ottawa, Ontario.

Mr. W. H. Miller,
Surveys and Mapping Bureau,
Department of Mines and Technical Surveys,
Ottawa, Ontario.

Mr. G. W. Rowley,
Defence Research Board,
Department of National Defence,
Ottawa, Ontario.

Lieut.-Col. C. H. Smith,
Army Survey Establishment, R.C.E.,
Department of National Defence,
Ottawa, Ontario.

Dr. L. G. Turnbull, Secretary,
Division of Physics,
National Research Council,
Ottawa, Ontario.

Subcommittee on Shoran Research

Mr. J. E. R. Ross, Chairman,
Geodetic Survey of Canada,
Department of Mines and
Technical Surveys,
Ottawa, Ontario.

F/L L. C. Card,
Royal Canadian Air Force,
Department of National Defence,
Ottawa, Ontario.

Mr. H. R. Smyth,
Division of Radio and
Electrical Engineering,
National Research Council,
Ottawa, Ontario.

Lieut.-Col. J. I. Thompson,
Secretary,
Army Survey Establishment,
R.C.E.,
Department of National Defence,
Ottawa, Ontario.

Subcommittee on Radio-Altimetry Research

Mr. R. Thistlethwaite, Chairman,
Legal Surveys,
Dept. of Mines and Technical
Surveys,
Ottawa, Ontario.

Mr. R. D. Davidson,
Army Survey Estab., R.C.E.,
Dept. of National Defence,
Ottawa, Ontario.

S/L J. A. Duncan,
Royal Canadian Air Force,
Dept. of National Defence,
Ottawa, Ontario.

Mr. G. S. Levy,
Flight Research Section,
Division of Mechanical
Engineering,
National Research Council,
Ottawa, Ontario.

Mr. M. J. Neale,
Division of Radio and Eletcrical
Engineering,
National Research Council,
Ottawa, Ontario.

Mr. S. Jowitt, Secretary,
Dept. of Mines and Tech. Surveys
Ottawa, Ontario.

Subcommittee on Plotting Methods

Mr. R. D. Davidson, Chairman,
Army Survey Estab., R.C.E.,
Dept. of National Defence,
Ottawa, Ontario.

Mr. T. J. Blachut,
Division of Physics,
National Research Council,
Ottawa, Ontario.

Mr. J. Carroll,
Topographical Survey,
Dept. of Mines and Tech. Surveys,
Ottawa, Ontario.

S/L N. G. Drolet,
Royal Canadian Air Force,
Dept. of National Defence,
Ottawa, Ontario.

Mr. S. G. Gamble,
Topographical Survey,
Dept. of Mines and Tech. Surveys,
Ottawa, Ontario.

Lieut.-Col. J. I. Thompson,
Army Survey Estab., R.C.E.,
Ottawa, Ontario.

Dr. L. G. Turnbull, Secretary,
Division of Physics,
National Research Council,
Ottawa, Ontario.

The function of the Committee is to coordinate work on new developments in survey methods.

Associate Committee on Wildlife Research

Mr. W. W. Mair, Chairman,
Chief, Canadian Wildlife Service,
Dept. of Northern Affairs and National Resources,
Ottawa, Ontario.

Dr. A. W. F. Banfield,
Chief Mammalogist,
Canadian Wildlife Service,
Dept. of Northern Affairs and National Resources,
Ottawa, Ontario.

Dr. R. Bernard,
Department of Biology,
Laval University,
Quebec, Que.

Mr. W. E. Godfrey,
Zoologist, Biological Division,
National Museum of Canada,
Ottawa, Ontario.

Dr. J. A. McLeod,
Department of Zoology,
University of Manitoba,
Winnipeg, Man.

Ex-officio member:
Dr. C. W. Argue,
Dean, Faculty of Science,
University of New Brunswick.
Fredericton, N. B.

Dr. L. Butler,
Department of Zoology,
University of Toronto,
Toronto, Ontario.

Prof. L. P. Chiasson,
Head, Department of Biology,
St. Francis Xavier University,
Antigonish, N. S.

Dr. I. McT. Cowan,
Head, Department of Zoology,
University of British Columbia,
Vancouver, B.C.

Mr. D. A. Munro,
Chief Ornithologist,
Canadian Wildlife Service,
Dept. of Northern Affairs and National Resources,
Ottawa, Ontario.

Mr. H. Williamson, Secretary,
Division of Applied Biology,
National Research Council,
Ottawa, Ontario.

The Associate Committee on Wildlife Research was formed in 1948 to provide the National Research Council with an informed body of opinion on matters in the wildlife field, and to aid Council in stimulaitng research in this field by recommending the best allocation of grants for this purpose.

The WITNESS: All I wanted to say was that I think that it is quite important with these committees that one does not try to line up a committee unless there is a clear job for it to do. We have had a lot of these committees when the necessity arose. A very good example is the petroleum committee which is now dead.

In Canada one oil company is doing research. The other oil companies are dependent upon research done by their associates; so under those circumstances there is no particular research co-ordination needed. During the war the question of petroleum specifications became very important because each of the various services was specifying different brands of grease, for example, and this cluttered everything up. So a committee was set up for industry and the armed forces to get together in order to establish petroleum specifications, and I think their work was very successful. At the end of the war it tottered on for a year or two, and then it became obvious that as a result of war-time experience the services no longer needed it, so it was disbanded at its own request.

I might say one further thing; that these committees are operated in such a way that they may have funds at their disposal. Some committees have no funds because they do not need them. But in other cases it is necessary to pay travel expenses and the committee may be given a small budget for travel. In other cases, in order to get the work stimulated in a certain field the committee may be given a limited sum of money to dispense as grants in aid to universities or elsewhere; and in some cases the committees have been given an amount as high as $50,000 a year. In general the principle has been that once a committee has stimulated research by means of grants and got the thing going, the council has felt that it was better to have the grant-giving power back in the normal channels and to let the committee carry on in an advisory way. So these committees have a very wide variety of functions. They cover everything from a committee set up for the purpose of attempting to collect material and funds to establish an aviation museum in Canada, to committees which are strictly grant giving bodies, established especially for the purpose of giving grants in aid; the prairie regional committee is an example of one of them.

I think this has been a very useful mechanism and I think we owe a great deal to the 500 or 600 people who have given their services for this purpose.

By Mr. Coldwell:

Q. How many of these committees are grants in aid committees?—A. We have been reducing them and at the present time there would be about five. The general thing has been to set the committee up and spark some interest in a given field. For example, corrosion was one. It was felt that there was very little work in corrosion in Canada and the committee was set up and given funds. This committee sponsored work in half a dozen universities, got the professors interested in it and got quite a volume of work going. At this stage it was felt that it no longer needed to do this, but it also felt that it might go ahead about the work of composing panel tests out of doors at various places. The committee is now essentially composed of industrial people.

Mr. MURPHY (*Lambton West*): I have a few questions.

The CHAIRMAN: Dr. Steacie is now finished with his general remarks and is available for questions by any member of the committee. If you wish I will call your names for the benefit of the reporter.

By Mr. Murphy (Lambton West):

Q. I think I should make it plain to Dr. Steacie that any questions which I have I do not wish to be construed as being embarrassing because I have every confidence in the National Research Council and the work you have done; but some of my questions might seem embarrassing although they are not intended that way. The first question I would like to ask is: you have on your honorary advisory council seventeen members and of the seventeen, as I understand it, sixteen of them are scientists or professors, or university men.—A. No. Fifteen.

Q. You have one industrialist and one labour man?—A. Yes.

Q. When you made the statement my concern was that industry should, somehow or other, be better represented in the council. Could you give us some reason for the set-up as at present?—A. Yes. I think the question is one that obviously should be answered. What happens is this: we have now had quite a bit of experience with council members. The council member is not of much use to us unless he will attend the full meetings of the council which means 15 or 20 days a year.

By the Chairman:

Q. 15 or 20 working days?—A. Yes. In which case he really knows the operation. We have discovered, over a period, that in general the industrialist who is not an industrial research director, is not too interested and will tend not to attend very regularly. At the same time in the council it is vital to have coverage of universities for the grant programs. At the present time Dr. Jane is president of Shawinigan Chemicals but he came up through the research route and has attended very regularly and has been a great strength to us. We have found, Mr. Chairman, that it is better if we can keep the council for scientific review of staff, work and policy, and make it as strong as possible from a strickly scientific point of view, and then get some industrial advice by appointing industrial members to our review subcommittees for each division; for example, the chemistry division is reviewed by a committee which over the year has had members from most of the chemical industry on it. There are 500-odd members on the associated committees. That is one method by which we get advice from the industries, and in fact we feel that we get better results by having the council aimed at picking the leading scientific people and getting industrial relations established through, first, working arrangements, since all our people have very intimate relationships with the industry, and, second, through the review committees, and, third, through the associate committees.

By Mr. Murphy (Lambton West):

Q. You mentioned that it is so difficult to get them to take continuous part as members of the advisory board and I suppose one reason for that is that so many of the industries in this country are subsidiaries of foreign corporations and they rely on foreign corporations for their research work. Would that be one reason why they lack the interest?—A. Of course it is only relatively recently that there has been any large research effort on the part of Canadian companies. There have always been a few spectacular exceptions. However, this is growing and I think that there is no question but that industrial research is developing very rapidly. As far as the pulp and paper industry is concerned, we have always had very intimate relations with the Pulp and Paper Institute in Montreal and I think through this we have kept in quite close touch with the industry.

Q. Doctor, there are two or three more questions which I would like to ask and then I will give way to some other member. The next question is in respect to grants to universities and scholarships. I wonder, Mr. Chairman, if we could have on the record the grants for scholarships and to universities over the last five years or something like that?—A. Surely.

The CHAIRMAN: We could have that tabulated and put in evidence by the witness on that subject when he is here.

By Mr. Murphy (Lambton West):

Q. That will be satisfactory.—A. Would you like this by the federal government as a whole of by the National Research Council, or both?

Q. I think it would be better to have both.—A. It is essential to take grants and scholarships together. I think they mean the same thing.

Q. You mean the grants to universities?—A. Yes.

Q. I would like to see them separated?—A. When we give a grant to a university man, he employs, very frequently, graduate students under that grant, and of the number of graduate students which we support in the universities twice as many are supported through grants than through scholarships. If you take the scholarship alone it gives a false impression.

Q. You mean for those going through university?—A. Yes.

Q. Take them separate, and then take the grants to the university separate. Would that be all right?—A. We only give grants to people; we do not give grants to universities. The direct grants that are given by the federal government do not come through us. Our grants are either to a university professor—

Q. Professor scholarships?—A. No. It would be a grant to a professor which would not pay him anything but would be for his work and he would presumably spend part of it on equipment and part of it on the support of graduate students.

By Mr. Coldwell:

Q. Would that be paid through the National Research Council?—A. The money for the grant would go to the university and would be deposited with the university, sir, and the only restriction is that if he wants to hire a man he has to satisfy the council (*a*) that the man is qualified and (*b*) that the salary scale is in agreement with the one which we have laid-down; but he has freedom to hire whom he likes. The scholarships which we grant are on a merit basis.

Q. You also give scholarships to some of your own staff?—A. That is very minor and does not come in these figures. We would call that our own operating expenses.

The thing I meant, Mr. Murphy, was that if you wanted the figures and if you take grants and scholarships together I can give you the total now.

By Mr. Murphy (Lambton West):

Q. Over five years or something like that?—A. Yes.

Q. That would be all right, Mr. Chairman.—A. Or we can bring in full tables later.

The CHAIRMAN: We will be devoting a meeting to this and perhaps we could get it better at that time which ever you wish.

By Mr. Murphy (Lambton West):

Q. That suits me all right. I have two other questions and then I will give way. You mentioned, Doctor, something which interested me. You mentioned research and construction, and your codes, and then the code for fire. You mentioned the numerous fires which have taken place. Will that affect municipal codes? For instance, would it apply to defective wiring, or heavy loading by the extra equipment that is in households which is apt to start fires?—A. I would say there are two separate things. One is our own research on the subject; the other is the proposed code. We have only gone so far as to set up a committee with representatives from the interested parties, including manufacturers of materials and everything else, municipalities, fire marshals, and so forth. Their terms are to look into the question and see if a national fire code would be a good idea. In other words, this is just in the formative stages. If this goes like the building code, it has to be a very cautious process; it must be. You cannot get into a field like this and make regulations offhand effecting an industry like the construction industry. It would effect too many people and there is the practical side of it to consider as to what you should do and how much it would cost. So all we are really proposing to do is to look into the question as to whether there is something which can be done. We are also doing work of our own in fire research. We have been trying to obtain information as to why fires start, what causes loss of life, or what is the main cause. We have a truck which is equipped. The head of the section is an honorary fire marshall and he visits all second-degree fires in the Ottawa area, or if possible all fatal fires in Ontario. I think that quite a lot of useful work can be done by inspection. He is getting very good cooperation and he has been welcomed very heartily by all municipalities and fire chiefs and fire marshals. What we are proposing to do when we get the work set up is to get into the investigation of certain of these things which involve the obvious question of fire resistance and various things of that sort. I want to emphasize that there are two things.

We are at the present moment doing some research because we think this is a thing of great importance. The other is that we are proposing to get together the widest possible group of interested parties to see if there is anything we could do that would be an improvement in the code.

Q. You have been connected with research into construction for four or five years?—A. Yes.

Q. Have the results been satisfactory in that they have reduced the cost of construction?—A. I think the results have been very satisfactory in that what we have done has been very highly commended by both the contractors and by all those such as Central Mortgage and Housing Corporation who are attempting to get prices down. The whole field is, of course, a complex one. I think no one is going to suggest you can make a discovery overnight that is going to provide you with a house for half price but what I think you can do is investigate new materials, types of foundations and proposed constructions and to my mind it is a gradual process of trying to see if we can improve efficiency and improve materials but I think it is bound to be a very slow process.

Mr. MURPHY *(Lambton West):*

I have a lot more questions to ask but I would like to give way for a while.

By Mr. Hosking:

Q. Have you kept any track of what is happening to the students to whom you have given grants as scholarships?—A. Yes.

Q. Do we lose many of them to countries outside Canada? What is the migration rate?—A. I have some figures, some notes that I have scribbled down. There is one thing on this that I think we should not overlook and that is that the loss of graduate students to the United States during the 'thirties and 'twenties was in one sense a God-send because it enabled our universities to build up graduate schools and turn out science schools at a rate faster than we could absorb them and when the war came along we were left with production facilities much greater than we would have otherwise had. So I think the early loss was something that was not all together unfortunate. We were the exporter; our production facilities were larger than would otherwise have been.

What has been happening is, I think, on the whole encouraging. We are in a position where we are next to the most highly industrialized country in the world. There is always going to be a move of technical people from less highly industrialized areas to more highly industrialized areas and I think the Maritime areas will agree that there is a move from the Maritimes to central Canada and has always been. I think you cannot deny this. Then there are opportunities in the United States that do not exist in this country, so I think what we have to do is to try to make as many opportunities as we can for the Canadian and at the same time as long as the trend is all right not to be discouraged by it. There is bound to be quite a move. At the same time we are up against a salary problem and you cannot make the standard of living for Canada for scientists equal to that of the United States if you do not do it for everybody else, and salary levels are higher in the United States. I think that if one looks at the figures, considering everything, the position is not too bad. One question we can take very directly is to what extent has the National Research Council lost people to the United States. We rather encourage a turnover of people especially if they go to Canadian industry of to Canadian universities. We do not call that a loss. The result of this is, on the average, from 1951 to 1956 we had an average total scientific staff of 438 and an average yearly number of terminations of 40 or about 8 per cent per annum which I think is a reasonable thing considering we are taking in younger people. training them and sending them out.

Of those who accepted employment in the United States—the average—was between 5·8 per annum, but only 3·8 of this number were Canadian citizens. The other two were people who had taken employment with us, coming largely from Britain and then moved to the United States. With regard to Canadians accepting employment in the United States our loss was ·9 of one per cent per annum which means that the effect over a five year period is simply negligible and practically none of those people were senior. So I think as far as the council is concerned we have not lost badly.

On the general problem I have one interesting set of figures which are Ph.D's from McGill. McGill has produced over 500 Ph.D's in chemistry since 1920, which is probably about half or a third of all the Ph.D's produced in Canada in all subjects, and they have followed up their movements to such a degre that they have kept personal contact with them. Over this period 31 per cent of their Ph.D's went to the United States. The worst period was between 1923 and 1939 which was the tail end of the depression and scientifically we were not as highly developed. We were producing Ph.D's at a high rate because the depression really increased the number of degrees by increasing registrations at the time when people could not get jobs. Those figures were very high but there has been a steep decline and in 1954, 27 per cent went; in 1955, 18 per cent and there is no doubt the trend has been downward since the war. I think it is not too bad, but I do not mean it would not be nice if we could keep these people at home.

Another way of looking at it is to take the fate of the various graduates, and we found that of everybody who got a Ph.D. in Canada in 1953, 67 per cent found employment in Canada and 12 per cent in the United States. The other 21 per cent were continuing their studies.

Q. Have you the McGill figure for the years 1933-1939?—A. It runs up to 50 per cent but at that time there was very little Canadian industrial research and a lot of people being turned out and the answer is that there were just no jobs in Canada.

Q. Have you any study of what would happen if the American changed their conscription policy so that these young graduates would not be liable for call-up as soon as they went there? What would the effect be then?—A. That is a difficult question. There is the other one: what would happen if the British changed their approach to National Service? It would cut down the number of immigrants to this country who are British engineers and scientists. At the present time it looks as though our gains through immigration are very much higher than our loss by emigration of engineers and scientists to the United States.

Q. Is that a good thing?—A. I would like to see more Canadians stay at home but at the same time I think what is needed is suitable jobs. I do not think it is all a question of salary by any means, and in many cases I do not think the record is too bad.

Another survey is from McMaster. Of 145 B.Sc's in chemistry in 1940-1954 they found 11 per cent in the United States and the rest in Canada, and of the 11 per cent one came from the United States to get his degree and went back, one was a girl who married an American citizen and four were in the United States studying at universities and would presumably come back. They concluded that only 7 per cent had gone permanently to the United States over the 14 years.

I think myself there are two features, one of which is the salary situation. I think we are losing very few pepole because of it. It is a question of whether you have a real professional opportunity in Canada. To my mind, if a man has a real professional opportunity in the specific field he wants, he will stay.

What is becoming serious, as far as we are concerned, that is as far as National Research Council is concerned, is that the industrial salaries for engineers and scientists are beginning to rise very rapidly. There are signs that the industrial salaries are beginning to approach those in the United States, in some fields. While I think this may end up by holding some people in Canada, I do not think it will have a very big effect. To my mind it is the kind of job that is available that is important. I do think it is going to make it a little difficult to keep pace with such a salary scale because the rise has been very rapid.

By Mr. Hosking:

Q. Changing the subject now, Doctor, I would like to ask one other question. Have you done any research with regard to using animal fats, since the drop in the use of soap has decreased the value of these animal fats? Have you done any research along the lines of developing them into a suitable spread to replace margarine? —A. I am afraid I cannot answer that. I would have to inquire about it.

Q. You do not know whether it has ever been thought of or not?—A. No, I am afraid I cannot answer that.

The CHAIRMAN: Mr. Weaver?

By Mr. Weaver:

Q. Dr. Steacie, you touched upon the relationship between the council and the departments of government that have research branches of their own, such as the Department of National Health and Welfare, and the Department of Mines and Technical Surveys. I was wondering if you would elaborate on that relationship. For instance, industry apparently comes directly to you, whereas the mining industry as distinct from general industry would come through Mines and Technical Surveys. I was wondering if you would elaborate on that relationship? Industry, apparently, comes directly to you, whereas the mining industry, as distinct from general industry, would come through the Department of Mines and Technical Surveys.—A. The general position of the Research Council is this: the primary industries that are engaged in research, and were established, of course, long before the second war, got going in regard to agriculture, mining, fisheries, and in forestry. These were set up and in operation long before we came into the picture at all. We came in first of all, to cover the interest of secondary interest, secondly to support universities, and thirdly with a sort of residual function. In other words, if it is not the duty of anybody else, it is ours. That is pretty well the situation.

We have worked out, with very close cooperation, our relations with the various other departments. There are border-line fields in some cases. We are in the field of utilization of agricultural materials, but not in the field of agriculture. We are into certain phases of metallurgy, as is the Bureau of Mines; but there is no overlap, because the phase we are in is essentially chemical and so on. So that the position has been pretty closely established as to whose duty is what.

Q. Who would initiate your research in these fields that you are in? For instance, would the Department of Agriculture ask you to supplement their research?—A. In general this would be done either way. That is, if there was a border-line field concerning agriculture they might ask us to get into it. On the other hand, we might suggest to them that we thought we should get into it, and ask them if they mind.

Actually what is really done is,—and I think you will find it true in most cases,—that the real discussion is at a technical level by the people doing the work, and this is where the real cooperation is reached.

By Mr. Coldwell:

Q. A moment ago you were speaking about animal fats and the utilization of agricultural products. The question I think was along the line of the manufacturing of margarine. You have done some work, though, in vegetable oils. For instance, the utilization of rape seed for edible purposes, which was impossible at one time.—A. We have done a lot in that field, but it is not a subject of which I know anything.

By Mr. Stewart (Winnipeg North):

Q. Mr. Chairman, a while ago Mr. Murphy asked Dr. Steacie a question about the influence of the research done by the council on building costs. I can testify from my own experience that it has been very useful.

A few years ago, after having been flooded out twice, I decided to build a house in Winnipeg. I phoned up the National Research Council and asked them for whatever details they could give me in regard to building materials that should be used in Winnipeg. They gave me voluminous details, and I accepted their suggestions, with very successful results.

The most important thing done was the research that was done in regard to an efficient kitchen. Most builders in this country cannot build an efficient working space for housewives to work in. The National Research Council went into this field, and I would hope that that information might be conveyed to those who want to use it.

As I said, I can testify personally to the value of the Council on these matters. What I wanted to ask Dr. Steacie is along another line. Are all the employees of the Council screened before they are taken on the staff?—A. I think the answer to that is no.

Q. Have you got any screening in these certain sensitive areas?—A. We have. It is rather decreasing. A great many of the people are screened, but the so-called sensitive areas are decreasing strongly because we are now concerned with only one or two aspects of defence that is to say, certain phases of aeronautics, and certain phases of electronics. In general, as far as permanent staff are concerned, they are screened, but not in every case.

Would it be possible to have an application form for employment tabled at some later meeting?—A. Certainly.

Q. One other question that brings up another subject which was asked about earlier, and that was the effect of increasing salaries in this country in industry. How is it affecting the Research Council; do you find you are losing many men to industry?—A. One of the most important things from the recruiting standpoint is the starting salary for a man with a Ph.D., and also for a man with a bachelor's degree, but the man with a Ph.D. particularly. What happens, of course, is that there is a continual process of adjustment as these salaries are rising. What we try to do is to keep within reasonable touch with industry.

I think we have certain advantages in the way of freedom as far as the type of work is concerned, and other fringe benefits, if you like. It means that there may be a slight differential.

Generally what happens is, the salary is adjusted, then it begins to rise, and there is a certain amount of time lag during which we fall behind, and then it is adjusted again. We have just gone through such an adjustment within the last two weeks. This, I think puts things back into a very reasonable position. I think what is needed is a process of steady adjustment.

Q. What is your starting salary, let us say for a Ph.D.? On the average I suppose it will differ?—A. At the present time it is $5,500.

Q. And what about a B.Sc.?—A. A B.Sc.; off-hand I would rather have that asked of Dr. Rosser.

Q. We can ask that question later. That is all I wanted to ask at this point.

By Mr. MacLean:

Q. I just thought the committee would perhaps like a little further information with regard to grants to universities, how they are applied, what conditions they are given under, and for what sort of work they are given.—A. The general policy is: one of our functions is to do what we can to promote research in Canada, apart from performing it. In general our attitude is that it is up to us, with regard to universities to back any good scientific research where we find it. For that reason there is no consideration given as to the project, other than whether it is good or not. That is to say, we are not engaged, in the universities, in trying to bribe the university people into doing work we want them to do. We encourage and support them in the work that they themselves want to do. In rare cases we may hire a university man as a consultant to do a job. That is a contract; it is not a grant. It would come out of our laboratory operating expenses. When we give a grant we are not concerned with whether a man is doing something we are interested in. We are simply concerned with whether he is doing good research.

Q. Generally speaking this research should be pure science rather than applied science?—A. It would be pure science rather than applied science in most cases. We are however very anxious to do anything we can to stimulate research in engineering, but at the present time there is not a great deal of engineering research in universities. We would like to support more.

Q. I am under the assumption that during the war the universities did quite a bit of research for the council and for various other bodies funnelled through the council, on contract. Does that exist any longer?—A. No, it no longer exists.

By Mr. Byrne:

Q. In regard to the research idea on the modification of noises, has the instrument you mentioned any application whatever to pneumatic machines such as drills?—A. As an entire amateur I would say it has not. On the other hand, it might be very well worth discussing with the acoustics people that problem of pneumatic drill.

By Mr. Green:

Q. We hear quite a lot about there being an over-all shortage of scientists and engineers, if not at the present time, at least for the years immediately ahead. Could you tell us whether or not you think that is the actual situation and, if so, have you any suggestions as to what could be done?—A. To answer it in a word or two, I think there is a shortage at the moment, that this shortage is about one that one would expect in a period of prosperity where all the skills are short; but that there are signs that, if nothing happens the shortage would become very serious in a few years. At the same time there are signs of a very great influx of university students and I think the two will balance each other. The new increased registration will provide the people needed. To me the whole question of scientific manpower boils down to the question whether the universities can be put in a position to take care of this influx of students. I think it is as simple as that.

Mr. GREEN: Will there be a need for a larger percentage to go into science and engineering than has been the case latterly?

The CHAIRMAN: I do not wish to cut you off, but earlier in the proceedings this afternoon we agreed that the whole matter of the universities, the grants in aid and scholarships would be dealt with at one meeting. I wonder if your question, which is a pretty large and important one, could be left to be dealt with at that meeting.

Mr. GREEN: That is the only question I have to ask.

The CHAIRMAN: I have no objection to it being answered, but it seems to me it is a pretty big question.

Mr. COLDWELL: We are going to discuss the whole thing at another meeting.

The CHAIRMAN: We will discuss it at a later date. If you wish to go ahead, I am quite agreeable, but I think the consensus of the meeting earlier was that we try to discuss that matter, which is an important one, at another meeting.

Mr. GREEN: It is really broader than just the question of grants to universities: it is a question whether, in the national set-up there is a need for a larger percentage of scientists and engineers.

The CHAIRMAN: That is precisely the point. It involves what there is now and whether there should be a larger percentage. We can have it dealt with now, if the meeting wishes.

By Mr. Byrne:

Q. There is a question I have on something which has been discussed. It is on the question of migration. We gain in immigrants from Britain and we lose to the United States. Do we gain any from the United States? Is there an appreciable migration from the United States?—A. We have been trying to get the figure but unfortunately have not got it. As regards the figure of migration of engineers from the United States to Canada, I am under the impression it is considerable, because of the Alberta oil fields and so on which involve quite an influx of Americans. I think there is at present quite a big influx of Americans.

The CHAIRMAN: If you agree to terminate the questioning now, I have three other matters to raise. It is understood now that the next meeting will be on Friday afternoon at 3.00 p.m., when Mr. Steacie will be here again. Furthermore, we have copies here now of the "National Research Council Review for 1955" and also of a book entitled "National Research Council of Canada, Organization and Activities, 1956". If it is your wish we will have copies of both these publications marked as filed and distributed to each member of the committee.

Agreed.

HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 2

NATIONAL RESEARCH COUNCIL

FRIDAY, MAY 4, 1956

WITNESSES:

Dr. E. W. R. Steacie, President, National Research Council; Dr. E. R. Birchard, Vice-President (Administration); Dr. F. T. Rosser, Director of Administration.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956

74002—1

SPECIAL COMMITTEE ON RESEARCH

Chairman: G. J. McIlraith, Esq.

and

Messrs.

Bourget	Low
Brooks	MacLean
Byrne	Murphy (*Lambton West*)
Coldwell	*Power (*St. John's West*)
Dickey	Richardson
Forgie	Stewart (*Winnipeg North*)
Green	Stuart (*Charlotte*)
Hardie	Weaver
Harrison	
Hosking	
Leduc (*Verdun*)	

(Quorum 11)

J. E. O'Connor,
Clerk of the Committee.

*Replaced by Mr. Stick, Thursday, May 3, 1956.

ORDER OF REFERENCE

THURSDAY, May 3, 1956.

Ordered—That the name of Mr. Stick be substituted for that of Mr. Power (*St. John's West*) on the said Committee.

Attest.

LEON J. RAYMOND,
Clerk of the House.

74002—1½

MINUTES OF PROCEEDINGS

FRIDAY, May 4, 1956.

The Special Committee on Research met at 3:30 p.m. this day. The Chairman, Mr. G. J. McIlraith, presided.

Members present: Messrs. Brooks, Byrne, Coldwell, Dickey, Green, Harrison, Hosking, Low, McIlraith, Murphy (*Lambton West*), Richardson, Stick, Stewart (*Winnipeg North*), Stuart (*Charlotte*), Weaver—(15).

In attendance: Dr. E. W. R. Steacie, O.B.E., Ph.D., D.Sc., F.R.C.S., F.R.S., President, National Research Council; Dr. E. R. Birchard, O.B.E., B.A.Sc., D.Sc., Vice-President (Administration); Dr. F. Rosser, Ph.D., Director of Administration.

The Chairman called the metting to order and introduced Drs. Steacie, Birchard and Rosser to Members of the Committee.

It was suggested by a Member of the Committee that authority be obtained to reduce the quorum. After discussion, it was decided to reserve further consideration of the matter.

During the course of questioning, Dr. Steacie referred to the following topics:

(a) Immigration and emigration of scientific personnel.

(b) Exchange of scientific information with iron curtain countries.

(c) Relations with industry.

(d) Parliamentary and Scientific Committee—United Kingdom.

(e) Recruitment of scientific personnel.

(f) Membership of National Research Council.

(g) Research in industry.

(h) Aircraft safety.

(i) Training of Scientists—Canada, U.S.A., Russia.

(j) Atomic Research.

(k) Co-operation with provincial research bodies.

Dr. Steacie's questioning continuing, the Committee adjourned at 5:00 p.m. to meet again at 11:00 a.m. Monday, May 7, 1956.

J. E. O'Connor,
Clerk of the Committee.

EVIDENCE

MAY 4, 1956.

3.00 p.m.

The CHAIRMAN: Gentlemen, we have a quorum.

In the evidence of the last meeting of this committee there was an answer given to a question asked by Mr. Hosking, I think it was, that was not complete. Dr. Steacie is able now to give the figures to complete that answer. Perhaps he could be permitted to do so now, then we would go into the subject of administration.

We have here Dr. Birchard, vice-president (administration) and Dr. Rosser, the director of the administration division, and we can go into their evidence immediately after the completion of this answer.

E. W. R. Steacie, O.B.E., Ph.D., D.Sc., LL.D., F.R.S., President of the National Research Council, called:

The WITNESS: The question was asked, "How many engineers have emigrated from Canada to the United States?" and I answered, "280 was the average for the past three years." I was then asked about immigration of engineers into Canada from other countries. I did not have the figures at that time. The figures are, for 1955:

From

United States	168
United Kingdom	754
Other countries	393

Making a total of 1,315. For 1954 the corresponding figures are:

United States	130
United Kingdom	1,003
Other countries	454

Making a total of 1,687. 1955 is incomplete. The records that I have are for nine months only. They are:

United States	120
United Kingdom	1,061
Other countries	532

Making a total of 1,713.

Mr. MURPHY (*Lambton West*): Mr. Chairman, before we follow your suggestion and go into administration, I wonder if I could continue to ask Dr. Steacie a few questions that I have in mind. I myself would like some information which I think would be of interest to the committee?

The CHAIRMAN: If they arise out of the evidence taken at the last sitting, and are on the subject matters we were discussing, there would be no objection.

Mr. MURPHY (*Lambton West*): As I said the other day, there were many questions I wanted to ask Dr. Steacie before I would be through. I did not expect for one moment that Dr. Steacie would come here for an hour and 20 minutes, that would be the end of his evidence.

The CHAIRMAN: Oh, it is not. It is not intended that we are through with him. It was stated in his evidence in chief at the first committee sitting, and it was his proposal, that he would outline administration, but instead of his giving detailed information we should bring the vice-president (administration) here to do that. Dr. Steacie will be here throughout.

Mr. MURPHY (*Lambton West*): I was wondering then, Mr. Chairman, if we could have a few minutes to clarify some points, so that we could deal with administration more effectively. I think there are some points that should be cleared up before we deal with administration.

The CHAIRMAN: That is quite agreeable. Has any member of the committee anything to say about that?

Mr. STUART (*Charlotte*): Before we get into that, Mr. Chairman, could some thought be given to reducing the quorum of this committee? We are losing a half hour every meeting, and it seems to me that we might consider reducing the quorum.

The CHAIRMAN: There is only one matter to be considered in that respect, and it is the old problem that if you reduce the quorum and call the meeting, some members come in late, and others come in later, and you have to go back over evidence that you dealt with a few minutes earlier.

Mr. STUART (*Charlotte*): It must be rather discouraging to those officials, who I know are busy men, who come here on many occasions and must sit waiting for a quorum. I think if we reduced the quorum we might get along just as well.

Mr. BYRNE: I want to offer my humble apologies for forgetting about this meeting today. I can assure you that I will be on time in the future.

Mr. MURPHY (*Lambton West*): Mr. Chairman, I think the idea suggested is sound. We have lost half an hour today. Many of us could be doing something else, and you must consider the members of the National Research Council who come here. A lot of their time is being wasted too. If it is in order, I would move that the quorum be reduced to nine.

Mr. BROOKS: Do you think we should wait and see if it happens again?

Mr. COLDWELL: I was just going to say that, there is some excuse today for the members, because the committee on the Federal District Commission did not adjourn until 1.30 today. I, myself, and other members here, are members of both committees. It makes it a pretty strenuous morning.

Mr. STUART (*Winnipeg North*): This is a very important committee, one of the most important. I do not agree with a reduction of the quorum; I think we should maintain it. We might have to reconsider the days on which we meet. I would like to offer the suggestion that we meet on Tuesdays, Wednesdays and Thursdays. Those of us who are on two committees will have to make up our minds as to which committee we are going to be on.

Mr. DICKEY: Mr. Chairman, I do not think it would be wise to reduce the quorum at the present time. I think the real value of this committee is the attendance of as many members as possible. We might be able to arrange different days for sittings; that is a matter the steering committee can consider. I certainly would not support any motion to reduce the quorum at this stage.

The CHAIRMAN: We are at the beginning of the second meeting of the committee. Would it be agreable to the committee if we left those two matters in abeyance, and Mr. Murphy would withdraw his motion for the time being, without prejudice to his right to raise it again at a later time?

Mr. MURPHY (*Lambton West*): All right.

The CHAIRMAN: Dr. Steacie.

By Mr. Brooks:

Q. I woul like to ask Dr. Steacie a question with reference to those numbers he gave of people coming in from Great Britain and the United States. Are most of those people remaining here permenantly, or do they come in temporarily to places like Chalk River? I remember when we were at Chalk River some time ago there were some English engineers there. They were only there for a short period.—A. This would apply both to Canadians emigrating to the United States and to others coming in as immigrants. I think the critical thing would be the definition of the word "immigrant" from the Department of Immigration's point of view. In other words, if they enter as landed immigrants they would be in this group. They may, of course, stay a year or two and move out again. The same would hold true of the Canadians who are emigrating to the United States. They might remain a year or two and come back. It is the same definition in both groups.

Q. Do you know whether most of them stay here or not? That is the point I wanted to get at. Do most of them remain in Canada?—A. They would be shown as emigrants if they left again. I do not think we have the figures on emigration from Canada to the United Kingdom. Perhaps we should try to get them. Would that be agreable? I think it is very small.

Dr. F. T. ROSSER (*Director of Administration*): It would be very small.

By Mr. Murphy (Lambton West):

Q. Before I ask any questions with regard to this industrial research that we got into just briefly the other day, I am interested, and I think the committee would be interested also to know what exchange there is between the National Research Council by way of pamphlets or other methods, and the countries behind the iron curtain, relative to scientfic matters?—A. The limitation on this is almost entirely a question of the policy of the iron curtain countries. The general situation is, if the iron curtain countries will exchange documents we are only too glad to do so. The exchange with Yugoslavia, Czechoslovakia, Hungary, and I think Poland, the satellite countries, has been fairly free. With Russia, we have been getting most of the journals, but with a certain degree of irregularity. In recent months this has improved very considerably. I would say that at the moment, with regard to all published scientific data the position is pretty good. We are getting most Russian published scientific data.

By Mr. Coldwell:

Q. Have you had any exchange of personnel from behind the iron curtain?—A. This has been, so far, limited to visits. Dr. Penfield, as I think most of you know, went to Russia, and there have been visits of the atomic energy people. In exchange there have been a number of Russian delegates who have come to meetings in this country. The total exchange is, of course, very small compared to the exchange with countries where everything is freely exchangeable, but it seems to be growing.

By Mr. Murphy (Lambton West):

Q. Have they asked for any information that is not in pamphlets, and that has been refused?—A. That I can only answer in so far as the National Research Council is concerned. The answer to that is no.

By the Chairman:

There is just one thing if I may interject here, Dr. Steacie. I think you referred to Yugoslavia as a satellite. I do not think that is correct.—A. I am sorry. I beg your pardon, I did not intend to say that. We have at the present time in our laboratory one Yugoslav.

Q. Doctor, at this meeting in Geneva last year of scientists from all over the world, was our country represented?—A. At Geneva?

Q. Yes.—A. Yes, by quite a large delegation.

Q. What I am concerned about now is—we just touched on it the other day—the position of industry in this country being able to compete in the foreign market, and in the home market. I think you did indicate and we all agreed with you, how important research is to these industries who must place themselves in a position to compete. Would you say how far industry in this country is behind, say the United States industry, scientifically speaking? The approach with regard to research in Canada today has reached what period in the approach of the United States?—A. I think it is very difficult to answer that with quantitative figures. We have made arrangements with the Bureau of Statistics to have a survey made of industrial spending on research in Canada. I think the results of that survey will be available about September. I think this will put it on a quantitative basis. At the present time, because of the fact that a great many companies are branches of American industries, or, if not branches, are associated with American firms, a great deal of the industrial research on which Canadian industry is based is done outside the country. Our per capita spending on industrial research, by government, is certainly as high as and probably higher than in the United States. It is generally agreed that our per capita spending by Industry on industrial research is much lower. I think that anything other than the statement "much lower" would be a pure guess. For that reason I would hesitate to say how much lower, but it is considerably lower.

Q. Are there not some companies, doctor, in Canada that do not avail themselves of the research that is available to them here in this country, or maybe in another country?—A. I think that would apply to some companies in every country of the world. One of the great problems of any public research organization is to get its information to the places where it will be of most use. This is a very difficult thing to do. One can read accounts of both Britain and the United States with regard to the difficulties of getting across the information that is available. I think it is a general problem of industry.

Q. Is the survey you are going to make intended to show the results of research in industry over this period—the activities of the research council and their effects on industry?—A. This survey is a factual one; it is a survey done by Canadian industry in connection with research.

Q. Will it indicate what should be spent by companies—companies, say in the 500 employee category, or anything like that?—A. I do not think the bureau of statistics would be prepared to suggest what should be spent. I think one has to be somewhat cautious. It would be very interesting to know what the figure for spending on industrial research is in Canada in comparison with the United States on some comparable basis—per capita, or gross national product; but one has to be very cautious about saying the Canadian figure should be as large as that in the United States. I think for the purposes of comparison you have to take into account that fact that we are not as highly industrialized, as yet, as the United States, and that we do have this branch plant situation; we must remember that we are next to a very much larger neighbour and that Canadian companies in general have a smaller market. I think we must take all these things into account. It is very difficult to say what the figure should be; my feeling is that the figure should be bigger than it is; but it is growing and I think the trend is an encouraging one. There is an increasing tendency by Canadian companies, even when they are subsidiaries of larger companies abroad, to open research laboratories in Canada and begin to do some of their research for themselves.

Q. Would not that apply particularly to the chemical industries?—A. It is particularly true in the chemical industry. I think the chemical industry has probably got into research first in most countries in the world.

Q. It is a more advanced industry, in other words.—A. It is more advanced; but the general trend is very noticeable, and I think it is encouraging.

Q. Looking at the petroleum industry in this country, is it not a fact that there is only one company in Canada which has a research group, and that is Imperial Oil?—A. To the best of my knowledge, yes.

Q. All the others get their information either from their parent companies or from engineers in Detroit and elsewhere outside this country?—A. In most of the petroleum industry you have subsidiary companies set up for research purposes solely. The parent company in the United States, and the Canadian company, both have access to the results of this research. Firms such as Standard Oil Development Company, Shell Development Company and so forth are instances of this. The same thing is true in the case of Aluminum Laboratories Limited, but in reverse; here the research laboratory for the companies is in Canada, and it does research for a great many other countries in the world.

Q. Like the Bell Telephone Company, for instance, only that is done on the other side.—A. They are, I believe, associates of the Bell laboratories.

Q. Would the tobacco industry come within your sphere, that is, within the scope of your department? Does the research council undertake any research with regard to improving the end product of the tobacco grown in this country in order that we might establish a better export market?—A. You mean with regard to manufacture, rather than the growing?

Q. Let us say in the processes which take place after the crop leaves the field.—A. I am not sure we have done anything; have a feeling that the Department of Agriculture has done something, but I am not sure.

Q. Would we be having someone from the Department of Agriculture as a witness, Mr. Chairman?

The CHAIRMAN: It depends on the time available. We could have someone.

By Mr. Murphy (Lambton West):

Q. It would not take long. The other point I wanted to raise was this: you mentioned the other day that your advisory council numbered 17 and that of this number 15 were scientists, one was an industrialist and one was a representative of labour. It has been mentioned on more than one occasion in the house, in the press and elsewhere that in Great Britain they have a scientific committee which apparently has been doing excellent work. That committee, as I think every member of this committee knows, is composed of members of both houses of the United Kingdom parliament, together with representatives from scientific organizations. It has been in existence, under both parties, for some years and it has been credited with bringing Britain out of her post-war difficulties much faster than would otherwise have been possible. I think we had one distinguished man visit us here—Robert Watt——A. Sir Robert Watson Watt.

Q. —who served in a very important capacity over there on the Defence Research Board during the war, and he said Canada should have a committee of the sort I have described.

I notice that several scientific magazines published on the other side have attributed to that scientific committee a great deal of Britain's success in the post-war period. What would be your comment on this?—A. I think there is quite a lot of misunderstanding as to the functions and status of that committee. It happens in Britain that, largely because of the existence of the House of Lords, there are, in the houses of parliament, quite a number of people who are themselves scientists. Lord Cherwell and Lord Adrian are among a number of people who have received peerages because of scientific accomplishments, and they felt that since there was a group of distinguished scientists who were members of the house, or of both houses, they would like to bring in some of the leading scientists in the country for informal discussions.

This body has no official status; it is not a part of the government; it has the status of a casual "get together" of a group of people who feel they are interested, and that is all. It advises the government solely in the way in which any organization could, if it wished, give advice to the government; it has no formal function as an advisory body and it does not appear at any point in the organization chart, which I have here, of scientific bodies within the British government.

I think that here conditions are a bit different. I certainly feel that if there were a group of members here who had some scientific knowledge and who wished to have a group of leading Canadian scientists meet with them once every three months, and if this was started by somebody informally, it could surely be done. But my own feeling is that Sir Robert Watson Watt has greatly over emphasized the importance of the committee to which you have referred. I think it has been very important in that it has produced debate at a very high level on some of the major issues, and started some thinking; but I should point out that this has no relation to our advisory council; it is on the same status as the Canadian club or any voluntary group that chooses to get together. It happens that what was done was to get together a group of members of parliament and a group of non members, but the body is not official.

By Mr. Stewart (Winnipeg North):

Q. Would it help the situation if the government were to make a number of scientists into senators?—A. I think, sir, that is not a matter on which I could express an opinion.

By Mr. Murphy (Lambton West):

Q. That committee in Britain was composed of 163 members of parliament together with representatives of 85 scientific technological institutions.—A. Yes, but it is a voluntary society.

Q. I know. I appreciate that; but apparently it was such a success that the government profited greatly by its advice. Incidentally the United States Department of Commerce, referring to this committee in February, 1952 and the rising inventive competition of Great Britain had this to say:

> "One of the principal instrumentalities of their industrial and scientific position was their parliamentary scientific committee—"

The Department of Commerce called it "parliamentary" but, as I have explained it is not really that.

> "—which is an unofficial partnership of members of the House of Lords and of the Commons on one hand and of national scientific institutions and recognized research bodies on the other."

The Department goes on to say that it is this committee, through its advice to different governments which have been in power during the years, which has helped to lift Britain out of a slump.—A. I think there is, also, a slightly unusual situation in Great Britain in that the Royal Society of London has a great deal of influence. There were three or four leading members of that society in the House of Lords, and I think we would find that what sparked this was a group of people from the Royal Society of London—three or four members in the House of Lords and three or four members outside—who got this organized and got it going. I do not think it is a thing you could start officially, and I would say that such a body could be quite useful here provided you got the group organized on a private basis—people who were interested and would maintain their interest and keep up the level of the discussion.

What I would like to emphasize is that this body has no similarity to the advisory council or to the Department of Scientific and Industrial Research in England, which is the equivalent of our advisory council.

Q. The reason I brought this matter up is because you mentioned the other day that your advisory body, consisting of some 17 members, advises the different departments of the government; and it seems to me, in view of the amount of time spent by those 17 members, that it might serve a more useful purpose if we had such a committee as I have mentioned as existing in Britain. —A. This group meets only once every three or six months, to the best of my knowledge.

Q. I understood it to be a continuing committee.—A. So is our council.

Q. I mean that they meet more often in small groups.—A. It is quite possible that they have subcommittees.

The CHAIRMAN: Have you completed your questions on that subject? Have you a question on that subject, Mr. Stick?

Mr. STICK: My question has to do with the lack of scientists in Canada—

The CHAIRMAN: That seems to be a new subject—

By Mr. Murphy (Lambton West):

Q. If I might continue, then.

You spoke the other day, Dr. Steacie, about the number of Ph.D's leaving Canada and the number graduating. Did the salaries paid by the National Research Council—let us say, last year—increase at the same rate as those in industry?—A. As a result of the recent salary adjustments there has been a considerable increase in the amounts we pay. Our starting salary for a new Ph.D. has been increased by approximately $550.

Q. Over last year?—A. Over last year. Wages in industry have also been rising rapidly.

Q. What was your increase for Bachelors of Science?

Mr. ROSSER: Let us speak in terms of starting salaries. Our starting salary a year ago was $3,750 for a new Bachelor of Science or Bachelor of Engineering. The average starting salary paid by industry was a few dollars ahead of that—$3,804, I believe—at any rate upwards of $3,800. We have determined that industrial salaries are advancing rapidly this year, so we have to strike in the dark, and we are setting $4,050 as our starting salary. My guess is that that will be very close to the average starting salary paid by industry.

The CHAIRMAN: The questions are getting ahead of the witnesses. Dr. Rosser will be discussing this subject of administration later on.

By Mr. Murphy (Lambton West):

Q. Is there today a shortage of top scientists in your organization or in Canada generally? Would you want more?—A. You mean senior people?

Q. Yes. Top men?—A. There is always a shortage of top scientists everywhere and always will be. From our point of view I feel that in our top people—by that I mean people who are leading groups—we have by far the best government scientific organization anywhere in the world. I think we have been extremely fortunate in our senior people. I would say there is always room at the top, there is a shortage, and there always will be. However, from our point of view we are extraordinarily fortunate in our position as far as key people are concerned and from that point of view I would say we are suffering far less from a shortage than we have any right to expect. We are very fortunate and have done extraordinarily well in this regard.

By Mr. Brooks:

Q. How do you account for your position as stated, as being the best in the world?—A. The general set up of the council is superior to that of any corresponding body in the world. We have been set up free of most of the restrictions. We are left in a position of flexibility and I think as a result we have been able to develop an atmosphere which is not too unlike an atmosphere of a university from the point of view of a research man. I think that is the basic thing. We have been successful mostly in developing an atmosphere in which a man can do the kind of work in which he is interested and feel that he is enjoying it.

Q. Do the other countries agree with that opinion?—A. I have heard nothing except expressions of jealousy from other commonwealth countries and a great many others, at the general organization and the general way in which the council was kept outside the strict government department set up and given more flexibility. I may say that in Britain at the present moment there is a complete reorganization of the Department of Scientific and Industrial Research. There is a bill before parliament there at the present time on that matter. I do not know what the result will be but I judge there has been considerable unhappiness over organization in Britain.

By Mr. Coldwell:

Q. Would you say it is to some extent a matter of interest in the line of work the man is following rather than the salary which attracts him to the National Research Council, though of course there are both factors?—A. There are both factors in it. One has to make sure of course that salaries are not too small. The salary scale is one in which we can say our position is a normal one and quite a happy one. It is up to me to try to get the maximum possible salaries and it is up to the treasury department to see that the taxpayers' money is not wasted. We strike some sort of compromise and there are always negotiations going on.

Q. I did not mean that. I mean that a man feels not only that he is getting a high salary but there is the fact that he is free to do such work as he wishes and it is up to himself whether he is liable to stay with the council.

By Mr. Hosking:

Q. If you had a good scientist and he went from the research organization after you had taught him and trained him and he went to A. V. Roe, is that actually a loss?—A. We would consider that no loss.

Q. That would be a loss or a gain?—A. We have always adopted the stand that anyone from Canadian industry or from a university is at liberty to come in and do any recruiting they wish to do within our laboratories, without any feeling of ill-will on our part.

Q. Would that not give a feeling to your staff that it is a good place to work? Would they not feel that in the National Research Council they can train themselves, and if they show ability, someone who specializes in this field is going to pick them up? Would they not feel it is the best way of advancement? Would this not create the desire for the right type of people to come in to your organization?—A. We never have been worried about the turnover, provided it does not become too great. The main thing one has to do is to see why there is a turnover. If the people are leaving for much better jobs, it is a compliment to you: if they are leaving for worse jobs, it is not.

Q. As long as they are not disgruntled, you would be quite happy?—A. Yes. At the same time, obviously we do not want salaries to fall so far behind industry that a man has to make a great sacrifice. From that point of view the salaries have been continually under revision and negotiation ever since the war. Since that time there has been a steady rise though at a given moment they may fall behind industrial salaries. In general, we are successful in regard to this matter.

By Mr. Stick:

Q. I asked a question in parliament in regard to this matter, as to whether there is a lack of scientists in the fisheries section, in certain developments where scientific knowledge is necessary and the answer I got was that they could not carry out the research because of lack of fishery scientists. Can you say anything about that or are you doing anything in your organization regarding fisheries?—A. No. I am afraid this falls outside our terms of reference. It is done by the Fisheries Research Board under the Department of Fisheries. We come in only to this extent, that we are administering for the Department of Fisheries some scholarships for graduate work at universities on subjects related to fishery research. We are administering those scholarships for them and to some extent we will finance work in zoology in universities which may be on subjects related to fisheries. That is all. Our only concern is with the sponsorship of a certain kind of work in universities, fundamental research in universities. The Fisheries Research Board is fully responsible for the development of the fishery research.

Q. Do they not work with you? Is there any question on which they can come to you and ask you about it? Is there any liaison there?—A. There is a great deal of liaison between the two bodies. We are doing certain things at their request but it is their responsibility. We are undertaking work at their request but in general, because of the fact that you have this sizable body doing work in fisheries, we have stayed out of the field, to avoid duplication. In borderline subjects, there is a lot of cooperation.

Q. Do you do anything about the shortage of fishery scientists?—A. No. other than to say that there has been somewhat of a chronic shortage of biologists. The output of biologists over quite a period of years has been rather smaller than it should be. I think it is part of the general program of support of research in universities of zoology and botany. We are doing anything we can to support research in universities in those fields.

By Mr. Brooks:

Q. In regard to the maritime laboratory, you do work in connection with fisheries?—A. That is being done in direct cooperation with the fisheries station in Halifax, between Dr. Beatty director of the Station Fisheries Research Board and Dr. Young of our Atlantic Regional Laboratory.

By Mr. Murphy (Lambton West):

Q. I cannot get away from the idea that instead of 15 scientists on a board of 17, with one representative from labour and one from industry, it would be more effective if you could have industrialists on that committee who are research conscious and scientifically inclined. What would you say to that?

—A. I think it is a question of the function of the council. The way we are operating at present is that we are using the council as the scientific body to review the work and keep an eye on it. In addition, the council has the very important job of the executive responsibility for the university support program. The cooperation with industry in our experience tends to be a rather individual matter. The electrical industry is nothing like the chemical industry; the chemical industry is nothing like the grain industry; and so forth. Consequently, we have felt that the cooperation with industry must be largely at the divisional level. Our divisions are organized roughly on subjects. There is an applied chemistry division which is concerned mainly with the chemical industry. It is the duty of the director of the division to make sure there is the maximum possible cooperation with the industry. This is done via reviews of that division by people from the chemical industry who are essentially therefore sitting as an advisory committee. We have advisory committees as such in several divisions. Then we also have the associate committees. It is our feeling that we get a great deal more by having our council make sure that the scientific level of the work is what it should be and limiting the council essentially to scientists and then the cooperation has to be at the working level. In other words, it is a full time responsibility of mine to cooperate with industry; it is the full time responsibility of the director of every division. From this point of view our cooperation with industry is extremely good. We very rarely refuse to do anything reasonable that we are asked to do. We are in very close contact with industry. Practically all our people are members of a variety of professional societies and the net result is that we have extremely close contacts with all the industries on the problems which industry has to face.

Q. You may incorporate the next question in your answer and that will be my final question. What can be done, in your estimation, to stimulate more industrial research in this country?—A. The trend is right, in that more is being done. We must recognize the difficulties, the markets and things of that sort. To my mind, it is a question of missionary work more than anything else. Over the last 15 years there has been a tremendous change in the attitude of industry to research in all countries in the world. It is a very rapidly expanding thing. We simply must do our best to stimulate industrial research wherever possible. All of us in senior positions in the research council have been doing a great deal of this in the way of speeches and otherwise. We have been with various groups as consultants. I myself on various occasions have been asked by a group of industrialists in a given field to go and talk to them and really "let my hair down" on the subject of what I thought of the lack of research in Canada. I think we are becoming much more research conscious in industry. From my point of view, this is all we can do. I do not think industrial research would be any use unless the industry itself is thoroughly sold on the necessity of it. I think we are getting to that point. I feel that the trend is good. One must make sure it is maintained. I think also one should emphasize that you cannot build up a research organization quickly. There has been a lot of criticism of various bodies in various countries in their attitude towards research. I mean that you cannot buy research as a commodity, but you must develop it. You cannot decide that if we spend $100 million we will get that much research, without reference to where the people are or where the laboratories are. We are stimulating this very much at the moment and the whole trend is a good one and I do not feel discouraged about it.

By Mr. Weaver:

Q. In all your discussions with Mr. Murphy you mentioned industry and I had the feeling you were speaking of secondary industry. I mentioned mining industry the other day, coming up through the Department of Mines and Technical Surveys. I wanted to be sure when you are speaking of industry, whether you are referring to the primary industry of the country or more to secondary industry; is that correct?—A. Yes. The function of the National Research Council is in secondary industry. I think also that in primary industry we are leading rather than falling behind.

Q. That is the point.—A. In agriculture, for example, Canadian research has a very high reputation. There is a famous statement that was made by a British Minister of Agriculture some 30 or 40 years ago when he said, when someone asked about agriculture research, that he saw no necessity of doing agricultural research in Britain because they had full access to the results in Canada. Britain has changed its mind a little since then. I think that our position in primary industry is very good; work got going a long time ago and it has developed and is on quite a fair scale.

There is rather different position in that in agriculture one expects that most of this research will be by government and not industry. The farm is too small an industry to do research. It has to be done by pools of some sort and is usually regarded as a government function.

Again, in mining, it is usually felt that in order to exploit mineral dicoveries it is necessary for the government to be there to give advice as to how to extract ores. So you do not have the same general position of research in industry when you are dealing with the primary industries; but I think the primary industries are away ahead of the secondary industries. I think that is rather reasonable in a country like Canada which is making a transition. I have the highest regard for the work done in mining and in agriculture.

By Mr. Stewart (Winnipeg North):

Q. Has any aid been sought from the N.R.C. by the airlines of this country? As their travel becomes more and more popular the space above airports becomes more and more cluttered with aircraft waiting to land. The result lies in the field of electronics, and I am wondering if anything is being done by the aircraft companies by which we might devise means where aircraft might land safely in what is, of course, the jet age?—A. I think that the answer is yes. In general most developments these days, because of financing and so forth, will tend to come through the air force—rather than through civilian airlines, although we have given considerable advice at one time or another to the Department of Transport and to the airlines on various things connected with navigation and so forth.

By Mr. Hosking:

Q. I would like to ask a supplementary question dealing with the principle of the question asked by Mr. Murphy. I see advertised a plug to go in the bottom of an oil pan, and in the advertising they state that N.R.C. has done something toward the development of this. Can you tell us how that came about?—A. It came about because of the work on the chemistry of lubricating oils being done in the division of applied chemistry. They did work on the deterioration of oils caused by heating.

Q. Who has the patents on it?—A. They are held by Canadian Patents and Development Limited which is a crown company owned by N.R.C.

Q. Is it extensively used?—A. It has only been on the market for a month or two I understand.

Q. Do the manufacturers put it in their cars when they are selling them new now?—A. No.

Q. Why do they not do that?—A. It remains to be seen whether or not they will do it.

Q. Do you think as much of it now as you did yhen it was developed?—A. Yes. We think it has very considerable possibilities.

By Mr. Stuart (Winnipeg North):

Q. Is this a calcium plug or is it sodium?—A. The original ones were calcium and the new ones sodium.

Q. I have one and I wanted to find out.

By Mr. Murphy (Lambton West):

Q. Coming back again to this survey which you are going to make, is that survey going to be focussed towards the assistance of industry in the field of research?—A. No. This is a survey on the spending by industry on industrial research; it is on spending, and on where it has been done, and it would include only work which the industry paid for.

Q. That is, paid to the N.R.C.?—A. No. No matter whom they paid; either they bought it from an outside firm, or they might have bought it from us, or have done it in their own labs.

Q. Would that include what they paid their parent companies in foreign countries?—A. Yes.

Q. That would be an interesting survey.—A. I think so.

Q. Would it be too much trouble to have a survey made of what your council has done to assist industry?—A. This cannot be done in dollars and cents. Our annual reports and press releases and various other things, point out recent developments of one sort or another, but we are not generally in this as a business. We are set up to do things for the benefit of industry with public money primarily. You cannot survey the National Research Council's accomplishments in research by saying how much they charge industry for doing small jobs. We could give the total expenditure.

Q. You do study the value to industry of your research?—A. I think we have done this in various ways, but I do not think that you can do it in dollars and cents. I think this is impossible.

Q. Could you do it by projects?—A. In the first place you would get thousands of projects, and the second thing is that, suppose someone is having corrosion trouble with a boiler and you give him some assistance and as a result the corrosion trouble stops, it is very difficult to estimate how much money you have saved the firm because he might abandon the process next year. I do not think that a survey of that kind would be very valuable. We could, and frequently do, summarize what we think are outstanding recent developments. We have press releases coming out regularly, the annual report attempts to summarize the main things being done and the review of activities attempts to do it in more detail and is in more technical language as it is designed for technical people.

By Mr. Hosking:

Q. On this point about the plug which I was talking about, would this plug not be more widely used if the public knew it saved them money in operating their cars?—A. We prefer to do this in the normal commercial way; that is we have a patent. We do not go on the market and sell them. We merely advertise that we are willing to licence this process. Someone comes along who happens to be an appropriate person to licence it to and we draw up a contract to him. It is now licenced to a company in Toronto. It is then entirely a question of their responsibility to see that they can sell these. I think that there has been a great deal of effort put on this and that it has become quite well known when you consider that it is a very recent thing and has been on the market for only a very short time. It would be a mistake to high-pressure it.

Q. The point I was trying to make is, do some of the things which you do meet opposition from the industry because they might hurt their business?—A. I cannot really say that I know of any case of this happening.

By Mr. Stewart (Winnipeg North):

Q. Perhaps the oil companies may not be too fond of this plug because it would save the consumers a large amount of money.—A. What this is trying to do is to prevent the deterioration of oil and that does not mean that you could avoid an oil change if your oil is getting full of sand or is otherwise getting dirty. I think that with a new development of this sort that anyone has the right to be sceptical until he is convinced, and it is perfectly normal at the moment that it is coming on the market that everybody is not convinced that it is as good as we think it is. Meanwhile, it is being tried out on a large scale by various people and time will tell whether or not it becomes an established product.

By Mr. Harrison:

Q. You mentioned that you do quite a bit of research for the R.C.A.F. However, you do some for the private aircraft industry?—A. Yes.

Q. I had in mind the accident sometime ago to a De Havilland aircraft in Toronto where there was some doubt expressed as to whether it was from a structural defect or whether from a blast of passing jet. Have you done any work on that at all for the De Havilland company?—A. I could not say. I could find out for you.

Q. It is something which is of interest in my area because the civilian aircraft are the lifeblood of that area. They have Beaver aircraft there and they are getting some Otters.—A. I will see if I can obtain that information for you. We are called in quite frequently in the case of aircraft accidents, but I cannot say whether we were called in in this case.

The CHAIRMAN: Are there any further questions?

Mr. MURPHY (Lambton West): I understand that Dr. Steacie will be available at some other meetings?

The CHAIRMAN: Yes.

By Mr. Hosking:

Q. I would like to come back to a question which had been asked at a previous meeting. How would you go about promoting some research being done on the fats that are found in meat processing? They are the very best of food and they are not selling at their value. It would appear to me that there should be some study given to using these fats, particularly when the farm industry is having a certain amount of trouble at the present time?—A. Would it be possible to call Dr. Cook of the biology division at a future meeting for this purpose?

The CHAIRMAN: I take it that we will be dealing with the heads of the divisions later on in our evidence and I think that question should come at that point.

Mr. HOSKING: That will be all right.

By Mr. Stuart (Charlotte):

Q. I have been greatly interested in radar equipment. On one of our visits to the National Research Council I remember talking to an official at that time who told me that they were making a study of equipment which could be produced at a very moderate cost in order that some of our boats might be able to use radar equipment. Down in the Bay of Fundy, as in every other coastline in the world I suppose, every man follows the water and is very interested in that equipment. So far the price does not seem to be down to a point where the ordinary fisherman can afford radar. Do you know whether or not they are still making a study of that?—A. They are still making a study of radar relating to navigation. I think that this is technical enough that I would prefer if it could be deferred so that the head of that division could be here to answer it. He would give us the answer with authority.

By Mr. Green:

Q. Mr. Chairman, near the end of the last meeting I asked Dr. Steacie a question as to his views with regard to the stories we hear that Canada is going to be very short of scientists and engineers. At that time you asked that the answer be deferred until another meeting. Could we have that answer today? A. I think we could give statistics of various sorts at a later meeting, if you like. Offhand I could answer it this way, Mr. Green, that there is at the present time a shortage of engineers. This is not a very great shortage, but the indications are that it will become a great shortage in the future if the supply does not increase. At the present time the number of engineers in Canada is increasing steadily, because the rate of production now is so much greater than it was, say 40 years ago. The loss by death is negligible, compared to the influx by graduation. It appears that the next 10 or 15 years will probably require a doubling of the rate of production of engineers. At the same time, the predictions of the national conference of Canadian universities, and of the Bureau of Statistics are that about twice as many under-graduates will be enrolling in the next few years. If the same percentage of students go into engineering, with that doubled enrolment this will just about meet the situation. I think, therefore, the essential thing is to see that we provide facilities to the universities to enable them to expand to meet the in-rush of students to be anticipated from 1959 or 1960, on. I do not think we need worry too much about persuading more students to go into engineering. The percentage going into engineering has been rising continuously.

One big question, and it is one that I am not qualified to talk about, is the question as to whether there has been a deterioration in science teaching in schools due to the lack of science specialists. This is something that is outside my sphere altogether, but I think it also needs to be considered at the same time. My own impression of the whole thing is that this is something that is serious, but it will be under control, provided we make sure that the development of universities to meet this crisis is sufficient to take care of it.

Q. The question has arisen, so far as I have been able to ascertain, as a result of the suggestion that Russia is deliberately training a very large number of engineers, and that other nations are not keeping up that same development. —A. There is a certain implication, of course, in this argument—and I think it is a very bad argument for a good cause. The implication is that anybody who is trained as anything other than an engineer is useless, because they compare only the engineering graduates in Russia with this country. Therefore the argument tacitly contains the assumption that lawyers and others are useless people.

Mr. Hosking: That is right.

The Witness: I think what you should compare is the total output of university students in Canada with those of Russia.

By Mr. Green:

Q. How do you know the total, if it is compared percentagewise?—A. In a comparison such as I have suggested, the output is much larger in the United States and Canada than it is in Russia. I think that it must be true in Russia that education has swayed far towards technology. It must be true that almost all the managerial staffs in industry must be engineers, if you are training nobody else beyond the public school level. These arguments about the Russian situation are misleading, but they are being used for quite a proper purpose. It has warned us that we need to do something about our facilities to train engineers.

By Mr. Brooks:

Q. You said that universities should be assisted in providing facilities. Would you care to tell us how you think they should be provided?—A. No, sir. I think that comes into the realm of public policy.

Q. Doctors are also very scarce in this country.—A. I think that is a question of public policy. It is not for me to say.

By Mr. Murphy (Lambton West):

Q. Doctor, were the engineers and scientists and the people from the free countries amazed and astounded when they went to Geneva and learned what the Russians actually knew? I am talking about the calibre of their top scientists?—A. I think there were a few people, who should have known better, who were astounded. I do not think that any well-qualified technical person was the least bit surprised. It was perfectly obvious that if Russia concentrated on science for a period of 35 years, at the end of that time they would have quite competent scientists. If they were willing to put the effort into it they could do a good job.

Q. You mean they have not got proper scientists?—A. I mean they have.

Q. My question, doctor, was were they not surprised; were not the scientists from the free countries amazed?—A. Not a bit.

Q. Not a bit?—A. I think a lot of people who had been kidding themselves were amazed, but I do not think that any competent scientists were in the least surprised.

Q. They appreciated, in other words, that Russia had top scientists?—A. Yes. I think that most competent scientists were quite convinced that Russians were capable of doing anything that anybody else was capable of doing.

Q. Sure. Just before I leave this, there was one point you raised the other day, and that was that some of your work is done by contracts with industry, and so on. Some of the work is originated because of some idea that some of your men in the National Research Council have given us. What I am interested in is this: after the scientist has revealed the idea, how far do you go along with industry in the development work? My point is this, unless the scientist who originated the idea follows it through, the project itself is going to suffer because he is more interested in it than anybody else?—A. Well, normally you would have to go through a variety of stages. If you take the ordinary stages of scientific development you have fundamental research, which is aimed at finding out what nature is doing, then you go to applied research, which is an attempt to try to solve a specific problem; then, if it is process development you will usually find yourself obliged to transfer those results to a small pilot plant to see what the difficulties will be in practice. It might be necessary to go on to a large pilot plant, and afterwards you could go on to a full scale plant. Now there is no necessity that the organization that does the fundamental research shall do the applied research. The way to exchange information is to publish it and make your contribution, and every one else does the same.

On the applied research side, if you develop something you have to make up your mind whether you should take out a patent—if the work has been successful—and try to license the patent to industry, and have them go on to pilot plant. Do you go into pilot plant and then try to license it, or do you go into it on a works scale? The cost of that is very high and in general it is very difficult for a laboratory like ourselves to get on to an actual pilot plant scale, so our normal method of operation is to try to interest industry at the earliest possible stage. We may not always be successful in interesting industry. Even if it is a good idea a man who has just built a new plant cannot afford to throw it away because you have an idea that might be a little better.

This problem of marketing a process is quite a difficult one, but I would say that in general we have tried to avoid going beyond a small scale pilot plant. We try to bring industry in at the earliest possible moment and our hope would be that the process would then be taken over by the industry. They would carry it through the final stage to see if it was practical on a big scale.

Q. Would you follow it through with them?—A. We would follow it through with them if we could help in any way, and in fact in quite a number of cases what they have done is to hire the man who did the job, and that seems to me an ideal situation.

By Mr. Hosking:

Q. Did the N.R.C. make any recommendation with regard to converting 25 cycle power to 60 cycle power in the province of Ontario?—A. I very much doubt it. On the other hand we have members of our staff on every reputable engineering professional body and they may have made this recommendation as private individuals. But this was not a matter we were called upon to consider, as far as I am aware.

Q. The reason I asked that question, as an engineer, was my belief that if there had been two companies permitted to sell power in Ontario we would have had no 25 cycle current, because we know that 25 cycle motors cost a third as much more than 60 cycle motors, so it would not have been economical to have purchased them.

We have another body in Canada now which is almost like the Hydro Commission, and that is the Bell Telephone Company. Are we doing any research to find out whether Bell telephones are doing a good job? They have been given a charter, and there is no competition; they are left to do what they want to do, protected by our government. Is there any way of keeping a check on how they are running these things?—A. We are supposed to be competent in the field of scientific research. We are not in any way competent as economists or in the field of market research, or in efficiency of production, and consequently we would not be capable of issuing a report as to the costs of operation of something of this sort, so I am sure this is outside our terms of reference.

Q. I know it is, but would it be possible for you to recommend that we make a study—

Mr. Dickey: Not on this committee I should think.

By Mr. Hosking:

Q. —of the conditions of our communications. This is real research, and valuable research.

The Chairman: That may be, but is the question: would it be possible for the research council to make such a recommendation?

By Mr. Hosking:

Q. Oh no. Would they be able to do the job if it was recommended to them?—A. No, we would not be competent to do it.

By Mr. Stewart (Winnipeg North):

Q. Has the council received any requests from the United States for technical aid in scientific research?—A. For advice? Oh yes. Actually we exchange a great deal of information. We have been called in as consultants and have given advice in a variety of ways. We have relations of one sort or another either through licensing processes or the giving of advice with the majority of countries in the world.

Q. Have you been asked for information or advice in connection with the armed services in the United States?—A. As far as the services are concerned a great deal of work has very definitely been done in agreement between the two countries. When work is done for the services our position is normally that of doing work which is really under the auspices of the Defence Research Board. It is the responsibility of Defence Research, but they have requested us to take over certain aspects of the work and in those fields we are then dealing with Britain and the United States.

Q. This is on a *quid pro quo* basis? It is not a matter of "all give" on our part?—A. Oh yes, very much so.

By Mr. Green:

Q. Is the council participating in the development of atomic power reactors? —A. No.

Q. What cooperation is taking place now between the council and the Atomic Energy Commission?—A. If I may answer the latter question first, the situation now is that Atomic Energy of Canada is a crown company and it is entirely independent of the N.R.C. We have nothing whatever, officially, to do with each other. Actually, of course, we have a great deal to do with each other in a cooperative way in that there are a variety of small things we do for each other and so forth.

The answer, therefore, to your first question is: no. We have nothing whatever to do with the development of nuclear power. That is a matter for Atomic Energy of Canada, Ltd.

Q. Are all the provincial governments undertaking research themselves at the present time?—A. At the present time almost every province is doing so, but not quite. In some form, I think, every province has some kind of set up. About five of them are modelled rather closely on ours, and in some other cases there is a government department of industrial development. Most of the provinces now have a quite active research group. We are pleased with this because we think the idea of having a local group in each province doing research is a very efficient set up. It enables us to go in a little more for longer term things and gives us a direct liaison with the provinces.

Q. What cooperation is there between the council and these provincial research bodies?—A. It is partly on an informal basis. As an example, Dr. Shrum, chairman of the British Columbia Research Council, has just retired from being a member of our council after a number of years; Dr. Grace, director of the Alberta Council was a member of our staff before he was appointed to that position; Dr. Thorvaldson of the Saskatchewan Research Council is a member of our council at the present time.

The connection with the Ontario Research Foundation is not as direct but we have had a great deal to do with Dr. Speakman over the years. So there are very close personal relationships.

We contract with a number of the provinces to carry on the technical information services for us, and we make modest grants to most of these councils in order that they can carry on a little fundamental work. Their trouble in most cases is that they have too few uncommitted funds; they can only for a job if the user will pay for it. We have supported them financially to a modest extent and in a number of cases, members of our council have been asked to act as a review committee for a provincial council and so forth. The relationship has been extremely close and a very happy one.

By Mr. Byrne:

Q. On the question of consumer goods and construction material, have you a department which customarily makes tests with new types of construction material or consumer goods? Do you make consumer reports?—A. In general, we have very definitely stayed clear of consumer standards. This is a function which is quite different from a research function. It involves an obligation to test samples of every material manufactured. I think that a distinct function of this sort is one which cannot be carried on by a research laboratory.

Q. Do we not have any such organization?—A. We have a Canadian Standards Association and there is a standards branch of the Department of Trade and Commerce. In building material the position is a little different, in that our building research division, since it is concerned with specifications because of the National Building Code, will always investigate any new building material which comes along and will report whether in its opinion it is compatible with the building code.

Q. In some instances, a roofing company may say they have a new type of roofing which will last for 30 years and which will be non-inflammable and fireproof and so on. Do we not make any tests there?—A. I think our building research division would certainly be interested in making tests under those circumstances. However, if a manufacturer came along and said: "I am making a building material and I want you to tell the public that this meets the specifications of your body," we would refuse to do it. That is to say, we are not in the testing business: we are in the investigation business. We consider that brand new material which could have useful applications may come within the functions of building research.

Q. From time to time we hear rumours and stories which seem to have some authenticity, where some enterprising young fellow has discovered a carburettor which will make an automobile give 50 miles to the gallon. Then again it will be said that light bulbs, for instance, are manufactured in such a way that they will burn out quickly, so that they will boost the sales. Have we any authority in Canada in which we can set about investigating such allegations?—A. We, that is the N.R.C., not only have no authority but it is the last thing we would want. If you were put in a position by law that you must investigate the usefulness of every gadget produced by anybody, you certainly would never do any research. On the other hand, we find a great many people writing or coming to us with ideas, people who want to know what can be done about those ideas. These range all the way from people with good useful ideas to those with complete crack-pot inventions. We do our best to give advice to anybody who we think has something of value. We do not manufacture things, we do not start a business for anybody. We get many people with some idea for some gadget, coming to us for help and we give them advice about it and advice as to how to patent it, or whether they should patent it, and quite often we will do things for them if it appears that the gadget has possibilities. We do our best to help the small inventor provided there is some real prospect of success in the invention.

Q. You do not investigate crack-pot economic theories?—A. No, though people write to us about those things, too.

By Mr. Stuart (Charlotte):

Q. When mentioning research, you stopped at Ontario. Have the Atlantic provinces the same committees?—A. There is a committee in Quebec on research. In the Atlantic provinces, New Brunswick has a department of industrial development. In Nova Scotia there is a council organized somewhat on the pattern of ours, the Nova Scotia Research Council. In Prince Edward Island there is not anything.

Q. Is there anything of that kind in Newfoundland?—A. There was a department but I think this is an embarrassing subject at the present time.

By Mr. Stewart (Winnipeg North):

Q. What about the prairie provinces?—A. In Manitoba there has been no direct development along these lines. In Alberta there has been for a long time. Since 1920 or so they have had a research council. It operated by giving grants to university people to sponsor fields of work. Recently, within the last three or four years, it has become a full time operation and has just moved into a new building on the Alberta campus. Saskatchewan also has been running in the same way as Alberta, by giving grants and they are just in the process of moving forward and there is a full time staff now. They are quite active and I think that the new setup, with the full time staff on the campus, means that they will build up a very effective organization.

By Mr. Stuart (Charlotte):

Q. If you told us about British Columbia, it would round off the picture. —A. In British Columbia, research was started in rather the same way, by a council, provided with some funds by the provincial government. Then they went to the university and offered to give them grants to do a certain type of work. After that transition period, the B.C. Research Council was then established in buildings of its own. It has built up its staff and now has a fair-sized permanent staff and buildings located on the U.B.C. campus. It is now becoming a very effective organization.

By Mr. Murphy (Lambton West):

Q. In all the universities in Canada are their teams of scientists or is scientific work done on every campus?—A. Not every campus. There is a great deal of research work being done in all the major universities. There are, of course, some very small colleges which are purely interested in liberal arts in which there is relatively little research being done; in this respect there are also junior colleges. In all the major universities now, or perhaps I should say in any university which gives a science degree, they do a little research although it may be very small in the case of three or four of the smallest institutions; all the others are now quite actively engaged.

Q. There has been a noticeable change in the last few years?—A. There has been a tremendous change. Before the war, with a few minor exceptions, only McGill and Toronto universities gave doctor's degrees.

By Mr. Brooks:

Q. How do you keep one university from duplicating the work of another, or one province from duplicating the work of another province?—A. As far as the universities are concerned, they are free to do what they like. We do not influence them in respect to our grants. On the other hand, before anyone does any research at all he has to know what everybody else in the world is doing. Knowing what another university is doing in Canada is relatively very simple. In respect to knowing what is going on abroad, on a scientific level, that information is complete in that it is all published. On the industrial level it is more difficult.

By Mr. Low:

Q. Did the National Research Council cooperate with the Alberta Research Council in attempting to find some successful process for extracting petroleum from the Athabaska tar sands? I understood Dr. Steacie to say yes. Could you tell us just what stage that is in now?—A. If I might amplify my first answer, I would like to say yes, and that so did the Bureau of Mines; we were both concerned with this problem. A report was made, the so-called Blair report, on the process. This recommended a combination of part of the development of ours with part of the development of the Bureau of Mines as being the most efficient. I am not sure what the exact state of this situation is at the moment, or whether pilot plant work is still going on, or what is being done in Alberta. I think that one could probably summarize this thing by saying that obviously the recent large oil discoveries in Alberta have rendered the tar sands position less attractive. I could not say at the moment whether or not it is considered that the further development is uneconomical. The only thing which I would say is that, even if it is uneconomical at present, the work was still worth doing because it established a method of tapping a potential reserve which will be valuable some day even if it is not economical today.

The CHAIRMAN: If there are no further questions, gentlemen, at this moment a motion for adjournment would be in order.

By Mr. Brooks:

Q. In connection with the oil shale, I understand that down in New Brunswick they are trying to develop the oil shales to produce electricity. Do you know anything about that?—A. I could find out for you.

The CHAIRMAN: I think that I might add a word about these two items by telling you that there are tariff items covering the subject in detail. This is a perfect example of legislation being in advance of the real need.

Mr. BROOKS: Tariff items?

The CHAIRMAN: Yes, on each subject—the development of the shale resource, oil from shale and from tar sands.

We will adjourn until Monday morning at 11 o'clock.

HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT
1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 3

NATIONAL RESEARCH COUNCIL

MONDAY, MAY 7, 1956

WITNESSES:

Dr. E. W. R. Steacie, President, National Research Council; Dr. E. R. Birchard, Vice-President (Administration); Dr. F. T. Rosser, Director, Administration; Dr. J. B. Marshall, Director of Awards.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956.

74274—1

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McIlraith, Esq.

and Messrs.

Bourget	Green	MacLean
Brooks	Hardie	Murphy (*Lambton West*)
Byrne	Harrison	Richardson
Coldwell	Hosking	Stewart (*Winnipeg North*)
Dickey	Leduc (*Verdun*)	Stick
Forgie	Low	Stuart (*Charlotte*)
		Weaver

(Quorum 11)

J. E. O'Connor,
Clerk of the Committee.

MINUTES OF PROCEEDINGS

MONDAY, May 7, 1956.

The Special Committee on Research met at 11.00 A.M. this day. The Chairman, Mr. G. J. McIlraith, presided.

Members present: Messrs. Brooks, Byrne, Coldwell, Dickey, Forgie, Green, Hosking, McIlraith, Murphy (*Lambton West*), Stick, Stewart (*Winnipeg North*), Stuart (*Charlotte*), and Weaver.—(13).

In attendance: Dr. E. W. R. Steacie, O.B.E., Ph.D., D.Sc., F.R.S.C., F.R.S., President, National Research Council; Dr. E. R. Birchard, O.B.E., B.A.Sc., D.Sc., Vice-President (Administration), Dr. F. T. Rosser, Ph.D., Director of Administration; Dr. J. B. Marshall, B.S.A., M.Sc., Ph.D., Director of Awards.

The Chairman called the meeting to order stating that Dr. Steacie was now in a position to answer two questions asked at a previous meeting held Friday, May 4, 1956.

Dr. Steacie, in answering the questions, referred to an accident involving a de Havilland aircraft, and the emigration of Canadian trained engineers to the United Kingdom.

Mr. Murphy (*Lambton West*) submitted for the consideration of the Subcommittee on Agenda and Procedure an extract from "This is Britain", entitled "The Parliamentary and Scientific Committee".

The Chairman called Dr. Birchard who proceeded to outline the administrative organization of the National Reasearch Council.

Dr. Rosser was called by the Chairman and dealt principally with the question of staff.

Members of the Committee were invited by the Chairman to ask questions of the witnesses and during the course of questioning, reference was made to the following topics:

1. Technical assistance to the Armed Forces and federal government departments and agencies;
2. Training of scientific personnel;
3. Emigration of scientific personnel;
4. Liaison with Defence Research Board;
5. Inventions of National Research Council employees;
6. Canadian Patents Development Corporation;
7. Fisheries Research.

Questioning of the witnesses continuing, the Committee adjourned at 1.00 P.M. to meet again at 3.00 P.M. Wednesday, May 9, 1956.

J. E. O'Connor,
Clerk of the Committee.

74274—2

EVIDENCE

May 7, 1956.
11.00 a.m.

The Chairman: Gentlemen, I see a quorum.

There are two questions that were asked at the last meeting for which Dr. Steacie now has the answers. Perhaps we can have them first.

Dr. E. W. R. Steacie (*President, National Research Council*): One was whether we had done anything about an aircraft accident involving a deHavilland plane near Toronto, and the answer is: we were asked by the deHavilland company to make certain measurements on parts of the plane in an attempt to establish the sequence of events in the accident. In other words, we are not investigating the accident as such. We have merely made certain measurements for the deHavilland company which they hope may help in solving the problem.

The other question was in respect of a breakdown of engineers emigrating from Canada to the United Kingdom. It does not appear to be possible to get data with respect to this exact question. There seems to be no doubt that the number of engineers emigrating to the United Kingdom is very small.

The Chairman: Dr. Steacie was being questioned when we adjourned the last meeting. Is it your wish to continue with Dr. Steacie's evidence, or do you wish to turn to the subject of administration.

Mr. Murphy (*Lambton West*): Mr. Chairman, I would like to put on the record—at the last meeting we were discussing that scientific committee operating in Britain. I intended to show this document to you, Mr. Chairman, and I used some quotations from it the other day. This is a copy of an extract from "This Is Britain", a monthly news letter from the United Kingdom information office, 275 Albert Street, Ottawa, dated May, 1954.

This just gives an outline of the committee and its functions. Instead of reading it, Mr. Chairman, I would just like to put it on the record. You could take a glance at it.

The Chairman: I did not anticipate this. I wonder if the agenda committee could deal with it.

Mr. Murphy (*Lambton West*): I could read it into the evidence, but I thought it would save time.

The Chairman: Could we not leave it to the agenda committee to deal with for report at the next meeting?

Mr. Murphy (*Lambton West*): We are on the subject.

The Chairman: I am a little doubtful about putting in the record as evidence hearsay of this sort, unless we know a little about it.

Mr. Coldwell: I think the chairman's suggestion is a good one.

The Chairman: It may be that it will go on the record anyway.

Mr. Coldwell: Probably it will go on the record, but I think somebody should see it first.

Mr. Brooks: You are establishing a precedent by putting that sort of information in, if you do so now.

The Chairman: Yes, and I am opposed to doing that without considering it and letting the agenda committee have it first. We will decide on it after that.

Mr. MURPHY (*Lambton West*): I do want to put it on the record, even if I have to do it by asking it in the form of questions of Dr. Steacie, you see.

Mr. COLDWELL: You can read it on the record.

Mr. MURPHY (*Lambton West*): Yes, I could read it.

The CHAIRMAN: I think it should go before the agenda committee first.

Mr. COLDWELL: It should go before the agenda committee first.

Mr. MURPHY (*Lambton West*): It is really important, because this committee functions under the present government, and functioned under its predecessor, the labour government, satisfactorily. Its chairman was one of the top members of the party in power, you see.

I will leave it at that, Mr. Chairman.

The CHAIRMAN: Thank you, Mr. Murphy.

Any other questions of Dr. Steacie? I will call Dr. Birchard, vice-president (administration) of the National Research Council. Members will recall that the National Research Council Act was amended in 1946 and provision made for a vice-president (administration). Dr. Birchard is the vice-president (administration).

E. R. Birchard, O.B.E., B.A.Sc., D.Sc., Vice-President (Administration), of the National Research Council, called:

The WITNESS: Mr. Chairman, I have prepared a short brief here on the administration services, and I think perhaps it would be best if I read it.

The administrative services of National Research Council are divided into several groups and are, in general, for the purpose of securing and providing the scientist with information, supplies and services as required and the dissemination to industry and other scientists of information as it is developed or required. It also includes the general administration which is necessary in the operation of an organization such as the National Research Council.

The groups and the officers in charge of each group are as follows:—

1. Library—Miss M. S. Gill, Chief Librarian.
2. Technical Information Services—F. G. Green, Officer-in-Charge.
3. Scientific Liaison Offices—
   - London—Dr. J. G. Malloch
   - Washington—Dr. J. D. Babbitt
   - Ottawa—J. M. Manson
4. Public Relations—M. W. Thistle, Chief.
5. Patents Section—F. R. Charles, Chief Patents Officer.
6. Plant Engineering Services—J. C. Elliott, Plant Engineer.
7. Division of Administration—Dr. F. T. Rosser, Director.

The division of administration is responsible for

Purchasing Branch
Personnel Branch
Awards Office
Research Journals
General Services, which include Estimates.

Since I understand it is the intention of the committee to call Dr. Rosser, director of the division of administration, I suggest that you might wish to defer for the moment the review of the estimates, awards and other services coming under administration.

Just a short description of each group, sir.

1. *The library.*

The council has one of the best scientific libraries and continued effort is made to secure all the latest publications so that it will be up-to-date at all times. As an indication of its scope, at the 1st of January of this year it contained 381,315 reference books and documents, and as an indication of the service which it renders there was a total of 54,206 loans made during the past year to scientists in universities, industries and other scientific organizations.

The 54,206 figure includes 4,511 photocopies of articles made in lieu of loans.

2. *The technical information service of the National Research Council.*

The technical information service was established in 1945 to encourage the widest possible utilization of scientific and technological information stated in terms that could be fully understood by those seeking such information.

It was intended especially to assist the secondary, or processing industries; and, in particular, the smaller industries.

For many years the primary industries, agriculture, mining, forestry and fishing had been provided with facilities to secure full information regarding scientific work in their fields of endeavour, and through various agencies, had been encouraged to adopt improved practices based on the results of these investigations. While the secondary, or processing, industries have also had available a wealth of material in technical periodicals and scientific reports, the very multiplicity of sources of information has made it difficult, if not impossible, for most of them to keep fully abreast of modern developments.

As originally established, the technical information service included field representatives in the various provinces whose duty it was to call on industries in their areas to learn the technical problems facing these industries. All these field representatives were graduates in engineering, or science, and in quite a number of cases were thus able to solve at once some of the inquirers' difficulties. Where this was not possible, the inquiries were referred to Ottawa where a central staff of information officers dealt with them. All information officers also had degrees in science or engineering together with laboratory, industrial and, in many cases, executive experience. These officers prepared the replies of about 80 per cent of the incoming inquiries while the remaining 20 per cent were transferred to other laboratories, or departments of government, where specialists in the subjects under inquiry were found. It is a pleasure to acknowledge the complete and whole-hearted co-operation we have continually received from such departments.

As time went on, provincial research organizations continued to be formed and in order to avoid repetition of calls and handle the work most efficiently, arrangements were made whereby the Technical Information field service of these provinces was discontinued, and in its place grants were made to the provincial research organizations to carry out these functions. This change has been most satisfactory because it brings the provincial centres increasingly close to their industries and also affords these industries the advice and services of specialists on the provincial staffs as well as the T.I.S. staff at Ottawa. Such arrangements are at present in effect in British Columbia, Alberta, Saskatchewan, Ontario and Nova Scotia. In New Brunswick, the provincial government has for ten years assumed the work of the service. In Manitoba, T.I.S. has had a field office in Winnipeg, and in Quebec there is a field office in Montreal with two appointees as well as a part-time appointee in Quebec city.

In the eleven years since the start of the service, almost every industry in Canada has been called upon and over 32,000 inquiries have been referred to Ottawa for attention. As time went on, the field representatives, because of increased experience, increased local assistance and material supplied from Ottawa, have been able to answer an increasing number of inquiries. At present, about 8,000 inquiries per year are handled by the field staff, provincial research staffs and Ottawa headquarters.

Initially, the Ottawa staff dealt only with inquiries received. Later, when some subjects tended to come up several times, brief reports on them were prepared and mimeographed. These reports saved the time both of the professional and stenographic staff and served to provide a more detailed survey of the problems than could be given in a letter. After trial for several years, these reports became a regular feature of the service and were given reference numbers. While they can be prepared only as time permits, 48 have been prepared to date.

From time to time replies to inquiries have involved the translation of articles appearing in foreign periodicals. Just recently, when a few translations of fair length were made, mimeographed copies were prepared; and, like the T.I.S. reports, have been distributed to interested applicants. These have been well received because few foreign-language journals are subscribed to by Canadian industries.

Still more recently, field representatives and associated research institutions have been supplied with information sheets pertaining to: (a) notes of new equipment; (b) interesting reports or other publications that have been obtained by the Ottawa headquarters; (c) outlines of new processes or methods and (d) summaries of inquiries in various fields of industry that have recently been answered at headquarters. The field men in their calls on industry can produce these sheets and find very often that the material is quite new to the person on whom they are calling and they are requested to provide more specific information.

Apart from such Canadian sources of information as the training and experience of the information officer and the availability of the N.R.C. library, etc., a good deal of additional information is obtained from foreign countries. Initially, this was arranged in part chiefly by an exchange of T.I.S. reports and notes with other organizations. More recently, a much firmer foundation for exchange for non-North American countries has been possible through attendance at meetings of Commonwealth and western European technical information services. At the present time, there have been established channels through which information for more difficult types of inquiries can be obtained from Commonwealth and practically all of the western European countries. In the case of the Commonwealth countries, outside of the United Kingdom, the credit balance will likely be in favour of Canada because of its higher degree of industrialization. Nevertheless, cooperation is gladly given as a means for strengthening Commonwealth ties. For example, all of T.I.S. publications are now going to India and Ceylon, and in the near future Pakistan will be included. From the other nations we receive copies of their reports and publications and place them to the best advantage.

Our European contacts are now in a very strong and satisfactory condition, mainly through our association with the staff of the European Productivity Agency in Paris. To this agency we contribute digests of articles appearing in the Canadian technical press and receive in return severalfold, similar digests from European countries. Some of these digests are brought directly to the attention of specific industries, while others are being made available to Canadian industries through the cooperation of Canadian technical journals.

Canada was one of the first nations to initiate a technical information service catering to the processing industries. Since its start, similar services have been started in nearly all European countries, the Commonwealth and one or two South American countries. In the last year, Denmark and Finland joined the number of European countries having such services.

The increasing tempo of scientific and technological change is apparent in the estimated 60 million pages of books and publications being produced annually. It is imperative that some means be available whereby this tremendous mass of material could be followed, digested and selected to aid national industry. The production man does not have the time, or the facilities, to do this work.

A new profession of information officer is coming into being in all countries. The preferred training for such a man is an engineering or scientific education plus special training in the gathering of information and industrial experience to enable its evaluation.

Larger companies are aware of the benefits of such information, but the only satisfactory means for reaching the small industries is by the use of a field staff which makes personal calls on them. This conclusion is based not only on Canadian technical information services experience, but also on the operations of similar services in the Commonwealth and Europe.

In Canada, constant thought is being given to means for improving both the placement and the value of this assistance. Repeat requests from the same industry and an increasing number of letters of appreciation indicate both the need for the service and its value to Canadian industry.

3. *Scientific Liaison Offices*

Shortly after the outbreak of the last war it became apparent that efficient exchange of classified scientific information between Canada, Great Britain and the United States could be achieved only by setting up appropriate machinery. The National Research Council set up liaison offices in Ottawa, London and Washington, through which information in the form of publications, letters and other documents moved freely under suitable conditions of control. Through these offices also arrangements for visits to laboratories and industrial plants were made and procurement of scientific devices was expedited.

At the end of the war it was found convenient to continue the system, to speed the flow of technical information from the laboratories and industries of other nations and to keep up contacts that had already been established for exchange of scientific information. The London and Washington offices became part of British Commonwealth Scientific Offices, in which each Commonwealth country was represented. These offices co-operate in the common tasks but operate as autonomous units.

The proportion of classified material handled by these offices has decreased, but the liaison offices have undertaken new tasks, some of which stem from Commonwealth Scientific Conferences held in 1946 and 1952. Among the projects undertaken as a result of these conferences was the establishment of an index of translations available within the Commonwealth, with the object of making better use of translation services by making known to scientists the titles and locations of translations already available. The Canadian section of this index was enlarged to include titles from United States sources, commercial as well as governmental, and at present it contains approximately 30,000 titles.

The Commonwealth conferences also promoted conferences in which specialists from Commonwealth countries could meet to plan efficient utilization of the research talent available. A number of these have been held, and the liaison offices in London and Ottawa have had an active part in the arrangements. As an example of the work done by these conferences, there are now available to microbiologists throughout the Commonwealth lists of all cultures of organisms held in the various countries.

The offices in London and Washington act in an advisory capacity to the Department of External Affairs in connection with matters involving science and industry. The London office is active in scientific contacts with the Organization for European Economic Cooperation. The Washington office assists in the work of the United Nations and in procuring isotopes from the United States. These offices undertake to assist any Canadian scientists travelling in the United States, the United Kingdom and the continent of Europe by arranging appointments, itineraries and accommodation. They also collect information in those countries on behalf of Canadian scientists. The Ottawa office acts as an intermediary between the outside offices and scientists and scientific institutions in Canada.

4. *Public Relations*

The public relations branch is responsible for compiling the council's annual report, the NRC Review, the NRC Research News, and press releases on laboratory work. Assistance is given to appropriate agencies in producing movies, television, radio releases, and public lectures on science. Magazine articles and special booklets are prepared, as required. The branch also assists in taking care of visitors to the laboratories.

The council's annual report is a statutory obligation for presentation to parliament.

The NRC Review is a book of about 260 pages, since the audience is largely scientific and more detail is required.

The NRC Research News is a small monthly bulletin of four to eight pages intended to supplement the annual review. The outside audience is mainly in the universities.

5. *Patents Section*

New developments made by members of the staff of the National Research Council are submitted through the director of the division concerned to the patents section where they are carefully studied by the officers of the patents section, who have a knowledge of both science and patent law, to consider whether they have patentable features.

If, after a search of the patents in the particular field, it is considered that the feature might be patentable, the subject is referred to an appropriate committee for consideration of the value to industry and to the general public and if it is decided patent action should be taken the officers of the section assist the patent attorneys in filing and prosecuting the application.

When the first application has been filed the specifications and filed particulars of the patents are passed to Canadian Patents and Development Limited to enable it to proceed with the exploitation of the development.

The facilities of the patents section and the Canadian Patents and Development Limited are made available to Canadian universities, provincial research establishments, certain crown companies and other government departments or agencies. During the past year approximately 120 new developments have been examined by the patents section, 10 of these from universities and provincial research establishments, 40 from Atomic Energy of Canada Limited, 12 from other government departments, 18 from the A. V. Roe organization and 40 from the National Research Council.

6. *Plant Engineering Services*

Plant engineering Services include the installation and maintenance of steam, air, gas and electrical services for all the laboratories of the National Research Council. The buildings of the National Research Council are located at four different sites. Additional responsibilities include the operation of two steam heating plants and a hydro-generating plant, laboratory alterations, equipment installations and occasionally structural extensions.

A central drafting pool and an engineering design office are also maintained, whose facilities are available to all Divisions.

A new building was completed in 1955 at the Montreal road to house the plant engineering staff and their necessary equipment as well as the layouts and records of all services.

7. *The Division of Administration*

The responsibilities of the division of administration will be described now by Dr. F. T. Rosser, director.

Dr. F. T. Rosser, Ph.D., Director, Division of Administration, National Research Council, called:

The WITNESS: Each of the divisions of the National Research Council has its own administrative officers to deal with its special and direct administrative problems. However, the main administrative functions are centralized in the division of administration which provides service to all groups. The aim of the division of Administration is to relieve the scientist as much as possible of time-consuming non-scientific work, enabling him to devote his efforts to research. At the same time, we believe that a centralized administration saves money, particularly in an institution the size of the National Research Council.

Dr. Birchard has already outlined the branches into which the division of administration is divided:—general administrative services, purchasing, personnel, the Canadian journals of research editorial office, and the awards office, which handles scholarships and grants-in-aid. I shall deal briefly with the work in each of these branches.

The general services branch performs all the regular administrative service functions, including the screening and assembling of estimates for presentation to parliament.

You have before you a small blue book on organization and activities. If you turn to page 11 you will see the estimates for this fiscal year. These are presented on a functional basis rather than by financial object as they are in the estimates presented to parliament. You will see that our engineering divisions are estimating the largest expenditure. The mechanical engineering estimates are $2,616,545. The radio and electrical engineering is next in size, followed by building research. These three make a total of $5,418,954 for the engineering divisions. There are 8 scientific divisions arranged in order of estimate, the total expenditure estimated being $3,895,371. The services include estimates for administration, plant engineering, library and public relations, coming to a total of $2,342,710. That makes a general total for laboratory operations of $11,657,035.

The foundation activities, as you will see, total $3,618,980. If we eliminate from these the amounts spent on post-doctorate fellowswhips in the National Research Council laboratories and other government laboratories, and also the assistance given to scientific publications, there is still more than $3 million left to go directly to the universities. Our external activities come to $2,420,713 and our total requirements are $17,696,728. There is an estimated revenue of over $2 million, leaving the net total estimated requirements $15,470,139.

Annually the general services branch registers over one million pieces of first-class mail, produces more than 8,000,000 prints, sells 500,000 publications, and provides stenographic, clerical and travel services for the entire organization.

The purchasing office aims to buy all materials and supplies required for the laboratories at the best possible price. There are five buying units in the office, each specializing in a particular field. Not only are the buyers concerned with prices but they try to maintain good relations with both suppliers and staff. Several related services have been made a purchasing responsibility. The purchasing branch operates a central warehouse for distributing bulk purchases of commonly used items. The receiving and shipping functions are in their hands as are customs clearances, the certification of accounts payable and the taking of discounts, which amounts to a considerable sum. A number of store rooms also come under purchasing supervision. All these complicated operations fit together to help save money, speed service and maintain good relations.

The personnel office is responsible for all staff matters. There are three sections in this office—(1) the employment section, to handle all applications up to the time a person is appointed to the staff; (2) the staff relations section, dealing with all staff matters from the time a man joins the staff until he retires; and (3) a small organization section. Since the council does not come under the Civil Service Commission the personnel office handles many of the functions of the Commission.

I would like to discuss employment problems for a few minutes, especially those related to scientific staff. In the past decade science has become one of the most highly competitive professional fields in the world. The research worker must be well trained but his value is measured largely by the talent, skill, initiative and ability to work, that he displays. The recruiting of scientists for research work must be handled in a manner markedly different from that normally followed in the hiring of other categories of staff. Since specialization in a particular field is an essential feature of scientific training, the number of directions in which a scientist can move is greatly restricted. It is not easy for him to transfer from one job to another in an unrelated field or to be trained in a new field while he is on duty. Thus his future lies in one direction only and his advancement must come with experience. For these reasons the initial selection of a good scientist becomes a matter of much greater importance than the selection of other types of workers. To ensure that the research staff of the National Research Council was maintained at the highest possible level of competence, the authority for selecting has been given to a board of selection made responsible for advising on all appointments, promotions and retirements. This board is composed of members of the honorary advisory council and therefore is an independent body knowledgeable of the requirements for the laboratories and of the qualifications of scientists. Over the years the board has done an admirable job in maintaining a high standard of excellence on the staff and much credit for the council's enviable reputation in the scientific world must be given to their guardianship.

The question immediately arises, how can such a body of men meeting only four or five times a year deal effectively, in the short time at its disposal, with the hundreds of cases that must be examined critically for an institution as large as the National Research Council? This is where the division of administration plays an important part. Inadequate administrative handling could render the work of the board completely ineffective. Therefore, I would like to describe to you the methods we have devised to handle these personnel matters.

In November of each year the personnel officer publishes a listing of all the graduate students in science and engineering attending Canadian universities—last year there were about 1,600—and he keeps in contact with a great many Canadian students at universities in the United States and Great Britain. At frequent intervals general announcements regarding the council's requirements are issued and are sent widely to universities all over the world wherever Canadian students might be found. From time to time scientists in various fields, our own scientists, visit the universities and bring the council's special needs to the attention of the student body. Students are invited to file applications with the National Research Council at any time. There is, therefore, on hand at all times a store of information on available people in nearly all the fields of science. In addition the close contact maintained with Canadian universities puts us in a favourable position to obtain information concerning graduate and undergraduate students.

When a vacancy occurs detailed information on suitable applicants is assembled by the administrative staff and mimeographed for presentation to the board of selection. The data placed before each member of the board includes adequate information on the applicant laid out in a standard form so that qualifications can be assessed quickly. To avoid confusion the form is coordinated with the scholarship presentation, since some of the same board members also consider scholarships. When the board meets it is then possible to deal with a large number of cases in a comparatively short time.

To prepare for a board meeting four or five times a year requires a tremendous effort on the part of a relatively small number of administrative staff in obtaining every detail of information, condensing, editing and assembling it. However, after years of practice the operation works smoothly. Only a competent and independent advisory body such as our board of selection could hope to establish and maintain the high standard of quality necessary to make a great research organization.

There are many questions of interest concerning the scientific staff. Some of these we have included in the booklet. For every scientist in the laboratory almost three supporting people are required. This ratio, of course, varies between laboratories and within our own laboratory. The largest number of supporting staff is in the engineering divisions and the smallest in the pure research divisions. In fact, the three engineering divisions employ 877 people against 631 in the eight scientific divisions. The list of universities from which the degrees of the scientific staff were obtained is shown at page 16 of the booklet, it reflects the amazing growth of post-graduate work in Canadian universities, for which the council itself can take some credit.

The increasing competition from industry has made it more difficult for us to recruit scientific staff in recent years. Since 1949 our net increase has been 97, or an average of 14 per year. Last year and this year the net increase has been 9 and 8 respectively, which is somewhat below our approved plan for expansion, which was at the rate of from 15 to 20.

Altogether close to 8,000 people apply annually for about 400 vacancies on the council staff; in other words, about 20 people for every vacancy. This covers all categories. We feel that the morale of the staff of the council is good; this is often reflected in such matters as the sick leave taken which compares favourably with other government departments and agencies.

This year there are almost 1,600 graduate students in science and engineering studying in Canada. A careful analysis of information available on Canadians doing graduate work in science and engineering in the United States would lead us to believe that there are about half as many Canadians there as in Canada. Although many of these students do come back to Canada, the loss of Canadians to the United States from this group is indoubtedly heavy. If support to the Canadian universities could be increased to meet the needs of these students it would not be necessary for so many Canadians to go abroad for their education.

There was one point raised the other day which I think would be of interest to the committee on the numbers of people going to the United States. We have figures on the terminations from our staff. The latest figures are for the fiscal year 1954-55 in which there were 436 employees classified as scientists. Of that number, 29 resigned; this is a turnover of 6·7 per cent which, when we make comparison with other research institutions, is rather low, particularly the American institutions where the turnover in government laboratories has been very high. What has become of these 29 people? Sixteen of them accepted positions in industry; thirteen in Canadian industry, three outside of Canada, which I presume is in the United States, although I do not have the information here. Three of them accepted positions on the staff of colleges and universities, two in Canada and one outside Canada; five of them accepted positions in other government departments or agencies; one of them went back to university to continue his studies, two retired on account of age and two are detailed as miscellaneous, and that is indicative of what has happened in recent years in the turnover of staff.

The editorial office of the Canadian journals of research is responsible for editing and handling the publication of the council's seven journals of research. Successful scientific research ends in publication. The growth of Canadian scientific effort may be measured by the growth of the journals in the past decade from approximately 1500 pages in 1945 to 6000 pages in 1955, an increase of 400 per cent. About 23 per cent of the papers published in these journals originated in the council's laboratories; the rest came mainly from scientists in the universities and other government laboratories.

The awards office divides its work into two main categories—grants and scholarships. Grants are made to university professors to assist them in doing scientific research. The trained men and the equipment are in the universities but often professors are hampered by a heavy load of teaching duties and the lack of trained helpers.

The CHAIRMAN: At this point we are coming to the scholarships and grants. I take it that that is the concluding part of your remarks?

The WITNESS: Yes.

The CHAIRMAN: I have a note here that after Dr. Rosser's evidence we will have Dr. Marshall. Now, the thought in my mind is whether or not it is the wish of the committee to complete Dr. Birchard's and Dr. Rosser's evidence on the other matters up to this point before we hear this bit of evidence and then we would have the grants in aid and scholarships at one time.

Mr. MURPHY (*Lambton West*): How much more is there?

The CHAIRMAN: Very little.

Mr. STICK: I think that if you go on to scholarships you are touching on another subject.

The CHAIRMAN: Would you rather question Dr. Rosser now or hear the remainder of his brief on scholarships and grants in aid?

Mr. STEWART (*Winnipeg North*): I think that you should keep the scholarships altogether.

The CHAIRMAN: Then if you care to question these two witnesses, they are available for questioning.

Dr. Rosser, had you something else to offer?

The WITNESS: I would just like to say that to work smoothly a research laboratory must have an administrative staff with a sympathetic understanding of scientific problems and the operation of its offices must be geared to the aims of the institution, otherwise the administration may become a policing unit crippling the work of the researchers and impeding the advance of science. The purpose of the council is to promote science in Canada and in administration we have not lost sight of that aim.

By Mr. Stick:

Q. Dealing with the question of security, in your board of selection, in reference to selection of staff, do you do any screening or do you leave that to somebody else?—A. The screening is handed over to the usual government organization. We handle the screening of staff in exactly the same way as it is done throughout the rest of the government.

Q. The screening is done by somebody else and they pass it on?—A. Yes.

Q. That would affect your selection of scientists and so on for your work? Do you make a selection of scientists whom you want without putting them through the screening board?

Dr. STEACIE: I wonder if I might answer that.

E. W. R. Steacie, O.B.E., Ph.D., D.Sc., LL.D., F.R.S.C., F.R.S., President, National Research Council, called.

The WITNESS: Any cases which have been influenced by security considerations are so very few as to be almost negligible. The authority is in our hands.

By Mr. Stick:

Q. The final authority rests with you?—A. Yes.

Q. You are satisfied, Dr. Steacie, with that situation?—A. Yes. I think actually, from our point of view, that there has been really no trouble over this. It is an extremely rare case where the question of security arises at all, that is anything adverse. In the past few years it has become an extremely unimportant matter from our point of view.

By Mr. Stewart (Winnipeg North):

Q. Is it not so that one of the troubles in American government institutions, as far as scientists are concerned leaving their particular jobs, has been this business of screening for jobs which are not essential?—A. I think that that is very definitely so. I think that any screening that is done here is done in such a way that it does not offend the man being employed and is never prominent. In other words, I think that the whole question of security has been handled in a way which, to my mind, is the proper way; that is, there is no fuss made about it and it is not something which bothers the employee. I must say, from my point of view, that it is something which I rarely think about; it is not in any way prominent in our operations the way it has been in some of the American laboratories.

By Mr. Murphy (Lambton West):

Q. What about scientists coming to you from the European countries?—A. It would all depend on what they were going to do with us. We have only a relatively limited area of secret work. We are not concerned in the case of people coming on fellowships and that sort of thing; the question of security does not arise.

Mr. MURPHY (*Lambton West*): Dr. Rosser, you mentioned revenue of $2,226,589. Would you tell the committee the sources of that revenue?

Dr. ROSSER (*Director, Division of Administration*): One of the sources of this is from the sale of publications. Another source is from charges made for work in our laboratories.

Mr. MURPHY (*Lambton West*): You mean, for instance, development work?

Dr. ROSSER: It may be development work. It is largely from other government departments; for example, for the St. Lawrence waterway we have done specific model studies; also a considerable amount of work is done for the Department of National Defence.

Mr. MURPHY (*Lambton West*): Would that be the major part of your revenue? Do patents come into that?

The WITNESS: No; that is Canadian Patents and Development Limited.

Mr. MURPHY (*Lambton West*): Would this include work which you did for industry?

Dr. ROSSSER: Yes.

Mr. MURPHY (*Lambton West*): About what part of that total would it be?

Dr. ROSSER: I should think in the neighbourhood of $150,000.

By Mr. Coldwell:

Q. Can you give us the results of the investigation, inquiries and development work to industry? What is done to guide the consumers of the country when you investigate certain products? Do you publicize that?

Dr. STEACIE: In general, sir, we are not, as you realize, primarily concerned with testing; that is, our attitude towards testing is that it is something which we should never do unless no one else in the country can do the particular tests and there is a particularly good reason for doing it. So, we are not concerned very largely with direct investigation of consumer products. I think that broadly you would say we are not in this game at all except in some special cases. One of these is the Canadian Government Specifications Board, where we have the responsibility of advising other departments in connection with purchases so that we get, for example, into consumer type testing on textiles because the Department of National Defence is buying large quantities of textile materials.

Q. That is the angle which I had in mind, of course.

Dr. STEACIE: Our general position is that we have no responsibility for consumer standards. The general criterion is that unless a material is bought by more than one government department, we will not do it. If one department only is buying it it is their duty to draw up their specifications. The Department of National Defence inspection services have the responsibility for their own specifications. But in some cases, for example, paint which will be used by the Department of Public Works as well as the Department of National Defence, we get into the matter of paint specifications and so on. However, in general we are not engaged in the question of consumer standards.

Q. If a department refers something to you, you undertake the investigation and report directly to the department?

Dr. STEACIE: Yes.

Q. But you do not publicize the results?

Dr. STEACIE: No. This is true also when we make tests for a manufacturer. We have made the rule on tests that we will only test a product either for the manufacturer to assist him or for the sake of the government. Otherwise you have one manufacturer sending you his competitors' products in the hope that you will find something wrong with them.

Q. Supposing a consumer wants you to test a product so that he might be guided?

Dr. STEACIE: I would say that unless there was some unusual aspect that we would take the stand that it was not our function no matter how desirable it might be.

Q. In other words, you do nothing like the consumer organization which is a private organization?

Dr. STEACIE: No, we do nothing like that.

Mr. MURPHY (*Lambton West*): Following up the question on revenue, there has been an increase in the revenue to your department for work done for industry and for other departments of government over the last few years?

Dr. BIRCHARD: Yes. There has been a steady increase. Perhaps 5 to 10 per cent each year.

Mr. MURPHY (*Lambton West*): Then, Dr. Birchard, would you comment on the increase on the returns from industry. That is what I am interested in mostly. Is there any indication, by the returns, that you are doing a great deal more work for and with industry than you did a few years ago?

Dr. BIRCHARD: I doubt that. I would like to say that there has been a great increase in industry, as Dr. Steacie said here the other day; but my own reaction is that industries are doing a little more research of their own because we have a number of industries coming in and asking us for advice in selecting scientists to put into their research establishments. We do our best, with industry, to provide the top scientists whom we think would make a success in that particular industry.

Mr. MURPHY (*Lambton West*): Then, following that up, we will take the smaller type of industry employing up to say 500 employees. I do not suppose many of those have research labs. Are they the ones mostly who are coming to you for research work?

Dr. STEACIE: The smaller company of that sort does come sometimes. Usually what they are concerned with is not research but is technical information which already exists. This is not always the case; but usually with the smaller company the problem is not to do something new, it is to obtain existing technical information. In the case of technical information we make no charge for any of these services, so that would not be reflected in revenue at all. In general there are exceptions, but they are rare. We do not charge for giving advice.

Mr. MURPHY (*Lambton West*): Following that up, is there some indication that there are groups of small industries in Canada who would, as a group, want information from you? Is there any evidence that these small industries, which do not have labs and which require technical assistance, get together as a unit in order to lower the costs and increase the value of the products?

Dr. STEACIE: That has not been very useful. Actually in Great Britain research associations have been successful. In the United States they have never been successful. The general tendency is to feel that you do not really want to bring your competitors in with you. In Canada, the Pulp and Paper Research Association is one which has been very successful.

Another small industry with a successful association is the laundry indutry. I cannot remember the exact title, but it is an association of launderers and dry cleaning firms. They are obviously far too small to have their own technical people, and we have been in close co-operation with them. As a matter of fact, originally all the work done for them was done in our laboratories and partially financed by us. That has been quite a successful venture. I think in general there has not been this tendency for the small industries to want to get together.

I feel that if you look at the situation as a whole, there has been a very great increase in the number of inquiries that we have received for information of interest to industries, of a technical nature, and of new processes and so forth. There has not been a corresponding increase in the charges for that work. I think you will see that we are not, after all, in business. We are financed with public money, and if it seems to us that it is in the national interest to do some work, we do it. Revenue, I think, will always be a relatively minor feature. If we were to regard revenue as the important thing, and put ourselves in the position of a normal consulting firm, I do not think we would be doing our job. I can answer your question by saying that I think there has been a vastly increased interest in technical improvement, and signs of increase in industrial research done by industry itself. There has been a great increase in the number of inquiries we receive, and the idea of increasing the charge for that service is not a good one.

Mr. MURPHY (*Lambton West*): I was not so much concerned with that, but I was concerned with a statement made by Dr Rosser, and I want to get it clear. You were referring to graduates and the loss to the United States. It seems to me from what you said—it is very hard for us as a committee to remember very much of what you did say, as a matter of fact, without having the brief before us. I think that you indicated that these people were going to the United States to get degrees and probably are still there absorbed by industry or some other service. I wonder if you could comment on that a little further. You mentioned that our universities are not in a position, probably, to absorb them. To me that is a very important aspect of this committee, the plight, you might say, of the municipalities as we see them today in Canada.

Dr. ROSSER: It is a rather complicated problem, of course, to analyze the reasons why students go to the United States for their higher education. I would think that in the majority of cases they go there because of the reputation of a professor in the field in which they wish to study. They seek a university offering a specialized discipline in which they wish to study.

Mr. MURPHY (*Lambton West*): You mean the universities are not staffed in Canada with top scientists that these students want to study under?

Dr. ROSSER: It may be that they have someone in the general field on the staff of a Canadian university, but the professor might not have a reputation in the specialty. If a student is very good, he usually wants to study with the name men in his special field.

Dr. STEACIE: Mr. Murphy, I think that is too broad. The point is that we are relatively a smaller country and we have a large number of very competent scientists in the universities. The United States has obviously a much larger number. So that this will happen, that although a university physics department has a very high reputation in Canada, it may well happen that there is no university in Canada offering graduate work in some very narrow specialized branch of physics. If there are 20 times as many universities in the United States, there will be 20 times as good a chance for a student, in many of these fields. You may only have five or six people in the world in a given specialty, so a small country will have less chance of having them. I think this has quite a bearing.

I think anything that can be done to build up the universities should be done. If you look the situation over, at the end of the first war essentially no one did graduate work in Canada at all. We have probably built up to the stage now where two-thirds, or 70 per cent of Canadians who do graduate work do it at home. That has been done over a period of 40 years, or 35 years. I think that is quite a creditable build-up. We want to make sure, however, that our universities continue to develop; and as they do, we will get a further increase in the number of students that study at home.

By Mr. Murphy (Lambton West):

Q. Would you include in your answer, doctor, that you are giving professor scholarships, grants to professors to further their studies?—A. To advance their research, yes.

Q. That will naturally aid universities in having a higher standard of professorship?—A. Actually these grants of ours have been given since 1917, and have had a very great deal to do with the build-up of research in Canadian universities in the last 30 years.

Q. How many years have we been giving grants to graduate doctors?—A. McGill and Toronto both gave a few degrees, at rather long intervals and in a sort of casual way before the first war. The first real steady production of people with doctor's degrees was around 1920, at McGill and Toronto.

Q. Have you any record, doctor, of those who graduated in Canada and took their doctor degrees in the United States, or went to the United States for their higher degrees?—A. This information would be difficult to get. One would have to go to each university.

Dr. ROSSER: That would be the only way to do it.

The WITNESS: We have a complete history of the students who have received a scholarship from us, since we have been in operation for 35 or 40 years. This is quite an interesting document, and if it would be of interest to have this distributed to the members of the committee, I could do so. It is a Who's Who of our scholarship awards, and it is quite an interesting document.

Mr. MURPHY (*Lambton West*): I think it would be very useful for the committee to have that on the record.

Mr. DICKEY: We might have it when we are dealing with that particular subject.

By Mr. Coldwell:

Q. There is a question running through my mind. We sometimes have university graduates going to the continent of Europe to study under a particularly eminent man in a particular field. Do you keep track of those who go to the continental universities? I am speaking of those who originate in Canadian universities and then decide they want to study a particular line, say chemistry or physics, and they go to one of the famous professors in Germany, or France or somewhere else?—A. One would have to get that from the university records. Actually I would say at any given time, because of previous applications for scholarships and the chance that the man may have been applying to us and may have been hired under one of our grants, and so forth, we would have information on a very large number of these people individually, but no consistent set of statistics. My own feeling is that of the ones that go to Europe, essentially all of them return.

Q. They all return?—A. This is not entirely true. There is the odd man at Oxford or at Cambridge who went over on a Canadian scholarship; but the vast majority come back.

Q. I was thinking more of the young man who decided he wanted to take a particular course in some scientific field, and there was a professor in Germany, or Austria, or Italy or somewhere else, and I wondered if you had any record, from the university which originally graduated him in Canada?—A. Not consistent records, as I say, sir. We would have records of a lot of them, because they might apply to us for the scholarship to go there to study, or in some way we might come into it.

By Mr. Hosking:

Q. Mr. Chairman, could I ask a question about the testing of equipment? Does the National Research Council not test any of the clothing worn in the northern country? Is that all left to the army to test?—A. No. We do some tests for the Department of National Defence on textile materials. In fact, we do quite a lot.

Q. I was not thinking so much of the textile; but I was thinking about the warmth of the clothing and so on.—A. This is a function of the Defence Research Board. It is one they have been actively concerned with. I feel we have done only a little in the way of cooperation with them, but I would have to inquire as to whether there has been any major effort. My feeling is that most of our effort in clothing has been on textile materials.

Q. That is the wearing quality?—A. More than that; thermal conductivity, and all sorts of other things. Our textile people have been acting as advisors to the Department of National Defence.

Q. We have heard quite a bit about the long-wearing quality of some new material that was developed with the corps; did you do any of the research on that?—A. No, that was developed actually in the directorate of inter-service development, I think.

Q. You did not do any?—A. It is a National Defence organization.

Q. You did not do any of the tests in connection with that?—A. Through Canadian Patents and Development we have been concerned with the patents on it and the marketing of the patents. Our textile people have certainly examined it and we expressed an opinion on it, but we had nothing to do with the developing of it.

Q. Have you any record of the opinion that you expressed?—A. Could we get that at a later time, sir, when we visit the laboratory?

Q. Yes. Have you done anything on the testing of rubbers—the type of rubber that stands up at very high temperatures, and low temperatures and keeps its qualities under those extreme temperatures?—A. Yes.

Q. Whom did you do that for?—A. To my mind again, most of that has been done for the services, or we have done some investigational work in regard to that for the Polymer Corporation, and we have been rather intimately concerned with the rubber companies. But again, I would have to get the details. I cannot answer in detail.

By Mr. Coldwell:

Q. You mentioned the work of the defence research board several times. Is there any lending of personnel between the two scientific groups in the field of the services and of the National Research Council?—A. There is a rather close relationship. As far as the board is concerned: we have quite a close administrative relationship. As president of the Research Council I am an ex-officio member of the Defence Research Board. We have quite definite tie-ins on subjects of salary, personnel requirements and so forth. Then we have two main fields of work which are really defence requirements. One is in aeronautics; and there is a coordinating committee as between the services, the air force, the Defence Research Board and ourselves.

Q. Is there any duplication of efforts or research?—A. I would say no. Because, in general, the problems of the services are specialized problems. As far as we are concerned, our interest is civilian. We will only do things for the services if they request us to do them; and in fact, perhaps if they twist our arm a bit as well. The general relationship with the services is we get many inquiries and requests for jobs where we happen to have people in the field in which the services are interested. Sometimes it is a request that we do something for them because they have not the facilities and we have. In that case, if it appears to us to be worth while doing it, we will do it.

Q. What I was thinking, doctor, the Defence Research is newer than the National Research Council, and I was wondering if they were likely to replace some of the activities of the National Research Council, if there was a danger of duplication?—A. No. They have replaced—they were set up to replace—our war-time activities as the research wing of the services. That, from their point of view, is a very big job. I do not think there is any danger of their wanting to step outside the defence field; and from our point of view, we do not want to step inside the defence field, except when it is essential.

By Mr. Stewart (Winnipeg North):

Q. Mr. Chairman, when an employee of the Council invents some gadget, and it is duly patented under the Council, what sort of reward is given to the inventor in the way of royalties; and when this patent is let out to companies operating in Canada, what steps, if any, are taken to see that the consumer is not exploited?—A. The first question: This has now been laid down under the Public Servants Inventions Act, and the rates of bonus are now specified under that act. They start, I think, at 15 per cent on the first $10,000 of gross royalties, and then scale down as the amount increases.

As far as the question of not exploiting the public is concerned: if we have a patent, our normal desire is to get it into use so that it will be of some use. We would certainly keep a close eye on the licensee. I think we have been more concerned with the difficulty of getting the invention taken up than we have with any question of exploiting, because one of the great difficulties with any invention is that the man who takes it up is being called on to gamble a very considerable amount of money, and you cannot always find people who are willing at any moment to gamble such an amount of money.

Q. If there was a patent available, and I as a manufacturer liked it could I come to the council and say, "I am willing to pay you a certain fee for the use of it, but I must have the exclusive use"?—A. With regard to that, the arrangement is that the council automatically turns all its patents over to Canadian Patents and Development Limited. Dr. Birchard is the president of Canadian Patents and Development Limited, and I think he could give you, much better than I, the details and the negotiations in regard to contracts.

Dr. BIRCHARD: In Canada it is very very seldom that an exclusive licence is arranged. It is done on this basis: first of all, we would write a non-exclusive licence with the party's requirement. Then, we would estimate his capital investment, because sometimes it is quite large. We survey the market to determine what the output might be, and we make a calculation of the time it might take to get a reasonable return on his capital investment. If it is an item that has a wide consumer demand, then we will have quite a number of other manufacturers wanting it. Our trouble has been to get a man, or get an industry interested in taking it up. Over the past few years there has been a large demand for consumer goods, the industry is making money on their present line of goods and they hesitate to take on any new item. In general we have been rather fortunate when we could get even one industry to introduce it. If that product is in demand, then you may find other industires that will also want to take it up. That is why we do not sign up exclusive licences in Canada, unless it is some particular, scientific instrument, or something of that kind where your market is very limited.

Mr. STEWART (*Winnipeg North*): So that before you license any invention you go very carefully into the financial capacity of the company which wants that licence?

Dr. BIRCHARD: Oh, yes.

Mr. STICK: If you did grant an exclusive licence you would put a time factor on it, would you?

Dr. BIRCHARD: Yes. If he does not follow up and get into production on that particular item, and if it is in the interests of the general public, then we put in our agreement facilities for cancelling the agreement.

By Mr. Stick:

Q. If you give a manufacturer an exclusive licence he is the only one who can use it, but you could in your agreement say: "We will give it to you for five years, and after that the exclusive licence ceases"—or the time factor, or something like that.—A. It may be for much less than that. Very few are given for five years.

Q. Patents are subject to time limits, are they not?—A. Patents in Canada are good for a period of 17 years from the date of the issuance.

Q. And they automatically cease then?—A. Yes.

By Mr. Brooks:

Q. I want to ask you a question more along the line of what Mr. Coldwell was asking, as to the coordination between your department and the Fisheries Research Board, for instance. Now, we have heard a lot about the Columbia river. The Columbia river is dammed, and they are trying to arrange the fishways so the fish can get up, and it will not affect the spawning and so forth. That is just an example. Is there cooperation between your department and the fisheries department?

Dr. STEACIE: Yes. In general, we have not gone in very largely for biological work. We do it in the prairies, a regional laboratory, and the Atlantic laboratory, and in the applied biological division we have people who are concerned with the processing of biological materials, but we have not gone in very much, relatively, for biology, mainly because the Department of Agriculture, the Department of Fisheries and, the Department of Northern Affairs with their forestry studies have been in this rather largely. Our cooperation with the Department of Fisheries involves a committee on aquatic biology through which we have given some grants, and the cooperation in awarding scholarships in fundamental subjects relating to the Department of Fisheries. We administer the scholarships through money provided in the estimates to the Department of Fisheries.

Then, on a few problems where we have people who are competent, we have done work in collaboration. This is true in the Halifax laboratory, particularly, where there has been a modest amount of work done in collaboration with the fisheries research branch in Halfax. So, I would say that the collaboration is excellent, but that the amount of work involved, from our point of view, is quite small, because normally we are not in that field and do not have people with the skills that are required.

Q. What objection would there be to having all research work, that is the Department of Defence, the Department of Fisheries and every other department, coming under the National Research Council? It would seem to me that the one body should handle it all.—A. I think, sir, that it was very definitely the view of the National Research Council at the end of the war that defence research should not come under the council. I think this was a wise decision, because it is our responsibility to think of science as such, and it is the Defence Research Board's responsibility to consider the actual needs at any moment of the armed forces. To my mind, this is true also in a case like agriculture and mining—

Q. Is it handled in the same way in the United States and Britain?—A. It varies from country to country. In the United States, defence is not only separate, but it is awfully complicated, because the liaison between the three services in the United States is not all that it might be, sometimes. Agriculture is separate; also mining is a separate department—the Bureau of Mines; then there is research under the Department of Commerce and it is all quite a complicated set-up. In England there is an agricultural Research Council which is something like our council which deals with agriculture, a Medical Research Council which deals with medicine, the Department of Industrial and Scientific Research which deals roughly with the rest of the non-military work, and the Ministry of Supply which deals with military work. I would say in every country there is this same separation, although the partners under a given umbrella are not necessarily the same in all countries. I feel that it is not desirable to put things all under the same umbrella. We have very good cooperation at the moment and I think that when you have a department whose sole concern is agriculture that the agricultural research is a part of their activities and their outlook. In my opinon, the existing situation is a better situation than if there was an attempt to group everything under one roof.

Q. It might be a little more expensive.—A. I think actually that the present set-up does not increase costs in any way. What I think would affect expense would be efficiency. I think the present situation is more efficient than one enormous department spread all over everything.

By Mr. Hosking:

Q. Do you think that you are losing anything from it? For instance, I am thinking of the work in rubber. You get a chain every day in industry; for instance, the gaskets which go around refrigerator doors are made of the same sort of rubber as for insulation on aeroplanes.—A. Of course, the manufacturing companies who are making things for the services are also the ones who are making things for civilian use. The rubber industry is a very good example. There is complete coordination on the industrial side because a company which makes the civilian material is the company making the military material and the moment they see something developing for defence purposes which has a civilian use, they try to apply it.

Q. You do not lose anything by it?—A. I do not think so. I think the coordination is very good.

By Mr. Stuart (Charlotte):

Q. I believe you said that in respect to information which is already available to you that if you have a request for the information it is given freely?—A. Yes.

Q. But if there is a request for some type of information which requires further investigation, there is a charge made?—A. There may be; there is not necessarily a charge.

Q. Any information which you already have is given without charge?—A. In a given case it would depend on circumstances; in this sense, that if we possessed some information and a company suggested that in order to make use of it we should lend one of our people to them for six months, then we might charge them for his salary. Any kind of an inquiry which we can answer in the normal way is answered free of charge.

Mr. HOSKING: Dr. Rosser, on page 16, are these people on your staff?

Dr. ROSSER: Yes. We have 558 people classified as scientists and engineers.

Mr. HOSKING: And this is the way they are chosen?

Dr. ROSSER: Yes; it is the breakdown.

Mr. HOSKING: I am wondering why there are not more doctors from Queen's University which has the best medical school in Canada.

Mr. STICK: You made a bald statement there.

The WITNESS: These would be Ph.D.'s. We do support the universities in medical research but we do not carry on any medical research ourselves. There might be one man there with an M.D. degree who has made a transition to some other field.

Dr. ROSSER: There are two men here with medical degrees. That is all we have.

Mr. HOSKING: What would they procure their doctor's degree in? Could you find out?

Dr. ROSSER: Twenty-eight people at Queen's; two with doctor's degree; eighteen bachelors, and eight masters.

The WITNESS: Queen's has only been giving the doctor's degree relatively recently. I think that about 1925 they began to give it in physics only. They gave a few in physics in that period and only started giving it in chemistry in the last few years. The total output of students with Ph.D. degrees in Queen's has been quite small. You will notice that Queen's has more master's degrees. Except for McGill and Toronto, the total number of doctor's degrees granted before the war by other universities was quite small.

Mr. HOSKING: That is what I thought. Then, I see London, 28, and I wondered why a comparatively small school would have so many.

Dr. ROSSER: That is London, England.

The WITNESS: Western Ontario is 9.

By Mr. Weaver:

Q. Mr. Chairman, I wish to ask a question on page 11 of the blue book with regard to estimates. I see pure chemistry and pure physics together for an estimate of just under $1 million. That is the only case where pure research is mentioned among the estimates. Is that an indication of the ratio between pure research and applied research?—A. We have made an attempt to estimate what should be the ratio. Our thinking was that in a large applied organization one does need some fundamental research. This provides, I think, a stimulus for applied work. It provides people who can be valuable as consultants to the people who are doing the applied work. The work in the engineering division would be all applied and, therefore, our estimate was that it probably was not unreasonable to put in something like 10 per cent for pure science, and, this, you will see, does not come very far from it.

Q. I wondered if that is considered as enough?—A. I think it is. I think our real function is as an applied lab. What we have tried to do is to get the best possible people in the pure science, and, of course, in applied science also, building up a small but very competent group. I do not feel that one should expand this too far because our duty is applied research. I feel that we have come to a reasonable balance where we are getting what we hoped to get out of this fundamental group and, at the same time, are not overemphasizing it.

By Mr. Murphy (Lambton West):

Q. Doctor, if you turn to page 16 again, the number of doctors you have on your staff from Canadian universities is 93, as I figure it, out of a total of 293, the balance coming from other parts of the world and many of them from the United States. Is that the usual proportion you have of Canadian doctors on your staff. Is that not low?—A. There are several points: one is that those members of our staff over a certain age would have come along at a time when there were only two universities in Canada granting doctor's degrees. There has been a tremendous upsurge since the war. Also, there are quite a number of Canadians who have obtained their doctor's degree by having taken their master's degree in a Canadian university and then going abroad and taking their doctor's degree.

Q. You have, in your master's degrees, 56 Canadians out of 109; bachelors, 120 out of 156. This would indicate that you are not getting those who acquire their Ph.D.'s in Canada in a good proportion to the number you have employed. The others, of course, which you naturally get are those with master's and bachelor's degrees.—A. We are on a very steeply rising curve as regards research in Canada. If you take a lab with any normal age distribution a lot of the people would have obtained their degrees at a time when there was not too much research being done in Canada. This is accelerating and the percentage of Canadian degrees is rising.

Q. What percentage would you have of Canadians, say, five years ago, who were doctors?

Dr. ROSSER: It has been rising steadily. There are 52 American doctorate degrees but, I know, they are all Canadians. They are not Americans.

By Mr. Murphy (Lambton West):

Q. One ties in with the other. Our graduates do not get their Ph.D.'s in Canada? They would go to the United States and come back here and you employ some of them?—A. They are obtaining their degrees in Canada to an increasing extent as time goes on. In 1918 it was almost unheard of to get a doctor's degree here; you just automatically went abroad. It is steadily rising and the percentage here is much larger now.

Q. Would the doctor tell the committee how many of these 293 would have been on your staff for, say, 15 years?—A. I think we could compile that.

Mr. HOSKING: Could I make a motion that we adjourn.

The CHAIRMAN: There will be a meeting of the agenda subcommittee later today. I will advise you of the hour later on. We will meet Wednesday afternoon at 3 o'clock.

Mr. MURPHY (*Lambton West*): Will the minutes, Mr. Chairman, be available soon?

The CHAIRMAN: I cannot tell you that. I do not know how far behind they are running.

HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 4

NATIONAL RESEARCH COUNCIL

MONDAY, MAY 14, 1956

WITNESSES:

Dr. E. W. R. Steacie, President, National Research Council; Dr. E. R. Birchard, Vice-President (Administration); Dr. F. T. Rosser, Director, Administration; Dr. J. B. Marshall, Director of Awards.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956

74298—1

SPECIAL COMMITTEE ON RESEARCH

Chairman: G. J. McIlraith, Esq.

and Messrs.

Bourget	Hardie	Richardson
Brooks	Harrison	Stewart (*Winnipeg North*)
Byrne	Hosking	Stick
Coldwell	Leduc (*Verdun*)	Stuart (*Charlotte*)
Dickey	Low	Weaver—(20).
Forgie	MacLean	
Green	Murphy (*Lambton West*)	

(Quorum 11)

J. E. O'Connor,
Clerk of the Committee.

MONDAY, May 14, 1956.

The Special Committee on Research begs leave to present the following as its

FIRST REPORT

Your Committee recommends that its quorum be reduced from 11 to 9 members.

Respectfully submitted,

GEORGE J. McILRAITH,
Chairman.

MINUTES OF PROCEEDINGS

MONDAY, May 14, 1956.

The Special Committee on Research met at 11.00 a.m. this day. The Chairman, Mr. G. J. McIlraith, presided.

Members present: Messrs. Bourget, Byrne, Coldwell, Dickey, Forgie, Green, Hardie, Hosking, Leduc (*Verdun*), McIlraith, Murphy (*Lambton West*), Stick, Stewart (*Winnipeg North*), Weaver.—(14)

In attendances Dr. E. W. R. Steacie, O.B.E., Ph.D., D.Sc., F.R.S.C., F.R.S., President, National Research Council; Dr. E. R. Birchard, O.B.E., B.A.Sc., D.Sc., Vice-President (Administration), Dr. F. T. Rosser, Ph.D., Director of Administration; Dr. J. B. Marshall, B.S.A., M.Sc., Ph.D., Director of Awards.

On motion of Mr. Stick, seconded by Mr. Murphy (*Lambton West*),

Resolved: That a recommendation be made to the House to reduce the quorum of the Committee from 11 to 9 members.

On motion of Mr. Hosking, seconded by Mr. Green,

Resolved: That Mr. Weaver be Deputy Chairman.

The Chairman called upon Dr. Rosser to complete his statement begun at a meeting of the Committee held Monday, May 7, 1956. Dr Rosser dealt, in a general way, with that phase of the work of the Administration Division relating to awards.

Dr. Steacie, at the request of the Chairman, introduced Dr. Marshall and outlined his duties as Director of Awards.

Dr. Marshall confined his remarks to the subjects of scholarships, fellowships, grants and bursaries.

During the course of questioning which followed the witnesses referred to the following topics:

1. Grants to University Professors;
2. Graduate studies in Canada by non-Canadian students;
3. Assistance by Industry in the promotion of graduate studies;
4. Solar energy;
5. Powdered coal;
6. Grants by Government Departments;
7. Fisheries research.

A copy of a document entitled "Fellowships, Studenships and Bursaries—Who's Who—1953" was filed with the Committee and copies distributed to members.

Questioning of the witnesses continuing, the Committee adjourned at 12.45 p.m. to meet again at 11.00 a.m. Thursday, May 17, 1956.

J. E. O'Connor,
Clerk of the Committee.

EVIDENCE

14th MAY, 1956
11 a.m.

The CHAIRMAN: Gentlemen, I see a quorum. There are three preliminary matters I would like to bring up. The first one is this: would the members of the agenda sub-committee please wait at the conclusion of this meeting in order to have a meeting of that sub-committee. Is that agreeable?

And in that connection could we agree as to the time of adjournment today? Twelve forty-five? Agreed.

Now, the matter of a quorum. I promised to bring that up again.

Mr. STICK: I move that we reduce the number of the quorum of this committee from eleven as it now stands to nine.

Mr. MURPHY: I second the motion.

The CHAIRMAN: Agreed.

Now, there is the matter of a deputy chairman. I might explain that the question of a deputy chairman is raised at my own request; it originated with me because I might want to be away a bit.

Mr. HOSKING: I move that Mr. George Weaver be deputy chairman.

Mr. GREEN: I second the motion.

The CHAIRMAN: Is that agreeable? Carried.

We are ready this morning to proceed with the matter of the examination of the policy and practice with respect to scholarships and grants in aid. We have the balance of Dr. Rosser's evidence which deals with that subject, following which Dr. Marshall will deal with it, and our plan is to stay on that subject during the whole of this meeting. Any other subjects will be ruled out of order for the duration of this meeting. I now call on Dr. Rosser.

Dr. F. T. ROSSER, (*Director, Division of Administration*): Mr. Chairman, The Awards Program falls into two main categories—grants and scholarships. Grants are made to professors to help promote scientific research in the universities. The trained men and the equipment are available in the universities but frequently a heavy load of teaching duties leaves little time for the professor to do experimental work. The money which the Council grants provides for essential assistance and for specialized research equipment that the universities might not normally be expected to purchase. Since many of the assistants hired by the professors are students, it means that our money works twice, helping to promote research and to train new scientists at the same time. Applications for grants are carefully considered by a subcommittee of the Honorary Advisory Council which takes full responsibility for awarding the grants. Once again the Division of Administration plays a vital role in summarizing applications and preparing briefs in a standardized form for consideration by the Committee. These summaries enable the members to assess quickly the proposed problems and evaluate the research done in the laboratory.

A second system for making grants is in the hands of the Associate Committees. These Committees, set up in many fields to coordinate scientific endeavour, are comprised of experts and interested people from all over Canada. They are the best groups possible to assess and evaluate research projects in their respective fields. Applications for grants in the fields in which Associate Committees operate are passed to the Associate Committee for review and recommendation before presentation to the Grants-in-Aid Committee of the Honorary Advisory Council for final approval. Cooperative research direction by Associate Committees as developed by the Council is greatly admired elsewhere and has been copied in many places throughout the world.

The Council's assistance to brilliant postgraduate students has kept pace with the country's scientific expansion. Scholarships are available for postgraduate students at Canadian universities, for Canadians studying abroad when it is desirable for them to do so, and for foreign students to come to work in Canadian laboratories. Again the direct responsibility for recommending scholarships rests with the Scholarships Committee of the Honorary Advisory Council. They set the standards for scholarships and see that all awards are made on an impartial basis for merit alone. Over the years they have done a magnificent job and their work is recognized and admired throughout the country. But an inefficient administration could sabotage this effort, as well as the others. A tremendous amount of work goes into the preparation for a Council Scholarship Committee meeting. As soon as an application is received it is checked for missing documents, letters of recommendation are requested, transcripts of university records are obtained, details of experience, publications, etc., are filled out. When everything is together, the file is summarized in the same standard form that is used for personnel work and mimeographed copies of the summary are made. When the Committee meets, every member has before him full information on every candidate in a form that can be evaluated easily. In this way the Committee can make reliable decisions on from 250 to 275 candidates per day. In the fiscal year now ending nearly 450 scholars doing graduate research work have received National Research Council awards.

Mr. Chairman, Dr. Marshall will be glad to continue and to give you detailed information on the administration of grants-in-aid and scholarships.

The CHAIRMAN: Just before he does that, would you care to say a little more about his exact position, in order to refresh our memory?

Mr. MURPHY (*Lambton West*): Please read the last sentence again.

Dr. ROSSER: "In the fiscal year now ending nearly 450 scholars doing graduate research work have received National Research Council awards." As I was saying, Dr. Marshall has to prepare scholarship details for the committee meeting, and the committee passes on about 250 cases per day, making two days of heavy work for them. If it was not for the administrative work that is done in Dr. Marshall's office, and done well, I am sure they would not complete it in a week.

The CHAIRMAN: I thought that either you or Dr. Steacie might say something by way of identifying Dr. Marshall.

Dr. E. W. R. STEACIE (*President, National Research Council*): Dr. Marshall is a scientist and a biologist. He has had considerable research experience. He also has had experience in administration with one of our laboratory divisions, and then some years ago he transferred to administration. Since that time he has devoted full time to the administration of our awards program with the scholarships, grants-in-aid, and things of that sort.

He has also done a considerable amount of work of a statistical nature in making sure that we understand where the program is going, and he has also had considerable outside dealings in the same field. His office has been handling the administrative work for the Canadian government overseas awards, that is blocked funds scholarships which are administered by the Royal Society of Canada; Dr. Marshall's office does the administrative work in connection with the competition. He has also, at their request, handled the administration of outside scholarships put up by the Nuffield Foundation, Merck, Shell Oil and a number of companies, so that the work of his office is quite extensive from this point of view. I think it probably is not realized that the total amount of money that is distributed in this way through Dr. Marshall's office amounts to something in the order of $\frac{1}{3}$ to $\frac{1}{2}$ of the Rockefeller Foundation or Carnegie Foundation programs in science. In other words, this is a major foundation program in the grants and scholarship field. I think, therefore, that Dr. Marshall has unquestionably had more experience than anybody else in Canada in this type of work, and there is no question of the importance of the work of the office. It is also essential that the man administering this should have started by doing research himself. It is essential that somebody with research training himself should be doing this work in order to understand the problems.

J. B. Marshall, B.S.A., M.Sc., Ph.D., Division of Administration, Awards, National Research Council, called:

The WITNESS: Mr. Chairman, the foundation activities of the National Research Council have expanded enormously since they commenced in 1917. This is set out in a blue book, which I believe members have. There are two graphs, one on page 32 and one on page 35, which shows fairly clearly how the work has expanded in 35-odd years. This growth, particularly in the last 10 years, has taken place without radical changes being made in the policies and principles underlying the scholarships and grants programs and is evidence of the soundness of the plans that were made by those who planned the National Research Council. These plans which were made towards the end of World War I and developed in the post-war years, were put aside through the depression period and the second world war. The awards office which became an operating unit in 1950 was, I think, planned in 1920. During the intervening years, those who administered council grants and scholarships had other responsibilities as well, but the growth of the council generally has brought about a certain amount of administrative specialization. I shall try to describe the responsibilities of the awards office and relate them to the post-war growth of research in the universities.

In preparation for the March meeting of council this year, about 1,500 applications for grants, scholarships, fellowships and research associateships were processed for presentation to various council committees. Dr. Steacie mentioned some of the original planning which went into the work of these programs. During the current year the office will administer between 400 and 450 scholarships and fellowships, about 400 research associateships, 425 research grants, and look after a variety of special extramural activities, including the relations with international scientific bodies and travelling for delegates to their meetings and things of that nature. In themselves, the numbers I have just quoted are not significant nor do they differ greatly from data for recent years. Research associateships are new this year, and some increase in their numbers can be expected in the next few years. Applications for scholarships and fellowships will no doubt increase as graduating classes grow larger in the wake of increased enrolment, and since universities must expand, more applications for grants can be expected as well. Changes in the foundation program, therefore, seem inevitable.

From the standpoint of the fields of the research represented, scholarships and grants awarded for 1956-57 are quite similar. This is not at all surprising; research projects proposed by university investigators are of their own choosing, and it is natural that students wishing to do research should be attracted to the fields which are near to the hearts of their teachers. Certain branches of chemistry, physics and biology are well represented this year as they have been in the past; geological sciences and most of the applied fields are less well represented. It is not difficult to trace the influence of past and present Canadian university scientists on the pattern of research reflected in current awards. There is nothing unusual about this development—nor is it peculiar to scientific disciplines. The reputation of universities and colleges in any field of learning can usually be traced to the outstanding abilities of the teachers, who have influenced and stimulated the undergraduates, arousing in them a curiosity and spirit of adventure into the unknown.

Individuals wishing to carry on experiments, to test their ideas have been able to come to the National Research Council for financial help to aid them in their work. The funds provided have enabled them to purchase special equipment and to hire assistants—very often students wishing to gain experience and further their training. In the five years 1946-51, 60 per cent of all grant money was used for the wages of assistants, 25 per cent to purchase equipment and about 15 per cent for supplies and other sundry expenses. The same proportions probably apply for the next five-year period, that is the period concluding this year, but expenditures for equipment may account for a somewhat larger proportion of the total in future years. New tools for research are being developed rapidly and are opening up vast new fields for investigation. There is also a very rapid rate of obsolescence in equipment.

Before 1939 and in the years immediately following the war, grants were awarded to individuals on a rather modest scale and in annual amounts. In keeping with the times the trend has been to somewhat larger grants; special grants for expensive equipment installations have been provided, and larger annual operating grants have become more common. This trend has encouraged university investigators to plan their work for longer periods in advance, feeling that they can depend on renewal of support from year to year and that their efforts to build up facilities for training and research would be protected. Administrative changes introduced during recent years have been largely in recognition of a stage of development in the scientific life of the universities. Grants are now made with assurance of continuity to investigators who have been active and productive, and in receipt of annual grants for some time. Groups of individuals working on related projects coordinated by a senior scientist are also supported in a similar manner.. Nearly one-half of the total amount to be provided during 1956-57 has been approved on this basis. Investigators have also been encouraged to plan ahead in another way. They can make separate applications for expensive non-recurring items of equipment, that are in addition to annual operating expenses.

Annual grants have not been discontinued; new investigators who are getting started, and others whose requirements are intermittent and subject to change may still submit applications for grants each year.

I have already referred to the proportion of grant money used for wages, without commenting on the classes of assistants employed. Professional scientists, technicians, some clerical help and relatively few unskilled labourers are employed, usually on a full-time basis. In addition a number of students work on the research projects using some of the results obtained as material on which to base theses, required for graduate degrees. Students are usually employed on a part-time basis and are paid wages that are set in relation to competitive Council scholarships. In this way the National Research Council has assisted in the training of many students in addition to those who have held scholarships.

Before going on to the scholarship and fellowship programs, some information on the distribution of grants by field of research may be of interest. Research in sciences related to medicine account for about 1/3 of the commitments for 1956-57; Chemical, Physical and Biological Sciences account for 17·5, 19·8 and 18·3% respectively; research in Engineering Departments 5·5%, Dental Research 1·8% and miscellaneous sciences (Geology, Mineralogy, etc.) less than 1%. A variety of special fields is represented within each group and a more elaborate breakdown would doubtless provide useful information. However, for the present two comments may be made. The Council does not have central Medical Research Laboratories, the medical research which it supports is, therefore, extramural; on the other hand, it has extensive engineering laboratories that could not be duplicated in university centres without an enormous outlay. Engineers, with or without graduate training, are in very great demand; traditionally they have been concerned with immediate problems of development, building etc., and, consequently, have not had either time or the inclination to carry on investigations. There are signs, however, that research in University Engineering Departments will develop as it did in Science Departments after World War I.

The Council's scholarship and grant programs have been mutually complimentary, and have many characteristics in common. Again data for 1956-57 scholarships awards are characteristic of previous years. About half of all the applications received were in chemistry and physics, and half of the awards were for advanced study in these subjects. Biological and agricultural sciences together make up the next largest group, about 18% of the applications and 12% of the awards. Mathematics, geology and mineralogy, various branches of engineering and chemical engineering each represent between from 4-8% of the totals. The applications and awards were at all levels—Bursaries for the first year of graduate study, Studentships and Special Scholarships for intermediate and final years, and Post-doctorate Overseas Fellowships for study abroad. For the term 1956-57 there were about 1,850 students registered for advanced degrees in science, engineering and medical departments at Canadian universities.

I think that figure differs somewhat from the one given by Dr. Rosser last week since it includes the students in the medical department. These are students usually proceeding to an advanced degree in a science "having a medical slant". If 145 Bursary applicants are eliminated from the total number of applicants for scholarships, 386 remain, or about $\frac{1}{5}$ of the total number of advanced degree candidates.

The applications for Bursaries are received from students who are to graduate this spring. Probably many have now graduated so they do not appear in that figure. Not all of the 386 applicants are resident in Canada when they apply. Applications are received for Special Scholarships and Post-doctorate Overseas Fellowships from many students already abroad. Thus about $\frac{1}{6}$ of the graduate students in Science, Engineering and Medical Departments of Canadian Universities have applied to the Council for scholarships this year. Of course, there are many other sources of financial assistance for graduate students, e.g. part-time teaching, employment as research assistants, other scholarships, etc. This assistance is not limited to Canadian universities, and is an important factor in the choice of institution for advanced study.

The amount of assistance and the place where it is available is important in a student's selection of where he will go to carry on his graduate work.

Most Council scholarships are awarded for study in Canada, but in recognition of the limitation of facilities in certain fields of study, in Canadian universities, Special Scholarships for study abroad are awarded in limited numbers. There is keen competition for these scholarships, and very few, Canadian students have difficulty gaining admission to universities in the United Kingdom or European universities after they have completed training to Ph.D. level in Canada. Council has limited the amount of support granted for pre-doctoral study abroad, preferring to give support to the promising young European Ph.D. graduates for a year or two in the United Kingdom or European universities. Proximity to the United States and the relative ease with which Canadian students can get support at American universities are important factors in regard to this policy. There are many ties between Canadian and American universities, because of the fact that many university teachers in Canada did their graduate work at American schools; geographically too, it is easier for some Canadian students to go to American universities; in the Maritimes and in British Columbia students go on to East and West Coast American institutions. In Central Canada students living in border cities also tend to go to the nearest institutions. The greatest attraction seems to be the greater variety and choice of opportunities for advanced study in the United States and the welcome given to Canadian students in that country.

The fact that many graduates from Canadian universities seek training abroad is not a reflection on our institutions. It is rather a compliment to the excellence of their undergraduate training, and experience in graduate work as far as it has gone, that they seek wider opportunities, and find ready acceptance at the large American institutions.

Not all of the movement of students is out of Canada. Since 1947 there has been a growing interest in the Council's Postdoctorate Fellowship program that provides awards that can be held in the Council's laboratories, those of other Government Departments with research facilities and in Canadian universities. These are the only "open" Fellowships awarded by the National Research Council. In nine years nearly 3,000 applications have been received; 338 individuals have held awards; 156 are currently at work, 79 in Council laboratories, 34 in universities, 13 in Science Service, Department of Agriculture and one at the Dominion Observatory. These Fellowships have had a very stimulating effect on the work in the laboratories where they have been held. The countries represented among those now holding awards are United Kingdom (52), Canada (20), India (16), Switzerland (7), Holland, New Zealand (6), Belgium, Germany, Japan, South Africa, United States (4), Australia, France, Turkey (3), Poland, Spain, Austria, B.W.I., Bulgaria, China, Egypt, Finland, Hungary, Israel, Portugal, Sweden and Jugoslavia (1 or 2). Ceylon, Denmark, Éire, Iraq, Italy and Pakistan have also been represented.

Most of the Fellows return to their homes abroad, a number go on to other Fellowships or employment in the United States, and some eventually accept positions in Canada. With the current demand for research scientists, the services of these Follows are much sought after.

Research Associates

To give further encouragement to research in the universities, the National Research Council has recently introduced a plan whereby university teachers who spend their summers directing the work of graduate students or carrying on their own research may receive tangible recognition for their work. These people may now apply for Summer Research Associateships which carry honoraria of $800 each.

Medical Research Associates

A plan to support a limited number of Research Associates in university Medical Faculties has been introduced and four appointments have been approved this year. The appointees will be able to spend all their time on research activities, including work with graduate students.

Mr. MURPHY (*Lambton West*): Dr. Rosser, you mentioned in your statement the awards and grants of scholarships, I think to professors. Is that paid to the universities? It is not paid to professors?

Dr. ROSSER: It is paid directly to the professor.

Mr. MURPHY (*Lambton West*): I understood the other day that these grants would be—

Dr. ROSSER: The universities administer the grants for us, but the grants are not made to the university.

Mr. MURPHY (*Lambton West*): That is all right. Would you tell us how many of these grants were given last year, say, to professors?

Dr. ROSSER: You are speaking of individual grants-in-aid? Dr. Marshall has the figure.

The WITNESS: About 425.

By Mr. Murphy (Lambton West):

Q. That is for professors?—A. Yes. Are you referring to the summer associates?

Q. No, I was referring to the statement made by Dr. Rosser and I was confining it to professors. Would there be that many grants last year to professors?—A. Yes.

Q. Would one professor get more than one grant?—A. In some cases, but not very often, as we have been getting away from that.

Q. Have you the breakdown of the universities in which those professors serve?—A. They are in nearly all the universities, with a few exceptions and there are some in hospitals and other institutions where research is being carried on. I could give you the names of the universities.

Mr. MURPHY (*Lambton West*): There would be universities in every province and in some provinces there would be two or three. There is Queen's, Toronto, McMaster, Saskatchewan and so on.

Dr. STEACIE: There would be grants to all the universities. In Ontario, they would go to Toronto University, to Western, McMaster, to Queen's and to Ottawa. I am not sure about Carleton. It has had one grant but of course, it is just getting started. Then in Quebec there is Laval and there is McGill, the University of Montreal, and the École Polytechinque. In the maritimes some of the universities are quit small and their grant history is likely to be intermittent. That is to say, in the very small universities they may not apply for grants each year. However, grants have been made at one time or another to all the maritime universities. Therefore, I would say that grants are made to all universities, where they give an honours degree. If they do not give an honours degree, of course, the probability is that no one is interested there in doing research.

Mr. MURPHY (*Lambton West*): You mean Ph.D.

Dr. STEACIE: No, even an houours B.Sc. But in general, the main interest in research is in a university which gives at least a master's degree and usually a Ph.D.

Mr. MURPHY (*Lambton West*): Do you find that there is some specified type of work carried on at different universities, the same type of work? Is there some way you have of directing efforts, where there may be several people interested in the same project or interested in solving something?

Dr. STEACIE: In general, the last thing we wish to do with grants is to interfere with academic freedom. These are not contracts to do work we want done: they are given freely to the university professor. The only governing factor is the ability of the professor and his reputation. The question as to whether work in an exact field may go on in several universities is not a serious one as work is going on in laboratories all over the world. It is up to the professor to see that he is not merely duplicating in a routine way what someone else is doing. If he has not got the imagination and initiative to do something novel, we would not be supporting him with a grant.

Mr. MURPHY (*Lambton West*): Is there not a way of finding that out, of correlating the work done by these professors in different universities, so that one at any university would know what the other is doing—or do they do that among themselves?

Dr. STEACIE: In the first place, pure science is done through open publication and through personal correspondence to get results a little more quickly. In the applied fields, our own associate committees have a great effect. This is particularly true in the prairie provinces regarding work on agriculture, on grain and so forth. The prairie regional committee is really set up for two purposes. One of them is to coordinate the work among the various people doing grain research and so forth. The other is to make grants. Therefore, their annual meeting is effectively a symposium at which every one discusses his own work. You do not need this as much in pure science because of the fact that open journal publication is the recognized way. I would say that in Canada our people are remarkably familiar with what everybody else is doing in his own field. We are small enough to make that possible still. In a country the size of the United States it is a little more difficult. Also, I would say that through our own contacts—both our own laboratory operations and our scholarships—we have a rather remarkable knowledge of, I would think it is fair to say, what every single university professor in the country is doing. I think that through our council we can make a remarkably good assessment as to how able a research worker is, how active he is and what the value of the work is.

By Mr. Murphy (Lambton west):

Q. One thing of interest is the number of graduates from our universities who take the Ph.D., what percentage of them take it in Canada and what percentage go outside Canada for it?—A. It depends to some extent on the field in which they pursue their training. In chemistry and physics, for example I would think about at least half of all the students who go to take an advanced degree, take their degrees in Canada in chemistry; and in physics more than half.

Q. Where do they take those degrees in physics and chemistry?—A. At the present time they are taking them mostly at McGill, at Toronto, at the University of British Columbia, New Brunswick, at McMaster, Saskatchewan, Queen's, and at Laval and Université de Montréal.

Q. How many years does it require? Is it the same in each university?—A. Yes, but you cannot pin that down. It runs about four years from graduation if they go straight through. It may take five or six years, but four is usual.

Q. Most of the rest of them would go to the United States, I assume?—A. Yes, with a fair number going to the United Kingdom and to continental countries in Europe.

Q. Doctor, I want you to appreciate that this is not a slight to our educational facilities or institutions in Canada. If you were hiring a Ph.D., in physics would you have some preference with regard to whom the man or woman associated his studies?—A. Well, I should not speak about a physicist.

Dr. STEACIE: I could do that, if you like.

Really, I think, sir, it is not always realized that a Ph.D. is a very personal degree. The student works from three to five years directly with a university professor who has not very many graduate students, in the normal case, seven or eight, maybe less, and occasionally more. The consequence of this is that the degree is specialized in a given field of chemistry or physics.

You may have in this country somebody that is as good as anybody in the world. In another narrower field it may be that there is not very much available in this country. I have had working with me personally, on these post-doctorate fellowships, people from about 17 different countries, and I would say that the Canadian product stands up very well to all of them.

There are obviously second-rate people in Canada and in every other country, and there are first-rate people in Canada as in every other country.

I would say that a Canadian Ph.D. is just as good a Ph.D. as is given in any other country. When one wants a specialist in a very narrow field, it may be that Canada is a very good country to go to for him, and it may be that Canada is not. In specialized fields you will obviously have this variation.

Mr. MURPHY (*Lambton West*): Doctor, can you tell the committee how many students from other countries come here for their post-graduate work, Ph.D.'s?

Dr. STEACIE: That is a figure I have not got.

Mr. MURPHY: (*Lambton West*): Would it be very few?

Dr. STEACIE: It is an increasing number.

The WITNESS: It is increasing all the time.

Dr. STEACIE: It is increasing all the time. There are a lot now particularly from the Columbo plan countries. There have always been a number.

Mr. MURPHY (*Lambton West*): Is that because of grants, doctor, to those countries for education?

Dr. STEACIE: I think these are under developed countries coming to a place that is more developed. We have always had in Canada from the earliest days a very large number of West Indian students, and we have been getting a scattering from around the world. There is also quite an appreciable number of foreign students from European countries and the U.S.A. taking Ph.D.'s in Canada.

Mr. MURPHY (*Lambton West*): Would there be many outside of the British Empire.

Dr. STEACIE: Yes. There is also, in certain universities, for one reason or another, a large concentration from a particular country and it becomes a habit. There are certainly a lot of students from Hong Kong in Canadian universities, for example, and in certain fields from all sorts of other countries.

Mr. DICKEY: Would this result from the influence of students on their fellow students back at home, and also the influence of professors in these particular places?

Dr. STEACIE: Yes, I think so. There is quite a large foreign enrolment in under-graduate courses, and of course, those students spark it. The student comes here and takes an under-graduate degree. He may stay, but even if he does not, and goes back home, Canada becomes well known.

Mr. HOSKING: Do we take reasonable care to see that these students that come from other countries and return to their own home again are receiving a good psychological training as well? The reason I ask the question is, so often you will see graduates from British universities go back to their own country and immediately turn around and hate Great Britain. I think that is something inspired in their post-graduate training. The system is criticized. There is something that creates this feeling that the British system is not good, and when they go back to their own country they immediately turn on the country which educated them. Do we do a good job in preventing that?

Dr. STEACIE: I think we have. One thing you must remember, not only is the university a cosmopolitan place, but the graduate school particularly has probably less nationalism than any other group of people anywhere. At the graduate level, you find an almost complete absence of nationalism. Also, I would say that as far as students, perhaps going to Britain and getting a bad impression, it is probably now the United States where they get a bad impression. The wealthiest country in the world at any given moment, of course, raises certain jealousies, and we are not wealthy enough, or important enough to raise the same feelings.

Certainly my feeling has been that amongst graduate students particularly, where I have had more experience, I think we are sending back people who are really ambassadors for Canada.

Mr. HOSKING: You would be very careful to see if there happened to be a very brilliant professor in some school, and he was doing a very good job in an educational sense and a very bad job in a public relations sense, that grants to him are very carefully worded. I raise that as a point of interest: we should do it.

Dr. STEACIE: No, we would not. We consider that our function is to back good science where we find it, and that these other questions are not those which concern us. The moment you get into this kind of thing, you are running into tampering with university freedom.

In the United States certain tendencies in that direction have had most undesirable results. From our point of view the professor, to us, is a scientist and we will judge him on his scientific work. The only time that you might ever judge him on any other ground would be if he were such a nasty person that students would not work with him for more than two months. This would, of course, spoil his scientific reputation. From our point of view we have been extremely careful to avoid any question of considering any political factors. I am using the word "political" in the widest sense.

The CHAIRMAN: Mr. Stewart.

Mr. STEWART (*Winnipeg North*): Mr. Chairman, perhaps I could add a sort of addenda to what Dr. Steacie has said. The other day I was travelling in a plane with an Indian student who had been over here on the Colombo plan doing some post-graduate work in agriculture. He could not get back to Travancore fast enough to tell his people what he learned in Canada. I asked him if there had been any attempt at indoctrination of any sort whatsoever, and that was the one thing that impressed him most. There had been none of that. He had been helped to do a terrific job, and he was going back as an ambassador to India to try to do some sort of a job there. I think those who are responsible for that sort of thing desire a great deal of credit.

Mr. MURPHY (*Lambton West*): Doctor, this question I have is based on the ads appearing in the New York *Times* or the Sunday *Times*. If you have looked at them you have noticed it; it seems to me that there are openings for thousands of engineers, and the reason I want to ask this question is, I notice that most of the requests for applications have been for those people who have taken post-graduate courses. I was wondering if the president, not being a university professor, could answer this question: could he tell us, in view of the demand for better educated scientists, what efforts are being made? I think you touched on it the other day; but in answering this question, could you, as president of the National Research Council give any idea to the committee about what methods are being employed, and if we should encourage more of our good students to do graduate work or post-graduate work?

Dr. STEACIE: You are referring to engineering specifically, I take it?

Mr. MURPHY (*Lambton West*): Yes.

Dr. STEACIE: The position is this: if I may use the analogy of the sciences: at the end of the first war there was in Canada very little research at the universities, but this work has developed very strongly since, and I think the Council can take considerable credit for its support through scholarships and grants. Actually, therefore, what has happened is that whereas in 1919 you had just an occasional university scientist doing a little research, it is now common place that in university departments in science you expect to find people doing research, and you do find them doing it, and we are turning out a lot of scientists. Well, in engineering research, that is a thing which is relatively new as far as its being a major factor is concerned. The tradition in engineering faculties has been not to do research, but to do consulting work and so on. Canadian engineering schools established a very good reputation in a pioneer country in helping its railway building, dam building, and hydro electric development. Now, especially in electrical engineering and in mechanical engineering, research has come in very markedly. Electronics is the biggest of these fields that has produced this result. At the moment there is a very big demand for research-trained engineers, but you will find this: that a great deal of the demand is for research-trained engineers with experience. Well, there are not very many research-trained engineers with experience, and it may be many years before there will be.

In Canada we are hoping to fill the need through developing research in engineering faculties. There is no question about the lack of it.

Mr. MURPHY (*Lambton West*): Do you mean the lack of facilities?

Dr. STEACIE: No, the lack of interest. We are anxious to do anything we can, but it is a slow process. You do not convert a middle-aged man into a research man if he has not done research right throughout his career. There is not much use in asking him to start. What is necessary is to increase in the universities the number of younger engineers interested in research. Now, this necessity is coming at a time when university salary scales are low, and when therefore the temptation to do consulting work is very strong.

We are very anxious to do all we can to spark this development. I think that it is a gap which can be filled slowly. When the university engineering departments become more interested in research, gradually they will get on their staffs younger people, fresh appointments of people who are interested in research, and who will stick with it. Certainly as far as we are concerned, whenever a man in a university engineering faculty is interested in research, we will do everything we can for him to help to develop his interest. In other words we are in the position in engineering research in Canada in general that we were in in science after the first war. I say "in general" advisedly, because there are a few striking groups in engineering which are doing fine work today, which are very much interested, and are making a major contribution.

Mr. MURPHY (*Lambton West*): I have two or three other questions on one of which I would like to have your opinion before we are through. You mentioned these foundations. Do you administer, let us say, the Rockefeller Foundation or other foundations?

Dr. STEACIE: We do some work for the Nuffield Foundation and the Merck Company.

By Mr. Murphy (Lambton West):

Q. How much is paid each year to Canada? It is paid to the National Research Council is it not?—A. We do not actually get any money from the Nuffield foundation.

Q. Where do the students go from here?—A. They would go to the United Kingdom and they are looked after by the Nuffield Foundation there. We did have funds from the Merck Company which ran to about $6,000 a year.

Dr. STEACIE: In some cases we administer them from the point of view of choice.

Mr. MURPHY (*Lambton West*): Would you tell the committee if you get funds from industry for scholarships or fellowships of that nature?

Dr. STEACIE: We do not get funds from industry, but we have been acting as consultants to industry, as members of selection committees and so on.

Mr. MURPHY (*Lambton West*): I understand that the Bickle Foundation and Imperial Oil have made grants for fellowships. Are you called in in that connection?

Dr. STEACIE: Well, as to the Imperial Oil, I am a member of the selection committee on scholarships or fellowships which are set up by Imperial Oil. I am not sure of the number, but I think something like four university nominees are nominated to this committee by the National Council of Canadian Universities, and two are nominated by the company. I am one of the company nominees and I sit on the selection committee which is also an advisory committee in the way of programs.

We have also been consulted in various ways other than by sitting on committees, and in some cases we have been asked to make the appointment of the entire committee, by a great many other industries.

An industry may come to us and say "will you appoint a group of four people as a selection committee to give advice on scholarships and to choose the successful candidates?"

We have also been consulted on various other types of supporting programs, and I can say that in one way or another we have been consulted in some detail by almost every one of the industries who are giving this kind of support.

Mr. MURPHY (*Lambton West*): Let us say that Imperial Oil is giving a scholarship or a grant for that purpose. Would those scholarships or grants be used for research in connection with further studies and scientific studies in connection with their own industry?

Dr. STEACIE: No. What happens with various companies is this: they choose the field of interest; that is, a firm which, let us say, is a chemical firm would perhaps be more interested in scholarships in chemistry than, let us say, in physics; on the other hand a company which is an electrical manufacturing firm is more apt to pick physics; but in general I would not like to go into all the details of any one firm too critically. There are one or two companies which do tie it up a little too closely, but the vast majority of them leave the entire field open, and I think their reputation has been very good in not trying to tamper with the field of work.

Mr. MURPHY (*Lambton West*): This is distinctly apart from my other questions, but I want to ask you this: are your research activities in anyway active or do they anticipate any of these programs which they have in Arizona? Is any research work being done here on sun energy, about which a good deal has been said in many publications in the last six or eight months? I wondered if through your council any work was being done in that connection?

Dr. STEACIE: No. There has been a little interest shown in the work of Professor Allcut of the University of Toronto. We are doing a lot of work in photochemistry which is the basic background of this, and which actually is my own specialty. Feeling has been that, from the Canadian standpoint at the moment, this is not a particularly important subject. At the moment we have very large hydro electric developments which we are very much concerned with and nuclear or atomic energy, and we are not a country that is noted for strong continuous sunshine and lack of other power sources. In other words, Arizona is a place where this is obviously attractive. What we have been doing is merely holding a watching brief on this. I do not think at the moment that it is a subject in which Canada should play any major role. However, I think that one needs to watch to see where it is going.

Mr. MURPHY (*Lambton West*): It would be most important in an area like Arizona and even in the South American areas.

Dr. STEACIE: It is a long-term problem. I do not think it is one in which you will get very many short-term results. We have people, for example, engaged in the biology division in work on photosynthesis, that is the study of the affect of light on plants and that sort of thing; in that sense you could say we are investigating solar energy as a source of power in connection with growing something. The engineering method whereby you try to collect radiation over a big area has a lot of great difficulties.

Mr. MURPHY (*Lambton West*): The reason I asked the question was not so much in connection with what they are doing in Arizona so far as energy is concerned, but rather in reference to home construction. As you know, many engineers today—construction engineers—are enthused about it.

Dr. STEACIE: Our building research people are definitely interested in this, but I think the general view is we are pretty far north for this to be too attractive a proposition.

Mr. MURPHY (*Lambton West*): Even when it concerns house heating?

Dr. STEACIE: It is an economic question and I think our building research people could give you some more definite views on the subject.

Mr. HOSKING: Are any of the provinces objecting to grants being given to the universities in any way?

Dr. STEACIE: By the National Research Council?

Mr. HOSKING: Yes.

Dr. STEACIE: No.

Mr. HOSKING: There is no interference?

Dr. STEACIE: No.

Mr. HOSKING: Do you keep any record of the students who we do assist and their end result, where they go, how many come back to the government, and how many go to industry?

Dr. STEACIE: I think that this "Who's Who" of ours has been distributed.

The CHAIRMAN: It has not been distributed. Perhaps it could be explained and then put on the record now.

Dr. STEACIE: We have a "Who's Who" of all past scholarship holders going back to the beginning in 1917. There are, of course, a few who have not answered our letters and we have lost track of them, but in general we have kept pretty detailed track of these. I think that Dr. Marshall could give you the information.

The CHAIRMAN: Perhaps I could file the booklet now. It is "Fellowships, Studentships and Bursaries, Who's Who", and was compiled by the awards office of the National Research Council. The last year for which it is available is 1953.

Dr. STEACIE: We bring it up to date about every 5 years.

The CHAIRMAN: There will be one for each member. Perhaps Dr. Marshall may make a statement first.

The WITNESS: In the introduction to this booklet there is a table numbered "table III" in which we show the occupation and the location of scholarship holders. In running down that we have those located in Canada, the United States, U.K. and Commonwealth, elsewhere, and so on. In Canada there are

330 engaged in government work, provincial or federal, 167 in industry—who are doing research in industry—28 who are in industry but probably in executive positions or administrative work of some kind, 281 in universities and hospitals in teaching and research positions, and 13 in high schools—they would be science teachers, I expect—and then private practice which deals with medical doctors and consultants of one kind or another. That is a total of 837 in Canada in 1953. The balance of those in Canada is made up of 316 holding scholarships at that time, 65 who were studying but not supported by the National Research Council, and 35 who had retired. There were a total of 339 in the United States, 61 of them were still students, 278 were employed there, 41 in industry and 120 in universities and hospitals. The total percentage of those in the United States is 19 per cent. There are not too many in the United Kingdom; 56 employed, and 63 are still studying. There are 22 in other countries employed, and 3 studying in other countries, probably in France and Holland. We accounted for in all 1,736 individuals in this table.

Mr. HOSKING: I notice that there are 330 employed by governments and 167 by industry. That is almost two to one working for the government. Is that because we give grants and aid in the types of subject in which we want graduates, and do we do it deliberately, or is it something which just happens?

Dr. STEACIE: The thing is that present-day government research in Canada is on a scale per capita which compares favourably with Britain and the United States and industrial research is coming up but it is still a long way behind. The consequence is that for research training people there are more jobs going in government, federal or provincial, than there are in industry, and I think that these figures reflect this.

The CHAIRMAN: Figures given are as of 1953.

Mr. HOSKING: Do you think there should be more opportunities in government than in industry?

Dr. STEACIE: No. The thing which one hopes for the most—and in which the trend is very encouraging—is the further development of industrial research in Canada. This is coming up very steadily. I think that the percentage, Mr. Chairman, would have changed considerably from 1953 to 1956. But one point is that government research developed during the war and continued on. Industrial research is coming up slowly. For example, there is no industry in Canada that employs anything like the number of research scientists that Atomic Energy of Canada Limited employs at Chalk River.

Mr. MURPHY (*Lambert West*): Would you comment, in the same line, on the steel industry in Canada from the chemical standpoint?

Mr. HOSKING: Before I lose my opportunity, I would like to ask one more question along the same line which I started. There was a discussion of development of powdered coal. What has been the encouragement given on the study and use of powdered coal in the construction industry?

Dr. STEACIE: The mines branch has done considerable work on this, I believe.

Mr. HOSKING: This does not concern you at all?

Dr. STEACIE: It would not be our function; this would be for the mines branch.

Mr. HOSKING: Then you do not recommend any grant to them either?

Dr. STEACIE: We do not make grants to industry for such research, but to universities only.

Mr. HOSKING: This, as I understand it, was done at McGill university—

Dr. STEACIE: We have given support to work by Dr. Mordell at McGill.

Mr. MARSHALL: Dr. Mordell also had grants from the mines branch; his work was supported by another government department.

Mr. HOSKING: Do you have any "say" in the amount of money awarded? Do you make any recommendations? Or, if another department takes an interest in a specific case do you just step out of the picture and let them go ahead?

Dr. STEACIE: Our position with regard to this is that we have, from the point of view of our laboratory operations, a certain defined field in which we operate. We stay out of agriculture, for instance, because it is the function of the Department of Agriculture, and we stay out of mining because it is the function of that particular department. On the other hand, from the point of view of supporting university professors or awarding scholarships, we cover both these fields; we are supporting students and professors in both agriculture and mining. What would normally happen would be this: we are mainly concerned with what one might call research in universities, not with development work. When the development stage is reached another department might give a contract or they might give a grant. These would tend to be rather few but relatively large—a given department becomes interested in a specific field and they might give quite a large grant. An example of this is the fact that the Defence Research Board is backing the Department of Aeronautical Engineering of Toronto in quite a large way because this work is very definitely concerned with service requirements. Actually the Defence Research Board is backing Dr. Mordell's work at McGill, and it is also being backed by the Department of Mines.

Mr. HOSKING: Supposing you felt that the assistance which had been given was already enough—supposing you felt that money awarded in grants was being wasted because a department was trying to carry out further research in a subject which you had already studied extensively—is there a proper arrangement for liaison? Could you talk to some of the officials and say: "Look, we have done this work."

Dr. STEACIE: I think liaison is very close because, in one sense, Canada is small enough for everybody to know everybody; we have completely detailed knowledge of what is going on in all government departments in the field in which we are interested and they know what we are going, in the fields related to them.

Mr. HOSKING: Do they ever come to you and say: "Should we do more work on this subject? Should we, or should we not, make more money available through our department"?

Dr. STEACIE: This is something which is discussed all the time at working level. There is a great deal of discussion of this sort, particularly with regard to grants. No one is given a grant unless we know or—in the case of a department—until they know all other sources of grants. This is one question that is always asked, and therefore if it appears that a scientist is receiving a grant from the Department of Agriculture we then discuss with them what the magnitude of the whole thing is and whether, if we both give grants, the total amount would be too large, or whether a man is asking for the same grant twice from two different sources. As far as these questions are concerned there is very thorough discussion between the different bodies.

Mr. HOSKING: Do you keep track of the American grants as well?

Dr. STEACIE: Yes.

Mr. HOSKING: And you do not think that there is an opportunity for the waste of money by departments on a considerable scale with regard to this type of research where they have access to more money than they can possibly use wisely?

Dr. STEACIE: No, I do not think so. There is another factor that enters into it, too. If someone is flooded with money that he does not need in a university it will not be a long time before other people in the university know it, and since universities as a whole are short of money a howl will go up awfully quickly. I think, myself, that considering the amount of money available we are making very good use of it.

Mr. STEWART (*Winnipeg North*): Obviously there are many more applicants for grants, fellowships and burses than the number allotted. Is it possible that some people who are worthy of help are turned down because of lack of funds?

Dr. STEACIE: Usually, what we have tried to do is this: we have tried to keep the scholarships on a reasonable prestige basis. The receipt of a scholarship does carry appreciable prestige and we make our decisions on that basis. Assistants are also hired under grants, but the same prestige does not attach to them. We feel, therefore, that we should not increase the number of scholarships too greatly and lower the standard; we would prefer that the men who are good enough, but only average, should be supported under a grant rather than by a scholarship. So, if you consider the two methods together and look at them both I do not think you will find that many people are being turned down. But the scholarship does carry an additional prestige and, in addition, a man who gets a scholarship is free to study where he likes. Otherwise, it is the professor who has the grant and who looks for students. We feel that by supporting students in this double way we are maintaining the scholarships for the better students with their high prestige value. Others get support through the grants.

We have made a survey, and if you consider all the students in science and engineering and all possible scources of support—university part-time instructorships, industrial scholarships, provincial scholarships and so forth—the conclusion one comes to is that essentially all graduate students in science and engineering are being supported.

Mr. STEWART (*Winnipeg North*): So there is, in effect, no lack of funds for productive purposes?

Dr. STEACIE: There is a great general lack of funds in universities.

Mr. STEWART (*Winnipeg North*): So far as you are concerned—

Dr. STEACIE: What, of course, would happen if the universities had more money would be that they would expand their staffs and so on. At the present time, as far as we are concerned, our university support has been rising quite rapidly. I think it is vital that it should continue to rise rapidly, but I would think that as far as graduate students are concerned they are being taken care of at the moment.

Mr. DICKEY: I think it would be very interesting to the committee if you could explain in general terms what these grants are spent on—support of students, purchase of equipment, and so on.

Dr. STEACIE: The grant is made to a university professor following an application in which he states what he needs and why is is applying. It would depend on how much money is available and the ability of the professor—both factors. The decision is made as to how much he will be given. Maybe it is the full amount or it may be considerably less than the sum for which he applies. He has specified on what he wants to use it but when we make the grant we make it as a lump sum.

Mr. BYRNE: Would you give just an example of what a professor might say? Would he say what he was going to study, say a particular line of produce?

Dr. STEACIE: The application would be for a specific subject, that is, he might be going to investigate anything under the sun. He would state a detailed and specified subject, that if he gets this money, he proposes to investigate the effect of this on that. He says he would like, say, $4,000 for special equipment, and he details the main items. Perhaps also he wants to hire a student for the summer at $800 and perhaps he wants to support two students during the term for $1100 each or something like that. It may work up to a total of $8,000. We may decide either that this is satisfactory or that it is too much in the light of the amount of money available. It may be necessary to do some cutting and we may give him $6,000. Then he is free to go ahead, to buy the equipment or to take on students. If he specifies students and writes to us and says he cannot get the student but needs extra equipment, we would normally agree. In fact he has quite a great deal of flexibility. What we do keep control over is the rate at which he pays students. If he is going to hire anyone under the grant, we insist that the salary scale be kept in line. If we did not do so, he might pay an amount more than the amount of money we pay in a scholarship. One student might then get more under the grant than he would under the scholarship. Actually we maintain a slight differential in favour of the scholarship.

As regards the things on which the money is spent, part is equipment, the second thing is the hiring of people. These people to a large extent are students, but to some extent there may be the hiring of a technician or there may be casual summer labour, for example, as is quite usual in the case of agricultural projects. There may be a little for general clerical assistance but we do not look favourably on this, under the grants, as we feel that sort of thing should be provided by the university. Travel comes into it but in general we do not look favourably on travel, unless it is an integral part of the project. That is, if there is a botanist proposing to do field work in the Arctic in the summer, then travel to and from the Arctic is obviously a justifiable charge. Basically, however, it is equipment, supplies and people—and the people are mostly students.

Mr. BYRNE: I would like to get clear in my mind the position when a professor asks for a grant to go into particular research? Is it something that would have general application? Supposing he wants to do research into special uses for a certain metal that would affect one industry particularly, could he go ahead with that or is he referred to the industry itself?

Dr. STEACIE: We are operating two distinct things. In our laboratories it is our responsibility to look into things which are of economic value to the country. In supporting research it is our duty to develop Canadian research to the best of our power. In giving grants we take no consideration whatever of the economic side of it. If it is good science, we back it: if it is poor science we do not. We back pure and applied science without discriminaton in favour of one or the other. We are not using these grants to university professors as a contract to persuade university people to do industrial work: we are supporting the research the professor himself wants to do. We would not discriminate against him on the grounds of the practical nature or otherwise of the project. What we consider is whether it is good science. If it is, it will develop science in Canadian universities, train graduate students and produce the type of trained people who in turn will be useful in industry.

Mr. BYRNE: Supposing it was something in which industry itself was doing research, would it not be the practical thing to say: "We will turn this work over to the industry itself who may be doing practically the same thing"?

Dr. STEACIE: Well, yes, but in general it is our responsibility to try to aid industry by doing research. Now, if the industry is going to do the research there is no reason why we should give them a grant to do it. It is a part of their commercial operation. In other words, we will not give grants to industry to carry out research which they themselves need in their operations. It is a bit different in the defence department because there there may be a specific project which the department wants to develop, in which case they may let a development contract to industry. We are not in the same position of being a user in the way the Department of Defence is. Our concern is to try to get research going, to stimulate it in industry. It is not our function to finance research done in industry; that is part of the commercial operations in industry.

Mr. BYRNE: I suppose in a measure they are a charge against profit, they do get certain assistance in that way, if the organization itself makes a profit.

The CHAIRMAN: That is a matter of policy of the government at the political level, as opposed to the technical subject we are discussing.

Mr. MURPHY (*Lambton West*): I think we can switch to another point which I am sure would concern every member of the committee. In a country like Canada, where we have to consider the production process as well as distribution costs, is there any work being done outside, say, industry by the universities, or how can work be done through your council, to make a study of distribution costs in Canada? I do not mean in a particular industry, but the distribution costs generally. It is the big factor in the cost of doing business.

Dr. STEACIE: I fear it would be a very big mistake for us to do anything whatever about that. We are set up to do research in the natural sciences, our competence is all in this line and our people are all trained in this way. What you speak of a job for economists and it would seem to me that anything along those lines would be for either the Bureau of Statistics or the Department of Trade and Commerce. It would be very foolish for us as a scientific research organization to go into the social and economic sciences.

Mr. MURPHY (*Lambton West*): Yes, I understand. In connection with the steel industry, I read in some place a statement by some scientist that research in the fundamental chemistry of steel is being neglected. Do you agree with that?

Dr. STEACIE: I think it is true that it has been neglected everywhere in the world. I think steel making has gone on in a rather empirical way. It has been an art, and it has been relatively recent that any attention has been paid in any country to the fundamental chemistry of it. We are ourselves getting into this in Halifax.

Mr. MURPHY (*Lambton West*): That is what I am interested in.

Dr. STEACIE: One of the most alive organizations is the British Iron and Steel Research Association, but even they have a very small group in this field. We felt that it was a good thing to go into, and we sent one of our people over for the better part of a year to work in the laboratory of their association. He has now come back, and we have established a group in the Atlantic Regional Laboratory at Halifax.

Mr. MURPHY (*Lambton West*): Would he be in the Dalhousie University group, would that be the logical place for that group?

Dr. STEACIE: Mainly, because of the interest of steel in the maritimes. Cooperation is going on with Dominion Iron and Steel.

Mr. MURPHY (*Lambton West*): Doctor, along that same subject, our steel companies would be able to get information, I assume, from the institute in Great Britain concerning itself with the steel industry?

Dr. STEACIE: I am not sure. The research associations are of course, associations of manufacturers.

Mr. MURPHY (*Lambton West*): Yes.

Dr. STEACIE: I believe that in general our experience has been that they are pretty liberal in giving information.

Mr. MURPHY (*Lambton West*): What about the United States.

Dr. STEACIE: There is no corresponding association in the United States. It would be an individual company matter.

Mr. MURPHY (*Lambton West*): We will suppose that your staff...

Dr. STEACIE: I think that the steel industry is one that is pretty thoroughly tied together by ownership and control, so that I doubt if there are very many independent steel operators; and ultimately, through their organizations, they would have a relation with American laboratories.

Mr. MURPHY (*Lambton West*): Yes. The startling thing to me, doctor, was this statement, and I am glad to have your concurrence in the use of these other scientists in Canada. To me and to all Canadians, it is amazing that the steel industry, an industry which has been in existence so long, seems to lag in this fundamental chemical research.

Dr. STEACIE: It is a very difficult and experimental problem. The difficulty is that, because of the enormous size of things like blast furnaces, the heat balance is all right, but you cannot operate a blast furnace on a laboratory scale. It is not self-sustaining and you have to use a very high temperature. It is very difficult to find materials which will stand up. I think it is probably only within the last 10 or 15 years that techniques have been available to enable much of an attack to be made, and some attention given to the problem.

Mr. MURPHY (*Lambton West*): Now, doctor, with regard to the steel industries in this country like Algoma steel or the Steel Company of Canada, will they be given grants for their projects, or assistance, at Dalhousie, or other places?

Dr. STEACIE: No, this is being done on our own.

Mr. MURPHY (*Lambton West*): On your own.

By Mr. Stick:

Q. Dr. Steacie, you mentioned that you were assisting the study of biology in connection with fisheries research with the giving of scholarships and in other ways. Could Dr. Marshall give me an idea of what scholarships you are giving for the study of biology in connection specifically with fishery research?—A. Yes. We should have mentioned that we administer approximately $25,000 in scholarship assistance for the Fisheries Research Board of Canada. That would provide support for about 10 students. We cover various fields in biology and zoology, and to some extent the fields that are related such as oceanography, and the sciences that are related to fisheries problems. We have one or two in biochemistry. We have one on mathematics and statistics applied to the fishing industry.

These were all subjects that had a slant towards fisheries problems. In addition to that, prior to the Fisheries Research Board grant being made available, we had scholarships in the same fields that were supported by the council funds.

Q. Where is the research taking place principally? You have a laboratory in Halifax, of course?—A. Yes. There is some in Halifax, a good deal in the University of British Columbia, and the University of Toronto has always maintained work in that field.

Q. We have a scientific research board, and the fisheries council down in Newfoundland. You do not give any grants to them. I suppose they would come under the Department of Fisheries?—A. They would come under the Department of Fisheries, and the Fisheries Research Board.

Q. If you got a report from the Fisheries Research Council, if I could call it that, stating there was need for more scientists in fisheries research—do you get that kind of a report, and if you do, is there anything you can do about it? The reason I am asking the question is that I understand there is a great scarcity of scientists in fisheries research. Some of us who come from fishing constituencies would like to see it stimulated, and would like to see more scientists available.

For instance, I asked a question in the House the other day on the study of herring on the west coast of Newfoundland, which is very important. They did get some scientists out from the United Kingdom on the matter, but the reason it was not carried to a final conclusion was, as the minister explained, because of a shortage of scientists in fisheries research.

Now, if this vacuum of scientists in fisheries research is acute, I was wondering what could be done about it? I understand that you are not directly interested in it, and you work through the Fisheries Research Council. This is probably a question that should be directed to Dr. Steacie: is there any possibility of getting the National Research Council to stimulate the study with regard to fisheries research?

Dr. STEACIE: I think, sir, that we have recognized—and this is not only with regard to fisheries—but we have recognized that there has been rather a shortage of zoologists, and in fact of biologists in general. We have been supporting these fields in universities whenever possible and there are some very good people in this field. The problem I think is the result of the relatively small number of students who go into these fields, and I suspect that this goes back to the fact that not so very long ago opportunities were rather limited in these fields. You find a considerable drift at the present time to the field of physics. There is no question that the development of all sorts of things has produced a rush into this field. There are great opportunities in physics, and jobs are plentiful.

I think the biological sciences are running a bit light as far as students are concerned, and this is really the problem. If more jobs became available, and more openings arose, I think there would be a drift of students back into these fields.

Mr. STICK: This is a comparatively new science as compared to agriculture for instance, or something like that, as I understand it.

Dr. STEACIE: I think the opportunities outside agriculture for biologists were pretty small before the war, and since then they have increased considerably. I think, similarly, it will take time to build up zoology.

Mr. STICK: Do you think, as I stated, that the need is there for more scientists in biology as far as fisheries is concerned? Is it your opinion that the need is there, and it requires a stimulation of interest in that kind of work?

Dr. STEACIE: We cannot, of course, influence the students as to where they go, but what we can do is support any work going on in this field. We have been leaning over backwards in that direction.

The CHAIRMAN: I wonder if this would be a good point to break off our evidence for today?

Mr. GREEN: I have one question. Is the National Research Council doing anything in connection with research into the question of fish versus power? That is a very important problem on the west coast.

Dr. STEACIE: No, I do not think we have. I think this is a rather complex problem; it is more economic.

Mr. GREEN: I mean getting the fish over the dams.

Dr. STEACIE: Yes, we have certainly at one time or another been consulted in that field. We have acted in a consulting capacity on these things, such as fish elevators and so on, but this is rather far outside our own field except for the hydraulic aspects. We get called in frequently on things like the design of a dam and that sort of thing.

The CHAIRMAN: I do not think we can finish this evidence today, so perhaps we can adjourn at this moment. Will the agenda sub-committee please wait.

HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 5

NATIONAL RESEARCH COUNCIL

THURSDAY, MAY 17, 1956

WITNESSES:

Dr. E. W. R. Steacie, President, National Research Council; Dr. E. R. Birchard, Vice-President (Administration); Mr. B. G. Ballard, Vice-President (Scientific); Dr. F. T. Rosser, Director, Administration; Dr. J. B. Marshall, Director of Awards; Dr. N. B. Hutcheon, Assistant Director, Building Research.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956.

74428—1

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McIlraith, Esq.

and Messrs.

Bourget	Hardie	Richardson
Brooks	Harrison	Stewart (*Winnipeg North*)
Byrne	Hosking	Stick
Coldwell	Leduc (*Verdun*)	Stuart (*Charlotte*)
Dickey	Low	Weaver—(20).
Forgie	MacLean	
Green	Murphy (*Lambton West*)	

(Quorum 9)

J. E. O'Connor,
Clerk of the Committee.

ORDERS OF REFERENCE

MONDAY, May 14, 1956.

Ordered,—That the quorum of the said Committee be reduced from 11 to 9 Members.

Attest.

LEON J. RAYMOND,
Clerk of the House.

74428—1½

MINUTES OF PROCEEDINGS

THURSDAY, May 17, 1956.

The Standing Committee on Research met this day at 11.00 a.m. The Chairman, Mr. G. J. McIlraith, presided.

Members present: Messrs. Byrne, Green, Hardie, Hosking, Leduc (*Verdun*), MacLean, McIlraith, Murphy, Richardson, Stick, Stuart (*Charlotte*) and Weaver—12.

In attendance: Dr. E. W. R. Steacie, O.B.E., Ph.D., D.Sc., F.R.S.C., F.R.S., President, National Research Council; Dr. E. R. Birchard, O.B.E., B.A.Sc., Vice-President (Administration): Dr. F. T. Rosser, Ph.D., Director of Administration; Dr. J. B. Marshall, B.S.A., M.Sc., Ph.D., Director of Awards; Dr. N. B. Hutcheon, M.Sc., Ph.D., Assistant Director Building Research; Mr. B. G. Ballard, Director, Radio and Electrical Engineering.

The Committee resumed consideration of National Research Council Scholarships and Fellowships, Awards, Grants and Bursaries in Canada and abroad. Dr. Steacie was called. He completed answers previously given thereon.

The witness placed before the members of the Committee the following tables, quoted extracts therefrom, and was further examined.

I Enrolment of Foreign Students at Canadian Universities 1953-54.

II Scholarships and Research Grants 1917-56.

III Enrolment of Foreign Students at Canadian Universities 1953-54.

IV Expenditures—Scholarships and Grants in Aid of Research 1954-55 and 1955-56.

V Summary of all scholarship and research associateship applications processed in the Awards Office, 1952-56.

VI Summary of Applications and Grants Approved in March 1953-56.

VII Distribution of Scholarships by Field of Research March 1956.

The above tables were taken as read and ordered incorporated in the evidence.

Dr. Marshall, Dr. Rosser and Mr. Ballard answered specific questions.

Dr. Hutcheon was called and introduced by Dr. Steacie. He read a statement on the work and functions of the Division of Building Research and his examination was commenced.

At 12.15 o'clock p.m., Mr. Weaver, Vice-Chairman, took the Chair in the momentary absence of the Chairman.

At 12.30 o'clock p.m., on motion of Mr. Hosking, Dr. Hutcheon's examination still continuing, the Committee went into an executive session.

The Chairman reported the discussion which took place on procedure at the last meeting of the subcommittee on Agenda and Procedure in particular in respect of:

1. The Committee's proposed visit to the National Research Council on the Montreal Road.
2. Suggested evidence from outside witnesses.
3. Proposed visit to Chalk River.
4. The advantages of distributing in advance prepared statements by officials of the National Research Council not yet heard, etc. etc.

After discussion, decision was left to the subcommittee on Agenda and Procedure.

At 1.10 o'clock p.m., the Committee adjourned to the call of the Chair.

Antonio Plouffe,
Acting Clerk of the Committee.

EVIDENCE

MAY 17, 1956
11.00 a.m.

The CHAIRMAN: Gentlemen, I see a quorum.

Perhaps, if we would continue with the evidence first, and then I should like, at the latter part of this meeting, to break off hearing evidence at 12.30 and then discuss some matters of procedure, and the report on the last meeting of the agenda committee. Perhaps if we could proceed with our evidence until that hour, and then deal with that part of our business at that time it would be the most satisfactory way of proceeding.

On the last day we were dealing with the scholarships and grants in aid to the universities. There was some further evidence, and some further clarification of some questions that were asked on that occasion. Perhaps I could start by asking Dr. Steacie to clarify, one answer that was given.

E. W. R. Steacie, O.B.E., Ph.D., D.Sc., LL.D., F.R.S.C., F.R.S., President, National Research Council, called:

The WITNESS: One member of the committee asked a question regarding the registration of foreign students in Canadian universities. The figures are as follows: for 1953-54, Canadian students—60,803; American students—1,418; British West Indies—320; United Kingdom—179; and other nationalities—1,401. So that there is a very considerable registration of foreign students in Canadian universities; about 5 per cent of the total.

The CHAIRMAN: And the total number?

The WITNESS: The total number is 64,121. With regard to the McGill figures I have a breakdown. I think probably McGill has more foreign students relatively than any other university. There are 5,741 Canadians at McGill; 384 Americans, who are mainly medical and graduate students; 149 from the British West Indies; 51 from the United Kingdom; 249 other. The figure 249 for other students includes 20 Commonwealth countries and 47 foreign countries. So that McGill has 67 foreign countries represented. The total, you will see, comes to some 10 or 12 per cent of the total registration at McGill.

One interesting thing is—we were discussing the enrolment of Canadians in graduate schools in the United States—from the figures that we have it would appear that about as many foreign students come to Canada to do graduate work as Canadians who go to foreign countries to do graduate work. There is approximately an equal balance in these figures.

The CHAIRMAN: Are there any questions on that answer?

I asked to have some further data gathered together in tabular form following a question at the last meeting. I had intended putting the questions at that meeting at one o'clock, at the time of adjournment. With your permission I would ask either Dr. Steacie or Dr. Marshall to give the data that he has readily available in tabular form. There is nothing new, except that it gathers up what was being said at the last meeting, in the form of tables and summaries.

The WITNESS: There is one table which shows the breakdown which I think was asked for before, of the scholarships and research grants from 1917 to 1956, year by year. It is rather a lengthy table.

Mr. MURPHY (*Lambton West*): Why not just table it without reading it. That is the one I asked for, I think, doctor.

The WITNESS: The table is as follows:

National Research Council
Awards Office

Scholarships and Research Grants 1917-56

Year	Scholarships	Grants-in-Aid	Totals
1917-18	5,550	8,244	13,794
1918-19	7,150	29,530	36,680
1919-20	20,100	33,316	53,416
1920-21	16,925	51,779	68,704
1921-22	37,725	24,617	62,342
1922-23	34,975	42,060	77,035
1923-24	37,830	63,828	101,658
1924-25	39,202	54,580	93,782
1925-26	40,082	66,132	106,214
1926-27	41,105	78,045	119,150
1927-28	41,855	112,736	154,591
1928-29	43,720	208,839	252,559
1929-30	49,990	220,442	270,432
1930-31	59,535	178,924	238,459
1931-32	38,490	170,834	209,324
1932-33	17,605	104,127	121,732
1933-34	9,160	195,929	205,089
1934-35	11,825	179,828	191,653
1935-36	13,205	150,979	164,184
1936-37	15,675	176,820	192,495
1937-38	22,813	190,843	213,656
1938-39	28,310	218,901	247,211
1939-40	31,562	337,997	369,559
1940-41	33,355	246,114	279,469
1941-42	31,438	250,371	281,809
1942-43	32,300	235,318	267,618
1943-44	33,256	194,432	227,688
1944-45	29,025	255,231	284,256
1945-46	52,185	255,706	307,891
1946-47	101,901	435,116	537,017
1947-48	137,745	811,870	949,615
1948-49	166,914	897,540	1,064,454
1949-50	210,670	1,342,106	1,552,776
1950-51	238,950	1,571,221	1,810,171
1951-52	310,945	1,525,638	1,836,583
1952-53	365,773	1,775,851	2,141,624
1953-54	422,097	1,701,227	2,123,324
1954-55	642,483	1,568,357	2,210,840
1955-56	768,249	1,718,720	2,486,969
	4,241,675	17,684,148	21,925,823

I might just give you two figures that are interesting. One is: in 1917 it was $13,000 total. In 1955-56 it was $2,486,969.

The other interesting point is the breakdown for 1955-56, which was $768,000 for scholarships and $1,700,000 for grants-in-aid.

Over the whole period $21,925,000 has been given in grants and scholarships to the universities.

By Mr. Murphy (Lambton West):

Q. I think an interesting comparison for the committee to make would be to take 1950. Have you got figures for 1950, doctor?—A. Yes. Will the total do rather than the breakdown?

Q. Yes, surely.—A. 1950-51 was $1,800,000 for the total. 1955-56 is $2,486,000. I might add that the estimated figure for 1956-57 is $3 million.

Mr. MURPHY (*Lambton West*): That is all, thank you.

The WITNESS: I have another table which gives the breakdown for 1954-55 and 1955-56 of the expenditure for various types of university support. That is, it specifies science, engineering, medical or others. It shows the breakdown as between graduate scholarships, post doctorate fellowships and so forth.

The table is as follows:

NATIONAL RESEARCH COUNCIL

EXPENDITURES—SCHOLARSHIPS AND GRANTS-IN-AID OF RESEARCH

1954-55 and 1955-56

SCHOLARSHIPS

	1954-55	1955-56
	$	$
Science and Engineering		
Graduate Scholarships	428,635	456,796
Postdoctorate Fellowships		
N.R.C. Laboratories	384,734	387,923
Other Govt. Dept. Labs.	—	33,143
Universities	103,308	168,362
Medical Research		
Graduate Med. Res. Fellowships	41,373	54,529
Senior Medical Res. Fellowships	34,733	20,267
Committees		
Applied Psychology	8,870	10,865
Dental Research	5,400	6,000
Total	1,007,053	1,137,885

GRANTS-IN-AID OF RESEARCH

	1954-55	1955-56
	$	$
National Research Council		
Science and Engineering		
Individual Grants	333,232	440,434
Grants by Committees	188,728	237,454
Consolidated Grants	95,000	95,000
Non-recurring Equipment Grants	177,560	187,822
Medical Research		
Individual Grants	430,820	425,173
Consolidated Grants	143,000	193,000
Total National Research Council	1,368,340	1,578,883
Atomic Energy Control Board		
Consolidated Grants (Nuclear Res.)	200,000	246,000
Non-recurring Equipment Grants	—	49,176
Total N.R.C. and A.E.C.B.	1,568,340	1,874,059
GRAND TOTAL—SCHOLARSHIPS & GRANTS-IN-AID	2,575,392	3,011,944

RESEARCH CONTRACTS

	1954-55	1955-56
	83,562	54,888

In round figures, for 1955-56 in science and engineering: graduate scholarships were $456,000; post doctorate fellowships: in the N.R.C. laboratories were $387,000; in other government department laboratories $33,000; in universities $168,000.

Medical graduate fellowships were $54,000; senior medical research fellowships were $20,000; applied psychology was $10,000; dental research was $6,000.

For the same period—grants-in-aid were: in science and engineering to individual professors, $440,000; grants made by committees in various fields to university professors, $237,000; consolidated grants, that is grants whose continuity is guaranteed essentially, $95,000; in non-recurring equipment grants, $187,000.

In medical research: individual grants were $425,000; consolidated grants, $193,000. This made a total on grants of $1,578,000.

In addition to that, the Research Council administered Atomic Energy Control Board grants. These grants are in the estimates of the Atomic Energy Control Board and the board makes the decisions. The Research Council administers the grants.

Consolidated grants for nuclear research, $246,000; non-recurring equipment grants, $49,000. This makes a total of N.R.C. and A.E.C.B. of $1,874,000, and makes a grand total, including Atomic Energy Control Board grants, of approximately $3 million.

By Mr. Murphy (Lambton West):

Q. Doctor, you mentioned medical grants; do you have anything with regard to agriculture? Is there a breakdown of agricultural grants, or is that part of your—A. As far as agriculture is concerned, it is not a responsibility of ours to do experimental work in our laboratories. We support agriculture, and so does the Department of Agriculture. There is a difference in motives. The Department of Agriculture supports, in the main, by contract on specific projects, on which they have an over-riding interest.

Q. That is in their estimates?—A. Yes. Our grants are given to science, and it makes no difference to us whether it is agricultural science or any other science. So, we will be supporting work in things like plant biochemistry, plant breeding—in other words, genetics, and things of this sort.

Q. Doctor, who supports the work of people like Dr. Spinks in Saskatchewan?—A. Dr. Spinks is supported partly by consolidated grants from the Atomic Energy Control Board and partly by grants from ourselves through our normal grants-in-aid program.

Q. Is most of his work in agricultural research?—A. It is an unusual arrangement. He is a physical chemist, and he has had a great deal of experience in work on radioactivity and radioactive tracers, so that what is largely financed by us is a tracer laboratory at the University of Saskatchewan. He then teams up with various members of the agriculture staff in the university on projects that are in their fields of specialization. Where they want to use these methods, the thing is done as a joint project in this tracer laboratory. There is a similar situation at Macdonald College, where one member of the staff is operating what is essentially a tracer lab., with some support from us. Then other members of the college team up with him for the specialized techniques necessary in radioactivity.

Q. Are there any other universities, doctor, to whom you make grants in one way or another that carry on the same work, for instance, as Dr. Spinks does? I mean respecting his particular field?—A. The use of tracers in science, in general, chemistry, physics and biology particularly, is now a standard technique, and I think you would find that this technique is being used to some extent in all universities where any appreciable amount of research is being done. It depends, in a given university, on the amount of interest and the extent to which they go into this field, and the kind of investigations they do, as to whether it is desirable to set up a centre for tracer work, or whether it is best for each individual to operate his own counting equipment. It is a very widespread technique now.

By Mr. MacLean:

Q. Doctor, you gave figures for engineering and science, and I was wondering if you could give a further breakdown regarding scholarships, especially in the fields of science, to give an indication in what fields of science the recipients of these scholarships are studying.—A. Yes, I have that breakdown here, sir. This table gives the distribution of scholarships by field of research for March, 1956. That is, the scholarships that were awarded this year in March and will be used during the coming academic year.

This table is as follows:

NATIONAL RESEARCH COUNCIL

Distribution of Scholarships by Field of Research
March, 1956

Field of Research	P.O.F. $2,500	Sp. Schol. $2,000	Student $1,200	Bursaries $800	Totals	Value $
Agricultural Sciences	2	2	8	3	15	21,000
Astronomy	1	1	—	—	2	4,500
Biochemistry	3	—	5	7	15	19,100
Biology	3	2	23	7	35	44,700
Chemistry	6	6	44	12	68	89,400
Chemical Engineering	—	—	5	6	11	10,800
Engineering	—	3	4	7	14	16,400
Geology and Mineralogy	1	3	4	1	9	14,100
Mathematics	1	5	10	7	23	30,100
Medical Research	1	2	—	—	3	6,500
Physics	4	3	43	15	65	79,600
Not Specified	—	—	9	—	9	10,800
Total	22	27	155	65	269	347,000

There are four types of scholarships: post doctorate overseas fellowships, which are given to people who have already got a doctor's degree; special scholarships which are given for study outside Canada to people having their undergraduate degree; student scholarships, which are given to people taking their doctor's degree in Canada; and bursaries, which are given to people in their first year of graduate work in Canada. That is, in the first year after the bachelor's degree not too much is accomplished in actual experimental work. Courses are necessary too. It is a little hard to judge the students at this stage, and the bursary is a bit of a trial baloon. At the end of the year you really know whether a man is going to make good in research.

It might be, perhaps, easier if I took each type of scholarship separately.

For post doctorate overseas fellowships the breakdown is: agricultural sciences, 2; astronomy, 1; biochemistry, 3; biology, 3; chemistry, 6; geology and mineralogy, 1; mathematics, 1; medical research, 1; physics, 4. That makes 22.

There are a number of things that have to be taken into account when considering these figures. One is that there are a very large number of travelling fellowships in medicine from other sources. Thus, there is not the same necessity for medical overseas scholarships that there is for some of the other fields, where support is very sketchy from other sources.

In special scholarships, that is to study abroad, our general attitude is that we want people, whenever possible, to do their graduate work in Canada, but we feel it is reasonable that a certain proportion of Canadians should go abroad. There are, also, certain specialized fields where a subject may not be well developed in Canada. We, therefore, give a relatively smaller number of special scholarships—27 as compared with 155 studentships. The special scholarships are divided: agriculture, 2; astronomy, 1; biology, 2; chemistry, 6; engineering, 3; geology and mineralogy, 3; mathematics, 5; medical research, 2; physics, 3.

For studentships, that is scholarships where the man will take his doctor's degree in Canada; agricultural science, 8; biochemistry, 5; biology, 23; chemistry, 44; chemical engineering, 5; other fields of engineering, 4; geology and mineralogy, 4; mathematics, 10; physics, 43.

There are no medical ones listed here, because medical scholarships are handled separately. The ordinary scholarships are handled by the medical committee. If we go back to the previous table you will see that there is a total expenditure of about $76,000 for medical scholarships.

Bursaries, that is the starting year: agricultural sciences, 3; biochemistry, 7; chemistry, 12; chemical engineering, 6; engineering, 7; geology and mineralogy, 1; mathematics, 7; physics, 15.

This gives the totals: for agricultural sciences, 15; astronomy, 2; biochemistry, 15; biology, 35, chemistry, 68; mechanical engineering, 11; engineering, 14; geology and mineralogy, 9; mathematics, 23; medical research, 3; physics, 65; other fields, 9.

I think in these figures one might point out that biology and agricultural sciences, of course, are a bit inter-changeable. It is rather hard to distinguish between the two.

In general, biology means not specifically specified as agricultural. Biochemistry, from this point of view, can be medical or non-medical biochemistry. In general, if a man has no M.D., he will probably be appearing here. If he has an M.D. and is in biochemistry he will normally appear under the medical grants.

Engineering you will notice is heavier on the bursaries than the studentships. This is because at the moment there is not a very great tendency for students to go in for engineering research. The tendency when they do is not to go past a master's degree. That is why they will be heavier on bursaries. Relatively few are going on to a doctor's degree. This, I think, pretty well covers the general distribution by fields.

By Mr. Murphy (Lambton West):

Q. Doctor, there is one question I had in mind; of those that go abroad for further education in any specified field, is there any understanding upon the completion of their course that they should return to Canada?—A. No. In one or two cases in fellowships given by charitable foundations and so forth, terms of this sort have been put in, and it has been our feeling that there are two bad things about it. One is that it is objectionable in the sense that the student himself does not really know where his career is going to lead him. I think it is very difficult to take a young man at an early age and tie him up in this way. I think also that, wherever they are going, we have some responsibility to Canadians who wish to be educated. We would hope that they will return to Canada.

The other objection is that such a restriction is essentially unenforceable. Any government or organization which has put strings on these scholarships and said "If you do not settle in a given country you will have to pay the money back", has always found that the clause is not in fact enforceable. They have never collected, and they have caused a lot of ill will. So that from our point of view we feel that it is far better not to put on any strings, and to do everything we can to encourage the man to come back.

Q. Would there be any individual cases in your field, for instance, someone, we will say, who had graduated, and that you felt, or some of your associates felt that this man should obtain further study in some particular field? I was rather hoping that there might be cases like that where he would be educated, not necessarily with the tacit understanding that he would return but that, to further the objectives that you have in research in this country, he might be tempted, on his own initiative, to return to this country?—A. Would you mean someone that already had a job with us?

Q. He might have a job with you, but someone you recognized as good material for a particular field, someone with an outstanding future, but who required further study?—A. We have quite often, for example, offered a man a job and suggested to him that he apply for an overseas fellowship. If he got it, he would then go overseas for a year or two and come back to us at the end of that period. In some cases we have actually appointed people to our staff on the understanding they would have leave of absence while they were away, because we wanted them to go abroad and have further study.

Q. That is what I meant.—A. We also have, as in the case with other government departments, an arrangement whereby, when we get an outstanding man on our staff, we will sometimes agree to give him leave with half pay, or some fractional pay, to go abroad and take a doctor's degree, if he has not got one.

By Mr. Richardson:

Q. In respect of the grants that have been given to these men, have any of them been repaid voluntarily?—A. In the way of scholarships?

Q. Yes.—A. I do not think so. There has been no obligation on them to do so.

Q. None of them has voluntarily repaid?—A. I know, actually, of at least one case where a student applied for one of our scholarships because he felt that he wanted it for prestige purposes but could afford to go to university without it. Upon being awarded the scholarship he gave his university an equal sum to pay for a scholarship for somebody else.

Q. You spoke earlier about certain fields in which men would have to go to other countries. Would you like to amplify that answer?—A. We are in this position, that we have made very great strides in our universities from the time of the first war to the beginning of the second war, and particularly since the end of the second war. It is now approaching the stage where in the sciences one can get graduate training in Canada in virtually any field. There still are, and of course always will be, narrow fields of specialization where you cannot get training in Canada; this would be true of the United States or of Great Britain. It may be in a given field that one country in the world or one lab in the world is the only place where this particular speciality goes on. We have felt, on the whole, that the desirable thing is to have the man take his doctor's degree in Canada and then go overseas at a stage when he is more mature. On the other hand, when you get outstanding students who have made up their minds that the one place in the world where they want to go is to a given outside university, we feel that one should, to a certain extent, support this. It would, I think, be a great mistake if we did it to too large an extent.

Scholarships to a graduate student have two purposes; one is to train the student, and the other is to develop research in the university. We are, therefore, providing a scholarship for the student and an assistant for the professor at the same time. Had we financed students, starting from 1917, to go overseas only, we would never have built up graduate schools; therefore, we support the students in Canadian universities. But we do recognize that there are some cases where it is a good thing, in order to have diversity of training, to have some Canadians trained elsewhere, and especially where the student is able and has a very strong feeling in this direction.

There are, again, certain specialized fields where it may happen that at the moment there is not very much going on in Canada. We feel if we can finance people in this field to go abroad for this training, and then have a university hire them when they are trained, that we will get a new field established in Canada. We recognize the fact that when a student goes abroad it is not contributing toward the building up of a graduate school directly, although it may later do so if that student comes back to a Canadian university.

So, we have accepted the idea of a certain number of special scholarships for study abroad. I see on this table that it is 10 per cent, but if you bring in the students' support under grants, and medical students and other things, it comes down to 2 or 3 per cent of the total number of students supported.

Q. There has probably been a tendency for industry, as such, to settle in the central part of Canada. Would you care to make an observation in respect to this in the matter of graduate work in universities. Are universities, so to speak, influenced in this way to a very large extent?—A. I think that one of the most spectacular developments in Canada since the war has been extension of graduate work across the country. Prior to the last war, McGill and Toronto universities were essentially the graduate institutions, and there was very little in the way of graduate work done in the other universities; some of the other universities gave master's degrees, and good master's degrees, but most of them did not give the doctor's degree at all. For instance, a student at Dalhousie and Queen's would stay there for perhaps two years for a master's degree and then move on to McGill or Toronto to take his doctor's degree.

Since the war there has been a very large development of work towards the doctor's degree in universities outside of these two, and there now is a very large group in British Columbia; there is a very considerable amount of graduate work in all the prairie provinces, in all the western universities, and in other Ontario universities; there is a very big development at Laval and Montreal and in Ottawa; and in the maritimes Dalhousie has moved rather slowly and is just starting to give a doctor's degree. The University of New Brunswick is giving the doctor's degree in Chemistry. I think, from the research and the graduate training point of view that there has been an immense development in universities on the periphery relative to the position in the centre.

By Mr. MacLean:

Q. I am not clear as to whom bursaries are granted. Are they granted to students in their first year of work towards their master's degrees, and who intend eventually to go on to doctor's degrees?—A. Yes.

Q. Regarding these overseas scholarships, would you care to say a word as to what general area these students go to, generally speaking—what countries?—A. To study?

Q. Yes.—A. It depends considerably on the field. I think that Dr. Marshall could answer this question.

Dr. J. B. MARSHALL (*Division of Administration*): The post-doctorate fellowships are all either in the United Kingdom or in western European countries. We have had the majority in the United Kingdom, but have had one in Portugal, half a dozen in France, some in Holland, Denmark and Sweden. I think those are the countries; there may be one or two others. As to the special scholarships, three-quarters of them are held in the United Kingdom, an occasional one in France and Holland, and the rest in the United States.

By Mr. MacLean:

Q. Are there cases where it might be considered beneficial, at least interesting, or cases where the student himself might desire to go to some area where study cannot be arranged; I am thinking particularly of Russia, but it is not only there but would include places where we may not have as close liaison in research as we might like to have?—A. Apart from Russia, I think at the moment that the average student who gets one of these overseas scholarships naturally feels like going to the major centre. For this reason, in general, it would not be reasonable to expect him to go to, say, South Africa as compared to Britain. So, the reason for the concentration in western Europe is that the man will tend to go to the lab which is very well known in his own subject.

As far as Russia is concerned, the problem has not arisen. I think, myself, that it would be very useful if we had an exchange of students between Russia and ourselves. It would be very interesting to have people coming back who could give an assessment of the quality of work, and so forth, going on in Russia and who would have some knowledge of the line which they are taking. I do not mean by this formal information but more the atmosphere and the ability of the people and that sort of thing. However, I think that the question of exchange with Russia is obviously one that is not in our hands by any means alone. This is largely a problem of policy.

Q. I believe I am correct in saying that about a year ago there was at least one Canadian doing graduate work in the National University of Australia. Would he be there on a National Research Council scholarship?

Dr. F. T. ROSSER (*Director, Division of Administration*): He was there on an Australian scholarship. At least, I know of one Canadian who held an Australian scholarship.

The WITNESS: In our own labs we have had a considerable number of Australians who came to us for post-doctorate work.

By Mr. MacLean:

Q. Regarding graduate studies in science, have any of the recipients of scholarships in recent years studied in the fields of anthropology and archeology, or in any of the ordinary less common branches of science?—A. We would consider that that is outside our terms of reference. It is getting into the social sciences. There are borderline cases. We have given grants to assist in carbon 14 dating method; this is experimental, although its object may be archeological. We have regarded archeology and anthropology as being outside our sphere of operations. We have indirectly given some support to work of this sort through the Sir Frederick Banting Fund provided by private donors and administered by us.

Q. Are there any other sources of encouragement or financial aid that are available to students who are especially interested in these fields, that are on the periphery, or which are completely beyond your terms of reference?—A. I think this is something on which I could not give an authoritative opinion, but it is certainly my opinion, and I think the general opinion, that the support of the social sciences is not nearly as good as the support of the natural sciences.

By Mr. Murphy (Lambton West):

Q. Doctor, you mentioned that some of these people are going to Holland. Have you any record to give the committee as to what subjects they specialize in?—A. Well, one which immediately comes to my mind—and I know a number of cases—is work in physics of low temperatures at Leiden, which is very well known in this field; there is also a very well known Dutch school of specteocopy; others are chemical reaction mechanisms, and zoology.

By Mr. MacLean:

Q. Do students who are specializing in such things as plant breeding and related sciences fall into the field of agriculture or biology?—A. It is a matter of definition, and is rather confused.

Dr. MARSHALL: I think that the answer to that would be in the school from which they come. If they come from agricultural faculties they would be slanted in the direction of agricultural applications; but, on the other hand, they might have come up through biology and would be considered in the biology group. There are a great many of them who are ultimately in the same fields doing the same type of work.

By Mr. MacLean:

Q. Taking the whole field, is there one reason why there are quite a number of students doing post-graduate work in biologoy at the present time?—A. If you take this table, you have totals both post-doctorate and others, of 15 agricultural sciences and 35 biology, which would make 50 out of a total of 269. There has been a shortage of biologists and this is really, I think, a shortage of students going into the field. It is not a lack of support in biology; there has been a drifting away on the part of students. This is probably due to the high salaries and opportunities in engineering and the romantic side of atomic energy and things. These things do have an effect in steering students at any given time.

Q. My impression is that we have established, in the past, a very high reputation especially in the field of plant breeding particularly in regard to varieties of wheat, as an example. I am wondering if we are keeping on improving our relative position? Some countries, especially Russia, have seemed to make good progress in this field.—A. I am not an expert on this, but I think there is no question that our universities in the west are very strong in the field of plant breeding and also the Canada Department of Agriculture in its science service laboratories. So, I think it is a field into which a great deal of effort is being put and there are a lot of extremely able people involved. My own feeling is that it is a subject which is in good shape.

The CHAIRMAN: If there are no further questions, we have another short table here: summary of all scholarship and research associateship applications processed in the awards office, 1952-56.

The WITNESS: Dr. Marshall mentioned the fact that his office was handling the administration of scholarships for other sources. I have a table here which might be of interest if I could summarize it at this point.

The CHAIRMAN: I take it that it is agreeable to place the table on the record in full?

Agreed.

The WITNESS:

NATIONAL RESEARCH COUNCIL

Summary of all scholarship and research associateship applications processed in the Awards Office, 1952-56

Application for:	Awards tenable in 1952-53	1953-54	1954-55	1955-56	1956-57
N.R.C.					
Regular—Science and Engineering....	444	436	526	546	531
—Applied Psychology	12	15	16	14	9
Medical	36	35	31	34	40
Dental	—	—	3	2	3
Postdoctorate Fellowships Council and University	385	370	433	472	432
Research Associateships—					
Continuing (Medical)	—	—	—	—	9
Summer	—	—	—	—	448
OTHER					
Canadian Government Overseas Awards	253	376	369	301	214
Shell Scholarships	—	—	—	15	13
Sir Arthur Sims Scholarships	—	12	—	—	9
Nuffield Dominion Travelling Fellowships in Medicine	5	9	14	8	7
Sir David Wilkie Fellowship in in Medicine	—	—	—	—	1
Merck Post-doctoral Fellowships......	14	19	—	—	—
Totals	1,149	1,272	1,392	1,392	1,716

There were a total of 1,716 applications for scholarships processed by the office. Apart from the direct National Research Council scholarships, Dr. Marshall also administered the Canadian government overseas awards which amounted to 214 applications. I do not know whether the members are entirely familiar with these; these are scholarships in certain European countries which are paid for through the Department of Finance out of blocked funds. These are open to the humanities, the fine arts, social sciences, and physical sciences. In general, because of the other sources of support in natural science and engineering, there are very few of these made in these fields; they are normally in the fields of social science, humanities and fine arts. Naturally we exercise no influence whatever in the choice of candidates. It is obvious that for us to give advice as to how to choose a scholar in fine arts would be rather silly. But we have the mechanism set up to deal with applications for scholarships, to summarize them, to pay the students, to assemble letters of recommendation, and all the mechanics; and that has turned into a quite large operation which we are performing for these scholarships. In addition to that, the system is also administering some scholarships put up by Shell Oil, the Sir Arthur Sims scholarships, Nuffield dominion travelling fellowships in medicine, Sir David Wilkie fellowship in medicine, and at one time we also administered Merck post-doctoral fellowships—they are now really administered in a different way. In addition to that, we have, through individuals like Dr. Marshall, Dr. Rosser, and various people in the scientific division—a large number of our people who are members of various of these industrial scholarship committees—or who have quite close contact with them. I think, therefore, the awards office is in a rather unique position in keeping in touch with and having knowledge of what is going on outside of our own scholarship program and that we have a great deal of knowledge of the whole general situation.

By Mr. Murphy (Lambton West):

There is one question I was going to ask earlier today. I understand that some graduates from Ryerson have the opportunity of going to Britain on some sort of scholarship. Can you tell us what that is?—A. This would be out of our field because they would not be graduates of a university.

Q. That is what I wanted to have cleared up. I do know of one lad who has gone to Britain on a scholarship or some sort of assistance program. I was wondering if it was through industry here associated with industry in Britain, or how they got the opportunity of going there. They are not university graduates.—A. No. That would be outside our sphere.

Dr. MARSHALL: I believe that there have been one or two graduates of the Ryerson Institute who have won industrial design awards.

By Mr. Murphy (Lambton West):

Q. This young man whom I have in mind, I believe, was in electronics or something similar.—A. There are, of course, a very large number of local scholarships. Every individual university, for example, has a variety of small —and some large—scholarships for which they have acquired the money by bequests and otherwise. These might be specific Ryerson scholarships or they may be from some other source.

By Mr. Green:

Q. Dr. Steacie, has the National Research Council any method of giving information and advice to students with respect to the field in which there is likely to be the most opportunity and which would be the most useful to the country. Your people would seem to be in a very good position to have a picture of the whole situation across the nation. I do not know whether there is any body in Canada which accepts any responsibility for counselling students as to the fields into which they should go.—A. There are, of course, some counselling bodies arranged through engineering and professional societies. As far as we are concerned, I would say that we have no direct mechanism for this. I think we do perhaps exert some influence because members of our council come from practically every university in Canada. They will certainly, therefore, be very familiar with the situation and take back to their own university this knowledge. I think, primarily, that this has to be a university function. It has to be done at the university level by personal counselling or at the school level. I would say where we do come into this is that we have, through various members of our organization, an enormous amount of correspondence with graduate students or students who are thinking of applying for a position or who are thinking of studying abroad. All of us really do a great deal of counselling as a side line. It is quite surprising the extent to which one does get letters along this line.

Q. You do put out certain publications. I know because I get some of them myself. Would it not be helpful if the National Research Council put out some information sheet that could be distributed to the students across Canada pointing out just what the trends are. These people are very young and their parents are very much concerned about the field into which they are going. I know because I have two graduates in my family. It is not too easy to decide what field a young man or a young woman should enter. It seems to me that your people are in a very advantageous position to give information. I do not say that you should give advice, but you are in a good position to give the students the broad picture and that would make it much easier for them to decide what field they should enter.—A. In general training, particularly at the undergraduate level, the Department of Labour puts out summaries at regular intervals on vocational training, on the estimated number of students graduating in given fields, not only science, but all fields, and estimates of the number of jobs available, and so forth. I think this is a very good document from this point of view. I would say that as one gets to graduate work, you are getting more on to a personal level, and I think the things can be done much better personally rather than formally in print. This is at the graduate level, of course.

Q. It might be then too late. The student is then committed to a set course, and cannot change. What I am suggesting is that you should be of some help in getting out general information which can be used by the student before he becomes committed to one particular course.—A. I would think, sir, that although we might help in this, this is a thing that would come far better from the National Conference of Canadian Universities, because we would be prejudiced since we do not represent the social sciences and so forth. This question of student counselling is a very serious one. We have felt that, although a lot of us have, as members of professional bodies, had something to do with it, it is a field we should not get into as an organization.

By the Chairman:

Q. I take it you do not want to operate a crystal ball?—A. I have a feeling that on the student counselling end, it is very important at the high school level. I think very much has to be done personally.

One of the great difficulties, of course, is that students at that level are influenced enormously by teachers. So that, given a good chemist in a school, you may have that school go in very strongly for chemistry. The opposite, unfortunately, applies, that given a bad science teacher, you will steer them away from science. One of the great worries of the day is this question of the lack of science teachers in schools. This is a major problem, which is outside our field, but we are very conscious of it.

By Mr. Green:

Q. This covers, as you will know, a very wide field. It is very difficult for a young student, say in British Columbia, to have much idea of what he is apt to develop in northern Quebec, or what the needs will be in other parts of Canada. Surely there should be some way that information of that kind can be made available. It may not be your responsibility at all. Perhaps it should be done through the national conference of universities.—A. I think the Department of Labour is doing this now on the trends and demands.

Q. I mean something different from the labour figures. The student never reads them anyway, in a million years. I mean the broader field and the trend in Canada. For example, we seem now to be in the position where we will need a great many more engineers than we have at the present time. The openings up in the north, the mineral deposits and all that sort of thing will have a bearing. Somebody should be able to tell these young Canadians where there are likely to be the best opportunities.—A. I think Dr. Rosser has something on that.

Dr. Rosser: Mr. Chairman, since the war, I think all the universities in Canada have developed counselling services and placement offices. I believe a number of them are publishing the sort of information that you are referring to for their students. The best publication I know of is from the University of British Columbia. They have produced a very excellent guidance booklet, that I believe, is published annually. In it all the professions open to students are outlined, and the students are given advice as to what the possibilities are in many fields, right across the board, in both sciences and humanities.

Mr. GREEN: Have you any set-up in the National Research Council under which you can give information of that type to the universities? Because you see, you should see what is happening all over Canada; you are in the best position of any group of Canadians to give out this information I would think.

Dr. ROSSER: We do, again, cooperate with the universities. Dr. Marshall and I are members of the University Counselling Officers Association. Counsellors write in to us for information and I have written to Mr. MacLean of British Columbia providing him with information on research opportunities for the booklet he publishes.

The WITNESS: You realize, of course, that our information in one sense is restricted, because we are concerned with research. We are not concerned with industrial production; and of course, when you begin to consider the total employment of engineers or scientists, there is only a relatively small fraction of them that will be employed in research. So that we are, in no sense, experts in the field of demand for civil engineers, for example, in ordinary construction and things of that sort. We definitely would be experts on the subject of the possibilities in research. This is only a minor phase when you are thinking of the undergraduate who will not know, until he gets his bachelor's degree, whether he is heading for research or practice.

By Mr. Green:

Q. But are you not in a better position than any other body in Canada to know where the changes and the important developments are most likely to take place, and in what fields?—A. The National Conference of Canadian Universities, in their brief to the Gordon Commission on the whole question of future university enrolment and future demands in various fields, and so forth, have done this sort of thing very well. The universities have got together themselves on the counselling of students. So I think that this is well taken care of. As I say, it is a field in which we all participate individually, but I do not think it is a proper field for our council to be in formally.

Q. You do not think you could get out any information along that line?—A. Not better than the information that is now available through universities. I think they have devoted a great deal of attention to this.

By Mr. MacLean:

Q. Mr. Chairman, there is evidence that there is a wide fluctuation in the number of students going into a particular field. It seems to me that some years ago, in any case, there would appear, perhaps at a certain time, to be a great demand for perhaps civil engineers. That would become a popular field for students entering universities to go into. By the time they graduated they may find that the field is filled. Is there a tendency for a certain field to become, in a sense, a fad for young university students to enter?—A. I have the feeling that this tendency has been most marked at between the various branches of engineering rather than as between different scientific fields. This is due to the fact that a man takes a common engineering course for a year or two, and specializes for only a couple of years before he gets through. Whereas in science he is a specialist for years before he gets through.

Perhaps Mr. Ballard could say something on this.

Mr. BALLARD: Well, with the demand for engineers as it has been for the last two or three years, the problem of not finding an opportunity in that branch of the professional field when he graduates is very remote today. What has happened is that some areas in professions have not been able to recruit graduates for their work. This is particularly true of the electrical power industry. It has been very difficult to recruit graduate electrical engineers in that field because, for the most part, they have been attracted to the newer and perhaps more exciting electronics field. There has not, as yet, been any excess of graduates in the electronics field. They have all been able to find jobs.

The CHAIRMAN: I have one other short table here, a summary of applications and grants approved in March 1953-56. Perhaps if we could deal with this table, then we could take the director of one of the divisions.

The WITNESS: I think, Mr. Chairman, there is nothing very striking about this. It was put in mainly to give an idea of the amount of material that goes through the awards office. The table reads as follows:

NATIONAL RESEARCH COUNCIL

Research Grants

Summary of Applications and Grants Approved in March 1953-56

	1953		1954		1955		1956	
	App's	Grants	App's	Grants	App's	Grants	App's	Grants
Individuals—								
Building Research	2	2	6	6	8	8	9	9
Medical	146	128	183	155	179	140	170	137
Associate Committees ..	103	96	101	81	80	72	80	75
General	163	131	206	167	217	183	231	206
Consolidated—								
Medical	5	5	5	5	7	7	8	8
General	6	6	7	7	7	7	6	6
A.E.C.B.	8	8	8	8	9	9	9	9
	433	376	516	429	507	426	513	450

Perhaps if I could just read the last figure, last year 513 applications for grants in aid were received, and 450 grants were made. The grants that were made were not necessarily for the full amount for which the applications were made.

The CHAIRMAN: Are there any other questions on the whole subject of assistance to universities either through scholarships or grants in aid?

By Mr. MacLean:

Q. Is there anywhere in Canada where students do post-graduate work in forestry, or related subjects, or have we any students on overseas scholarships at the present time in that general field, and if so, where?—A. There are schools of forestry in B.C., Toronto, New Brunswick, and Laval. I think that is all. As to scholars overseas—

Dr. MARSHALL: We have one at Oxford. He is just finishing now. I think he has had three years there at the school of forestry.

Mr. GREEN: There is a school of forestry at U.B.C.

The WITNESS: Yes, I mentioned that. There is one thing, of course, also about forestry which is that in certain phases of forestry you may want a biologist who has not necessarily come through a forestry school. So that your forestry research organizations would be getting a botanist, for example, who had taken his training, not in a forestry faculty, but a science faculty.

Mr. MACLEAN: Do many of these four forestry schools give post-graduate degrees in forestry?

Dr. MARSHALL: Yes. Toronto, the university of New Brunswick and British Columbia.

As Dr. Steacie said, though, a great many of the students going on to graduate work may, however, start in forestry and go into say forest pathology or forest entomology, or forestry soils, or something of that nature. Or they may come up in the botany schools and specialize in forestry later on.

The CHAIRMAN: If there is no further question on that subject, we have here the director of the division of radio and electrical engineering, who is also the vice-president of the council (scientific). In the division of building research we have the assistant-director here on that subject. What does the committee wish?

Mr. MURPHY (*Lambton West*): Could we take building research, would that be satisfactory?

The CHAIRMAN: We have Dr. Hutcheon here, the assistant director of that division. Perhaps I could have Dr. Steacie identify him a little more fully than I have done, and then proceed directly with the evidence.

The WITNESS: Mr. Legget, the director of building research is in Europe at the moment. Dr. Hutcheon, his assistant director, came to us one or two years ago from the University of Saskatchewan. He is an engineer, and he had had a great deal of experience in engineering research along these lines.

The CHAIRMAN: I wonder if the deputy chairman could take over for a moment. I will be back very shortly.

The vice chairman Mr. G. D. Weaver, assumed the chair.

Dr. N. B. Hutcheon, M. Sc. Ph.D., Assistant Director, Division of Building, called:

The division of building research is the most recently formed of the operating divisions of the Council. It was established in 1947 for the purpose of providing a research service to the construction industry of Canada. Although at first sight building research might appear to involve work only of a very practical character, it has already been found that the proper prosecution of building research calls for not only such practical research as can be carried out on construction jobs but also laboratory studies of a fundamental character in the search for explanations of the many problems which arise in the practice of construction. Accordingly, the division is privileged to have well established laboratories in its building research centre in Ottawa in addition to carrying on outside research work in every province of Canada, the Yukon Territory and in the Northwest Territories.

As early as 1933 the Council convened a meeting in Ottawa to consider the research problems of the building industry. Serious consideration was given to the start of building research work in 1937 but it was not until ten years later that a start was finally made, the demands of war having necessarily set aside this essentially civilian development. The establishment in 1946 of Central Mortgage and Housing Corporation to co-ordinate the housing interests of the Canadian government, and the need for a research body to be closely associated with the continued revision of the advisory National Building Code of Canada (first published in 1941), were two of the main factors which led the Council to establish its division of building research in 1947. It was rather more than a coincidence, however, that in the same year the U. S. National Bureau of Standards established its division of building technology and that similar steps were taken at about the same time in countries as widely separated as Australia, South Africa, Denmark, and Sweden.

The task of providing a research service to the building industry of a country such as Canada is easy to state, harder to define, and most difficult to implement. In the first place what is meant by the building industry? Canada's other language here displays its incisive terminology, for the word "bâtiment" embraces all the operations which go to make up what is intended by the somewhat ambiguous English phrase. Not only the design and erection of buildings but also the carrying out of light and heavy engineering construction work are included in the activities of this, now one of the greatest of Canada's industries. It embraces, therefore, the design work of engineers and of architects, the office and field operations of builders and contractors, the associated labour of building employees, and the provision of the specialized materials which help to make up finished structures. This four-fold character of the industry must be stressed since one finds in some quarters a disposition to regard the supplying of materials as, in itself, the building industry whereas it is only one component part, an important part and the only one directly allied with general industry, but certainly no more important than any one of the other four branches of the industry.

The industry is peculiar in that the actual operation of building is carried out by a large number of individual contractors, none of whom have large organizations in any way corresponding to well-known Canadian industrial units, such as the pulp and paper companies. Building is dispersed throughout all parts of the land and is therefore subject to all the vagaries of climate and soil and terrain characteristics. The separation of design and construction is another special feature of the industry which adds its own complications to building research problems.

It follows that, if the work of a building research organization is to be effective, the organization must be well known by and enjoy the confidence of the industry it is serving. The division of buildings research is well favoured in this respect, its formation having been welcomed by all sections of the industry it was intended to serve. Acceptance of what work the building research division has been able to do up to the present is well shown by a recent call to all parts of the industry for voluntary assistance on a large number of technical committees. Not one of the more than two hundred requests then made was refused and they were addressed to architects, engineers, contractors, trade union representatives, material manufacturers and scientists.

With such links well forged, there still remains the major problem of selecting from the innumerable urgent problems those groups of research projects which alone can be tackled with the staff and facilities now available. Accepting the fact that the entire field cannot possibly be covered by one organization, an immediate consequence is the necessity for ensuring that no unnecessary duplication of work can possibly occur. The closest liaison is therefore maintained with other divisions of the Council and with all other organizations in Canada in any way associated with building research, notably the Forest Products Laboratories (regarding all uses of wood) and the mines branch of the Department of Mines and Technical Surveys (in connection with metals and the non-metallic minerals from which building materials are made). This co-operation extends also internationally.

The work which the division itself is doing has been selected on the basis of a very definite policy—that of concentrating upon building research problems peculiar to Canada, drawing upon other countries for their assistance with problems met with in Canada but shared with these other countries. Construction in the far north of Canada provides one rather obvious branch of inquiry peculiar to this country if only because the economics of building change completely when one goes north of the transcontinental railway. Fires in northern buildings are always serious but so are they also in any buildings when human lives are involved. Canada's total annual fire losses provide one record in which the Dominion cannot take pride. Fire research is therefore a second matter of obvious concern. The high incidence of fire in Canadian buildings is closely related to winter climate conditions, thought of which calls readily to mind the fact that snow and ice are native materials which affect building in a variety of ways. Snow and ice research is therefore another essential division of Canadian building research work and one that is shared with few other countries of the world.

Snow covers the land of Canada for only a part of each year but building has to take account of the terrain at all times. Even though many of the soils and rocks of Canada occur elsewhere, study of the problems they create in building design and construction must be carried out in situ. Soil mechanics and foundation research constitute the fourth major group and they readily suggest another, the study of the actual performance of buildings and engineering structures under Canadian conditions, notably in relation to the Canadian climate.

Housing has yet to be mentioned but its technical problems are common, to some degree, to those of all buildings; it is a study of those problems under Canadian conditions that constitutes the greatest building research task of all. Canadian conditions include the inside environments resulting from modern living and other occupancies and, more particularly, from the climate of Canada. Although the wide range of this includes hot and humid conditions that vie with tropical records, it is naturally the extremes of winter that are almost peculiar to Canada and that therefore dictate the character of this branch of building research work. "Houses for Cold Weather" is a title that can accurately typify a large part of this grouping of work involving building materials, building design, the services in buildings and their thermal performance.

"Bridging the gap" between research and practice is a problem far from peculiar to building research and yet there must be few fields of work in which the need for getting the results of research work into actual use by the industry being served is more urgent on the one hand, or more difficult to implement on the other. Allied with building research work, therefore, must be an effective extension service. In Canada, this has come to be called building practice work; it is already recognised as an essential complement to building research of equal scope and of equal importance.

The answering of inquiries is an obvious starting point for such work, with the development of the necessarily associated library facilities. Publications are equally important but they have to include a great deal more than the usual type of scientific paper through which the results of research are commonly communicated. The division has, for example, started a series of popular "Better Building Bulletins", pocket-sized and each dealing with one type of building problem. Although far removed from the usual dignified type of NRC research publication, they have yet been warmly endorsed by members of the council and seem to be meeting a real need.

The division is fortunate in being closely allied with the National Building Code of Canada, published and distributed by the National Research Council at cost. All work on the code is directed by a special associate committee of the council. The secretariat of the committee is provided by the building code section of the division. In this way, the entire resources of the division are available to the associate committee for use in all revision and extension work on the code. Correspondingly, new building problems and research needs revealed by the use of the code throughout Canada are directed to the division and add still further to the challenging tasks ahead for its staff. The code is an advisory document only, of legal standing only when officially adopted for use by a municipality or province. As its use extends, so also will the application of the results of building research, for the code is so arranged that revisions of its separate parts can readily be made with a minimum of delay.

These brief notes show the direction in which the division of building research has been developing its work in the few short years since its formation. It remains only to note that much special research work has been carried out actually on construction jobs, not only in the form of investigating special problems which have developed but also by the actual utilization of construction operations as, in effect, outside research laboratories. The division was privileged to utilize the construction of the Toronto subway in this way and it has been similarly privileged to use the Steep Rock Iron Mine as an outdoor soil mechanics laboratory. Similar studies on construction have been carried out in all parts of the country.

The bearing of climate on all such outside work has become increasingly evident as the division's work has developed. For some years now the division has numbered amongst its workers a full-time climatologist who spends his entire time on climatic research in relation to building, being seconded to DBR for this special duty by the meteorological division of the Department of Transport, another example of the inter-agency co-operation which is a feature of building research in Canada.

Housing research must be mentioned again, in conclusion, since it lies behind practically all the activities of the Division, being its chief responsibility and the main concern of its staff. In this field, the division is privileged to serve the Central Mortgage and Housing Corporation as its research wing. Through this link and also through associations with the National Association of House Builders, progress is being made toward improving the economy and standards of Canadian housing. The division is determined to continue to do everything within its power in this direction.

The VICE-CHAIRMAN: Thank you, Dr. Hutcheon. This has been a very interesting statement which you have made and I am sure that you will have a lot of questions to answer on it.

By Mr. Murphy (Lambton West):

Q. Doctor, I was wondering if you could give a review in connection with your department on the research work which has been done which has materially affected construction. You could divide up the construction side into homes, because I suppose in many aspects they are related anyway, and then take the material side.—A. I am afraid that I find this rather a big order.

Q. I know it is a big order. You can separate and divide it any way in which you like.—A. First, I would like to say that as has been hinted at in the note which has been presented, we are dealing with an extremely complicated industry with a very great range of materials, not only with respect to type but also variations in qualities and properties within what we might consider a general type.

We have a great complication introduced because of the diverse agencies which have to work together. So it is extremely difficult to modify in any major way any part of this picture.

We have probably $150 million of consulting services bought for construction in Canada which is many many times greater than the amount of money involved in carrying out building research.

Q. I did not just get that.—A. That the whole of the construction industry already uses or buys the services of professional engineers and/or architects who are giving advice on buildings.

Q. That is in the amount of $150 million.—A. This is a very rough figure which one can obtain by taking the total output of the construction industry at $5 billion. Assuming that $3 billion is covered by the work of architects and engineers in design, if one takes 5 per cent of that you come out with a figure of $150 million paid for services; whereas, we are spending something in the order of half of 1 per cent of that in building research. It is clear that there is a large establishment in this country, and we are on the small end of it although we accept responsibility in it. The results are hard to describe in terms of progress. I venture to say that in practice they appear slowly as a contribution on many fronts. However, as I say, it is a little difficult to itemize our work in this way on such short notice.

Turning to materials, we have at the present time two men involved in a study of reactions in concrete which occasionally lead to difficulties in Canadian buildings.

We have been working with two firms who are interested in producing new lightweight masonry materials in Canada. Again, there has been a process of carrying out certain tests and making certain measurements for them in the course of their development of this and it gives us an opportunity to study these materials and to acquaint ourselves with their particular properties. Assuming that they will achieve some considerable measure of acceptance in Canadian building there will be questions asked about them.

In the case of brick masonry, this is one of the very large subjects brought forcibly to the attention of the devision almost from the very start. For a long time it was known that the climate of the Atlantic provinces was quite severe so far as the leakage of brickwork was concerned and so far as breakdown through wetting, drying, and frost action was concerned. It was not known so readily that these difficulties were general across Canada. We have since discovered that in fact they are. These difficulties of masonry are by no means confined to the Atlantic provinces. We have for a long time been interested in this and have conducted surveys in the Atlantic provinces. We have been studying the properties of Canadian brick and feel we know them rather well.

We are proceeding with studies on the properties of Canadian mortar. We have, over the past year and a half, set up in our laboratory experiments using masonry panels, combinations of brick and mortar, and are studying their leakage characteristics and at the same time are able to study the durability of these materials using laboratory methods.

We have been working, in the same building materials section, on plasters. We have begun work on plasters. We have one man engaged in that work.

Mr. Hosking: Mr. Chairman, I understood that the meeting was to end about 12.30.

The Vice-Chairman: I think, that the statement which Dr. Hutcheon is giving will be a long one and I think that the committee will have a great many more questions to ask him. I do not see how his complete remarks can be finished up in a short time.

Mr. Murphy (*Lambton West*): I think that we all agree that it will be a very valuable contribution to the committee and it might be better to continue with this at the next meeting.

The Vice-Chairman: It would be in order for someone to move that we adjourn.

Mr. Hosking: I move that we adjourn.

HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 6

NATIONAL RESEARCH COUNCIL

TUESDAY, MAY 22, 1956

WITNESSES:

Dr. E. W. R. Steacie, President, National Research Council; Mr. B. G. Ballard, Vice-President, (Scientific); Dr. N. B. Hutcheon, Assistant Director, Building Research; W. H. Ball, Associate Research Officer.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956

74652—1

SPECIAL COMMITTEE
ON
RESEARCH

Chairman: G. J. McIlraith, Esq.

and Messrs.

Bourget
Brooks
Byrne
Coldwell
Dickey
Forgie
Green
Hardie
Harrison
Hosking
Leduc (*Verdun*)
Low
MacLean
Murphy (*Lambton West*)
Richardson
Stewart (*Winnipeg North*)
Stick
Stuart (*Charlotte*)
Weaver—(20).

(Quorum 9)

Antonio Plouffe,
Acting Clerk of the Committee.

MINUTES OF PROCEEDINGS

TUESDAY, May 22, 1956.

The Special Committee on Research met this day at 10.30 o'clock. The Chairman, Mr. George J. McIlraith presided.

Members present: Messrs. Byrne, Dickey, Forgie, Hardie, Harrison, Hosking, Leduc (Verdun), Low, MacLean, McIlraith, Murphy (*Lambton West*), Richardson, Stick, Stewart (*Winnipeg North*), and Weaver.

In attendance: Dr. E. W. R. Steacie, O.B.E., Ph.D., D.Sc., F.R.S.C., F.R.S. President, National Research Council; Mr. B. G. Ballard, O.B.E., B.Sc., F.I.R.E., Director of the Division of Radio and Electrical Engineering; Dr. N.B. Hutcheon, Assistant Director, Building Research Division and Mr. W. H. Ball, Associate Research Officer.

The Chairman suggested May 30th or June 1st for the Committee's proposed visit to the National Research Council Laboratories on the Montreal Road. In respect of the proposed visit to Chalk River, June 11th and June 12th were mentioned. The final decision was left to the Chairman.

As agreed at an executive meeting of the Committee held on May 17, Mr. Murphy read a paper entitled, "This is Britain" by Lord Samuel of the Parliamentary Scientific Committee and issued by the United Kingdom Information Office in Ottawa.

The Chairman commented thereon and read an extract of a report from a Committee of Enquiry, dated Oct. 6, 1955, and presented to the British Parliament in April, 1956.

Dr. Hutcheon was called. He read a supplementary statement on the construction industry and was questioned.

In the course of his examination, the witness referred to National Research Council printed publications listed below, and as requested by Mr. Low, copies of said publications will be circulated to committee members:

1. Bulletin No. 1—Condensation in the Home
2. Bulletin No. 2—Insulation
3. Bulletin No. 3—Concrete
4. Bulletin No. 4—La Condensation dans la maison
5. Bulletin No. 5—Permafrost & Buildings
6. Bulletin No. 6—Winter Construction
7. Fire Resistance Ratings
8. National Buildings Code (1953)
9. List of publications by the Division of Building Research

The Committee concluded its examination of Dr. Hutcheon.

It was agreed to hear next Mr. Ballard, Director of the Division of Radio and Electrical Engineering.

Copies of his statements will be sent to the members of the Committee in advance.

At 12.35 p.m., the Committee adjourned to the call of the Chair.

Antonio Plouffe,
Acting Clerk of the Committee.

74652—1½

EVIDENCE

May 22, 1956,
10.30 a.m.

The Chairman: Gentlemen, I see a quorum.

(Discussion with respect to the proposed visit by the Committee to National Research Council laboratories, Montreal Road, and to the Atomic Energy Control Board's installation at Chalk River, Ont.)

We will now go on with the evidence from the point where we broke off at the last meeting.

Mr. Murphy (*Lambton West*): Could I read into the evidence that statement which I wanted.

The Chairman: Mr. Murphy wants to make a statement about a point which was under discussion at the third last meeting. Perhaps, if it is agreeable, we could have him give such statement now.

Mr. Murphy (*Lambton West*): We were discussing previously the idea that they have in Britain of a scientific committee which actually is not a parliamentary committee but one composed of members of parliament and others.

> This Parliamentary and Scientific Committee, which has been described by Lord Samuel as "unique in its history and, indeed, unique among the parliaments of the world", recently published its annual report for 1953.
>
> One of a number of informed, unofficial, all-party groups which have grown up spontaneously, the Parliamentary and Scientific Committee has, for various reasons, managed to establish itself with more continuity and formality than some of the others. Membership is open to members of parliament of any party in both the House of Lords and the House of Commons, and also to the nominated representatives of those scientific and technological organizations in the country which, under its constitution, can be affiliated. No organization can be a member of it which is engaged in promoting some scientific process or project for profit or commercial gain. Societies must be engaged in research or scientific education, or be concerned with protecting or advancing the interests or professional well-being of those engaged in scientific work.
>
> Membership in 1953 comprised 163 members of parliament—

That includes, I assume, the House of Lords.

> —and representatives of 85 scientific and technological institutions. The committee has a modest revenue of about 11,500 a year, drawn from the voluntary subscriptions of M.P.'s who belong to it and from affiliated scientific bodies.
>
> By bringing together representatives of a wide range of sciences and technologies with a number of M.P.'s who are interested in the better use of science, the Parliamentary and Scientific Committee has been able to influence the development of government policy to enable the benefits of scientific research and technological advances to be applied to practical problems.

> Aims and Activities:
>
> The committee's aims and objects are to:
>
> 1. Provide members of parliament with authoritative scientific information from time to time in connection with debates.
>
> 2. Bring to the attention of M.P.'s and government departments the results of scientific research and technical development which bear upon questions of current public interest.
>
> 3. Arrange for suitable action through parliamentary channels whenever necessary to ensure that proper regard is had for the scientific point of view.
>
> 4. Examine all legislation likely to affect the above and take such action as may be suitable.
>
> 5. Watch the financing of scientific research.
>
> 6. Provide its members and other approved subscribers with a regular summary of scientific matters dealt with in parliament.
>
> Broadly speaking, the activities of the committee may be divided under two headings. First it provides, as far as possible, for a regular exchange of information between members of parliament and scientists; secondly, it endeavours to ensure that something is done to right matters seen to be wrong in the light of such information.

That, Mr. Chairman, is an extract from "This is Britain", a monthly news letter issued by the United Kingdom Information Office in Ottawa.

I am going to add to that some information which I have just received. Dr. Steacie commented on this the other day.

> As a result of the Jephcott Committee set up to advise on the future of D.S.I.R., there is a bill before parliament which gives us a new constitution and places us in fact under an Executive Council, which will consist of senior industrialists, professors and trade unionists. The chairman of our new Executive Council will be a senior industrialist, who will spend several days a week in the office.

That, Mr. Chairman, looks like an advanced set-up and a type of organisation which I think we need in this country.

The CHAIRMAN: Could you give us the date of the excerpt which you read from the news letter?

Mr. MURPHY (*Lambton West*): May, 1954.

The CHAIRMAN: I think I should point out that the Department of Scientific and Industrial Research in the United Kingdom, under which the type of organization we are discussing is administered, is now in process of being reorganized. That reorganization is based on a report of a committee of inquiry presented by the Lord President of the Council to parliament in April 1956. It is pretty difficult to summarize and report a conclusion, but in essence it is that they are changing their system from departmental administration to a system similar to the Canadian organization of the National Research Council.

Mr. MURPHY (*Lambton West*): I assume, Mr. Chairman, that that is the one to which I have just referred which will be chaired by a senior industrialist.

The CHAIRMAN: Sir Harry Jephcott, chairman; he was chairman, and is managing director of Glaxo Laboratories, Limited. The committee of inquiry was appointed a year ago, in April 1955. The reference of the committee of inquiry was into the organization and functioning of the Department of Scientific and Industrial Research. The report was submitted on April 6, 1955, and presented to parliament in April, 1956.

Mr. MURPHY (*Lambton West*): That is the report to which I have just now referred.

The CHAIRMAN: If we could now revert to the evidence with which we were dealing at the last meeting, I would ask Dr. Hutcheon to continue.

Dr. N. B. Hutcheon, Assistant Director, Division of Building Research, National Research Council, called.

The WITNESS: Mr. Chairman, I would like to begin by continuing the answer to the question which was before the committee at the last meeting. With your permission, I should like to give some information by way of background on the ways in which our research information is fed out to and influences the construction industry, before reverting to the detailed discussion of projects which I had begun at the last meeting.

The job of the Division of Building Research is mainly dealing with information for the construction industry. For this, the Division is organized for building research, which involves essentially the development of new information by our own research efforts, and building practice, which involves the collection, coordination, dissemination and application of information. We place roughly equal emphasis on these two functions.

The total amount of new information which results from our research efforts is only a small part of that made available to the construction industry through our building practice activities each year. The total information we are able to pass on is only a small part of that available to and used by the industry from all sources.

Information obtained through our own researches may be introduced into the information stream in various ways and at various stages in the sequence of activities which go to make up the over-all construction operation.

Mr. MURPHY (*Lambton West*): Is this in answer to my question?

The CHAIRMAN: Yes.

The WITNESS: It is first of all made available in publications and in reports which may range from papers presented before technical societies to booklets specially prepared for the small builder or the home owner. The information presented may influence a materials manufacturer, an engineer or architect designing a structure, a contractor, a tradesman, or the owner or client for whom the construction is being carried out. It may be introduced along with other information at a meeting of a codes or specifications committee and may, through its influence upon the content of the code or specification which results, be brought to bear upon the activities of the construction industry.

Information obtained through our own researches may be used, along with information from other sources, by our building practice group in answering inquiries, in talks before various building organizations and in the series of courses on house construction which have been instituted.

Members of our staff serve on about 100 committees and subcommittees of technical societies and other organizations in Canada and the United States which have interests allied with building research, including committees of the National Research Council, Canadian Government Specifications Board and Canadian Standards Association.

The Division has already issued 150 papers and 300 reports. Publications are being distributed at the rate of about 18,000 per year.

About 1,000 inquiries are received and answered by the building practice group each year, and about 200 references involving technical assistance are received from the Central Mortgage and Housing Corporation. It is through this latter activity, by which we act as a research and technical wing of Central

Mortgage and Housing Corporation, that our work exerts its greatest and most direct influence on Canadian housing.

It is exceedingly difficult to trace the influence of any particular piece of research work upon the output of the construction industry. Only very occasionally will one particular piece of work have a substantial influence which can readily be identified in the final construction work. In general, the information obtained from building research becomes effective through its introduction in small portions at various stages in the over-all picture.

Our own completed researches are not as yet extensive since we have been able to carry on a full program of research only over a part of the 3 years since we occupied our new building in 1953. Of the 200 separate project studies which have been undertaken since the Division started, only about 40 have been completed.

I might turn now to the building research activities. The building research side of our activities is organized in 8 sections. These are: building design; soil mechanics; building services, building materials; building physics; fire research; snow and ice research; and permafrost research.

In reviewing the research which has been done, the work is most readily classified in accordance with this sectional organization. I shall, therefore, outline the work by sections indicating first, in each case, the more significant projects which are most directly related to housing.

The Building Design Section is concerned primarily with studies of the strength and rigidity of buildings. Houses, in contrast to other larger buildings, are not readily analyzed for these characteristics and this provides one of the greatest challenges for research in this field. Much of the work to date has been concerned with these aspects of houses. This work is shared, as far as wood is involved, with the Forest Products Laboratory of Canada. We work closely with them on all matters relating to wood. In this Section, we have instituted tests of wall panels. These are only portions of houses but this is the way in which we must approach the matter of the structural performance of the over-all house frame. We have been particularly interested in measuring the adequacy of the various types of sheathing on wood frames and of various bracing methods. The tests which have been carried out have been primarily those of racking which determines the resistance imposed by a wall to horizontal force applied in the plane of the wall. We have also done work in the laboratories on rafters and on trusses.

There is much interest at the moment in the possibility that trusses to extend from one side of the house to the other, made on the ground and then moved into place, might provide economies in construction. This is being watched very closely and we actually have investigations of many of these going on in the laboratory. At a recent meeting with the National House Builders Association, discussion was held on the probable merits and usefulness of this particular approach. We have conducted a full-scale house test which involves all these elements; so far as I know, this is the first full-scale test done on a house, and the results of that are available.

We have carried out special tests on beams and panels. These have, in the main, been for Central Mortgage and Housing Corporation and in some cases have been for manufacturers when they have brought proposed innovations to us or to Central Mortgage and Housing Corporation for evaluation.

Similarly, we have carried out in the laboratory work on masonry floor and roof slabs, mainly those made of reinforced light-weight concretes. This Section has also been concerned with some tests which we have had underway for more than 2 years on the structural performance of concrete slabs laid on the ground as foundations for basementless houses.

Turning now to things which are less related to housing: several years ago we cooperated in a very large test of pre-stressed concrete beams which were used as the main roof girders in very large warehouses in Cobourg. These were being built by Defence Construction Limited; Ontario Hydro was also very much interested in the question of pre-stressed concrete. The beam was 100 feet long and consisted of two precast 50-foot units. We cooperated with these agencies and others interested in this field in these tests. The Sussex Street bridges are also pre-stressed concrete. That work was so arranged that there was provided for testing one prototype of the girders which were used to make the bridges. The building design section participated in the test work on that beam.

Recently we completed for the Department of Public Works a floor loading test on part of the floor of one of the buildings which had been constructed in Ottawa, just to prove finally to everyone's satisfaction the adequacy of that particular design.

The Soil Mechanics Section is concerned with the engineering properties of soil and with the designing of engineering structures using soil; these would be roads and road bases, bases for airport runways, earth dam, and foundations of various kinds. We are not concerned immediately with all of these things, but the study of soil mechanics has to do with the information which is required in these particular kinds of work.

This Section has not as yet completed a great deal of work on houses, although it has been called on many times, in the course of providing information to Central Mortgage and Housing Corporation and others, for advice based on a soil mechanics background.

Research projects related to houses have been on the adequacy of housing foundations, particularly in regard to the settlements which take place when houses are built on clays in Canada. Referring again to the tests on slabs for basementless houses, this section was concerned with the action of the soil under these test slabs which were built on the ground. Studies were made of the shrinkage and swelling of soil under them due to changes in moisture content, and of other things affecting the performance which are involved in the inter-relation between the slab and the ground when used for a foundation for a house.

Turning to other research projects of this Section, they have been very interested in landslides, which sometimes occurs through natural action and sometimes by virtue of some of man's construction. These are always very nasty when they occur in the neighbourhood of building construction. It is, therefore, very important to be able to predict when these are likely to occur, and for this purpose scientific and technical information must be collected.

A special project was carried out at Steep Rock when an opportunity was provided for a special study of a unique situation which resulted from the presence of varved clays in the beds which were exposed when the lake was de-watered. A very serious problem arose when these clays, which had been laid-down in water and never dried and consolidated, had to be excavated. In the course of the excavation the wall barrier which was left had a great tendency to liquify and to slide. Consequently, some very special work had to be carried out in the design of a suitable barrier to permit the operation to be carried out in an economical way. The Division participated in some of this work but in particular was interested in the opportunity provided for a special study of these varved clays.

One of the interests of this Section is the measurement of ground temperatures and determination of frost depth penetration. This information is largely of interest in the design of water mains so that one may determine how deeply they must be put in the ground to avoid freezing. This is a large project and we have across Canada very many stations at which these measurements are being taken. We receive cooperation from water works engineers in the various cities. This information is very keenly sought after by such people.

We also have work going on in the study of frost action in the ground. This is perhaps one of the most important pieces of work which is being carried on. It is frost action which is responsible in certain areas for the loss of very large portions of our highways. The action of freezing upon the water in the ground leads to a high water content near the surface and in the spring when the thaw comes the soil and the ice in it is thawed. We then have a liquefied soil due to the excess of water, on top of a frozen layer below, which is unable to support the traffic. This is of very great economic importance. We are making very good progress, I would say, in investigating these phenomena in the laboratory and have every confidence that in time we shall be able to offer very definite assistance, certainly much more than we are at the present, in respect to this particular difficulty.

This Section is also collecting information on the settlement of large buildings. Several large buildings including two hospitals and the National Museum, have been used as outside laboratories, so to speak, in the course of acquiring such information.

The Building Services Section deals essentially with the mechanical engineering aspects of buildings. It is concerned with heat, moisture and air flow in buildings. Its responsibility extends to heating, ventilating and air conditioning, but so far in Canada we have been paying rather less attention to the equipment itself which can be developed and is developed in other places, than we have to the action and performance of our Canadian structures in relation to Canadian weather conditions. This work has emphasized the insulation, moisture flow and air flow problem in walls and roofs of buildings, including houses, and has led us to a large number of studies in this direction. We have had a very considerable measure of success in this work through laboratory work carried on at Saskatoon were we have a small regional station. This laboratory has been operating for nearly 6 years, was not involved in the move into our new building and has therefore been able to carry on rather more undisturbed than we have been in Ottawa. It has been concerned with the thermal performance of frame walls.

We have been able to discover some useful things about the effect of air space in walls. At first this may not seem to be very important but it has permitted us to proceed to a very adequate understanding of the operation of reflective insulation, for example, and to understand why we had been having problems with various types of insulation. We are now in a position, with the information we have gained, to give very adequate guidance in the selection and application of insulation in houses.

In this work we employ test huts which are set up at Saskatoon, Pennsylvania State College—where we actually operate one—Ottawa, and Churchill, Manitoba. These are in effect small houses in which we can check and verify the results of laboratory investigation.

We were called upon, in the course of the manufacture of the general purpose huts for the army several years ago, to provide assistance in respect of the insulation and vapour barrier protection for these huts. This was an emergency program and although these huts were of limited interest, the contacts with the insulation industry and the information which it was possible to develop at that time have had a considerable effect upon the insulations offered by manufacturers.

We have been able to assist with the Canadian Standards Association's specifications on insulation by providing information from our laboratory programs. We are presently involved in studies of insulation for concrete slabs laid on the ground as foundations for basementless houses.

One of the problems which arises with insulation is the protection of it from condensation which occurs particularly in this country, when vapour passes from the inside of the house into a cold part of the wall in winter, collecting as frost to be released on the first warm day. Very substantial quantities of water can enter in this way into the insulation and frequently into the inside of the house itself from the attic space. We have done a good deal of work on these problems and have been able to assist, with support from Central Mortgage and Housing Corporation, in the establishment of two very important specifications relating to building papers; these are C.G.S.B. specifications and are widely used in the work of Central Mortgage and Housing Corporation.

We have not done too much work on heating systems, but have a co-operative agreement with Queen's University where facilities for research on house heating systems and oil furnaces have been available for some time. This work has been of special interest and value to Central Mortgage and Housing Corporation since they require for their operations assessments of the performance of heating units.

We have begun studies on windows. This has been a pressing matter for a long time, but only recently have we been in a position, with the full development of our facilities, to undertake the proper studies of windows. The first of these is a study of double glazed sealed units which are now being offered. There are a great many new windows of this type being offered and it is important to know whether their performance will be adequate, and in particular whether the seal between the two sheets of glass will perform sufficiently well so that no moisture and no dust can enter between them.

The whole field of insulation and control of water vapour is one I would think in which we have probably had our greatest influence so far on house construction. These matters are very important ones since Canadian houses must operate successfully under our extremely cold winter temperatures. This is one of the branches of work in which we have been called upon to do a great deal of standard testing although this is not normally a type of work in which the National Research Council engages, if there are commercial laboratory facilities for such tests elsewhere. At the request of Central Mortgage and Housing Corporation we have for several years carried out all insulation tests and all building paper tests as an assistance to their over-all operation.

To turn to other things which have been done by this Section, which are not specifically related to housing, several years ago we assisted the Department of National Defence in some studies of heating of Arctic huts. I have already referred to the assistance rendered in connection with the insulation of the general purpose army huts. We began studies on an experimental heat pump installation made at the Montreal road laboratory. This project, unfortunately, has had to be set aside. One of the reasons for this is that the land which was occupied by our experimental ground coil has been turned over to other uses.

Our Building Materials Section is concerned, as the name implies, with a wide range of materials used in construction. I had begun at the last meeting to discuss some of the work going on on cement and concrete and on masonry materials. The other materials of interest are plasters, paints, caulking compounds, adhesives, water proofers, roof coverings, and many more materials of rather lesser importance. Wood is not included in the list because this is covered by the Forest Products Laboratory. Metals and the raw materials from which many of these building materials are made are left to the Mines Branch, since they are well established in these fields.

I will not attempt to detail further the work going on with these various materials, but I would like to mention especially a number of projects which are of rather more significance than some of the projects on the smaller types of individual materials which have been carried out in the building materials section.

I might mention particularly a study made at the request of Central Mortgage and Housing Corporation into the deterioration of hot water tanks. Central Mortgage and Housing Corporation had a number of housing developments which they were operating. They discovered that tanks deteriorated in less than 6 months in some places, whereas in others they would withstand deterioration for 4 or more years. They requested assistance with this, as it had become a matter of some economic importance to them. While we are not essentially corrosion people, we were able to institute a limited study of this and eventually to offer a means of reducing the corrosion through the addition of a small protective device. We have had tanks in operation for a number of years testing out finally the effectiveness of this arrangement. This protective device is presently being considered for patent purposes.

Another project of a special character has involved a study of the requirements for hospital operating room floors. Because of the hazard of explosive anaesthetic gases, it is necessary to do everything possible to reduce electrostatic sparks. One of the ways to do this is to use a floor which is semi-conducting and through which, therefore, the charges will be dissipated before they build up to dangerous proportions which might produce a spark. This project was begun in cooperation with the Division of Radio and Electrical Engineering. Our part of it was the study of the electrical resistance properties of flooring of various kinds, including the problem of learning how to manufacture floors having adequate properties. Studies of floors are still going on in our laboratory.

One very important class of project is that involving studies of the stability and the durability of materials. All materials used in construction must be reasonably stable and must, of course, be durable. For much construction, we think of a life of as long as 50 years. It is necessary, therefore, to consider the durability of materials over a 50-year period. Obviously if a new material comes along, we cannot wait a great number of years to try it out in the field. We usually require some sort of an answer in a matter of a few days or a few weeks. The development, therefore, of quick laboratory evaluation tests for the determination of the durability of materials is one of our major interests.

To give you an example of the importance of stability, certain floor coverings when laid down on a concrete base in contact with the ground will expand to a point where they will pry themselves off the floor due to the increase in their moisture content.

A similar problem has arisen in the case of asphalt shingles which are laid on roof boards. Wood is of course a material which expands and contracts, with change in moisture content. Asphalt shingles do the same thing. When they are nailed together and there is a change in the moisture content one can get some rather nasty buckling and poor performance.

The wood industry is of course opposed to any restriction on the use of wood under asphalt shingles, and they are not happy about the requirements that only narrow boards should be used. As a result of this difference of opinion, our Division was brought into the picture and we have, over the past several months, been conducting tests.

By Mr. Murphy (Lambton West):

Q. You mean tests on roof sheathing?—A. Yes, roof sheathing, to determine what the situation is exactly. After this the problem arises as to what can be done about it.

In the matter of paints we have a paint laboratory within our Building Materials Section. Paint has now become a very difficult material. A few years ago one might recognize perhaps ten major formulations which covered most of the paint used in building construction. But today with new materials being offered, there are probably, hundreds of different formulations. This has made research into paints extremely difficult. We have assisted the Central Mortgage and Housing Corporation through studies of paint peeling on houses in Vancouver and in Ottawa, these difficulties having arisen in connection with their housing projects, and we are doing everything we can to begin to put ourselves on a much better basis to evaluate paints. There is a great deal of activity in the preparation of specifications, particularly within the Canadian Government Specifications Board. Our laboratory staff is of course called upon to assist in this work and they devote a great deal of time to it.

We have been able to carry out one very significant experiment relating to the way in which paints blister. It is extremely difficult to discover the exact cause of such defects, but we are gaining information on this through our laboratory experiments. Another project has been carried on in collaboration with the oil companies, the R.C.A.F. and the Division of Mechanical Engineering in the matter of fuel storage in the north. This particular project has been going on for some time and our part in it which involves the development of suitable coatings for drums is still under way.

We are carrying on some fundamental studies, which we consider to be of some considerable importance, on the way in which moisture moves through materials. We should like to know exactly why and how it moves so that we will be able to predict when moisture is likely to move from a particular point in a particular construction. Without this information we are frequently in the dark as to what the conditions of moisture will be in a particular design.

The stability and durability of materials are very much bound up with moisture. Almost all deteriorating actions in materials involve water in one form or another. Therefore a study of water and how it affects materials, is a matter of some very considerable importance to us, and involves much laboratory work which is not of immediate use to the construction industry.

We have as part of this major study investigated concrete water proofers. These are ingredients which are to be mixed in concrete and which are purported to impart desirable waterproofing properties. I do not wish to comment on those materials, but as a result of this work we have recently obtained some substantial insight into the permeability of concrete to water. I would like to mention a special use to which this was put just the other day, by way of illustrating that we never know when any particular type of information may be used. We were visited by two gentlemen involved in the design of a new plant at Des Joachims which is to be used for the production of power from nuclear sources. They came to us in very great need of information on the way in which water passed through concrete. As a result of this work which was started for another purpose, we were able to give them very definite help and they went away extremely happy that such information was available to them.

Our Building Physics Section is largely concerned with sound and vibrations in buildings. Under this Section we operate the only sound chamber in Canada which is available for the evaluation of sound absorbing materials, and as you can imagine, we get a great deal of testing work to do. Another thing which we are able to do is to test the sound transmission properties of various constructions, which is of considerable importance to the construction industry. This Section does not have too much time for research, but they have been able to develop an impedance tube and horn with which it seems possible to test, for development purposes, rather small samples, without having to have a very large sound chamber in which seventy-two square feet of material must be laid out for the test. With this development the manufacturer will be able to test his materials for himself before coming to us for the larger test. We were able to assist the Government of the Province of Alberta in the acoustical design of two large auditoria. We are called upon frequently to make measurements of the vibration caused by blasting, and sometimes by gunfire which may be affecting buildings.

The Hydro-Electric Power Commission of Ontario came to the Building Physics Section with a problem of transformer noise and we were able to work out for them in the laboratory a very satisfactory method of absorbing a great deal of this noise close to its source. We were also able to work out the design of a transformer duct filter which filtered out the sound which would normally be transmitted through the ducts.

The Fire Research Section is concerned with a wide range of things having to do with fires in buildings. We have carried out many studies at the scene of the fire. The head of this section has attended every major fire in Ottawa and he is well known to the fire department. He has been increasingly able to be of assistance to them even at the time of the fire. Of course information gained at the fire and subsequently is very revealing, and is very useful in giving direction to our fire research program.

A rather special project was carried on in the form of a study of statistics involving fire fatalities. That is a subject that has come to the fore in the last few years, when so many people have lost their lives. This Section has cooperated in the work carried on by a Canadian Standards Association committee on the measurement of combustibility and flame-spread characteristics of materials, and they have given assistance with various tests to the Department of National Defence in connection with dry chemicals and foam for R.C.A.F. crash trucks. The things I have mentioned are typical of the work which is being carried on. There are two other Sections, and there are more general projects which have been carried out, but I shall have to forego making reference to them at this time.

The CHAIRMAN: What are the names of the two sections?

The WITNESS: The Snow and Ice Section, and the Permafrost Section.

By Mr. Stewart (Winnipeg North):

Q. The witness has opened up a most interesting area. I do not intend to go into it just now because we shall, I think, get a chance to do so when we visit the laboratory. I would like to ask him this question: apparently most useful work has been done in the matter of building research, which ought to be of the greatest assistance to what has been termed the most backward industry in this country. Are the results of those tests made available, and if so how are they made available?—A. Well, the first thing which happens usually as a result of a laboratory study is the production of a scientific paper which is presented before the usual technical or scientific societies. Prior to the writing of the paper, there will usually have been a report incorporating all the results, which will be distributed to many people we know are vitally interested in this particular thing. In the course of answering enquiries this information will be used by the Building Practice Section. Such new information becomes part of the thinking of everyone in our group and is used in a variety of ways, in every contact we make, in answering enquiries, in talks given to house builders and other or in courses which are given. In addition we try to make it as available as possible in various types of literature. This Building Note is one form in which information is passed out. It is essentially an information sheet and is listed with other material in our publication lists. We do not have too many of these at the moment, but we have a number and it is proposed to increase them, as well as the other kinds of publications as rapidly as we can.

The CHAIRMAN: Would you mind telling us what the circulation of these building notes would be? Can you tell us the approximate figure?

The WITNESS: This is just one of several publications, I do not have a breakdown with respect to the type of publication, but I can indicate briefly that we have 80 people on an automatic free list who get all publications, and 1,100 people who are sent our publication list covering all publications available; they get publications on request, and we have another 6,000 people receiving our publication list who must pay a nominal sum for the publications.

By Mr. Stewart (Winnipeg North):

Q. I take it that a large majority of the builders are being given this service; but there are many small builders in this country, men who will build from twenty to thirty houses a year, some of whom are very competent and some not so competent. How would men of that type get the information, for example, on the matter of damp basements and the water proofing of damp basements, if they do not have this source available?—A. We do everything possible to make it known that this information is available. We are having some success at it. We are in contact with every trade association in the country which relates to building. We are in contact with every builders' exchange across Canada and we take advantage of every opportunity to inform organized groups that they can obtain this information.

Q. You depend on these organizations to let the members know that this information is available?—A. Yes, and we do everything possible to put our information out at various levels and in various ways and to publicize it and to make it known. For the small builder we have this Better Building Bulletin series. We only have six of these publications at the moment, but two of them are published in French as well as in English. I have number three in my hand, dealing with concrete. It is illustrated and it attempts to explain to people how to make good concrete. It is written in such a way that they should be able to do so. It takes a lot of research work first to provide a basis for the publications we put out at various levels, and finally it takes a great deal of time to prepare them. We are most conscious of the fact that we do not have too many of them at the moment. The circulation of Better Building Bulletins to date has been about 8,000.

By Mr. Leduc (Verdun):

Q. May we get these bulletins from the Queen's Printer?—A. Yes, and also from the National Research Council as well as by direct contact with us in the Division of Building Research.

By Mr. Murphy (Lambton West):

Q. Is it within your sphere of work to make a study of the costs of different types of construction? Take a home that is built, a frame house, of certain dimensions, let us say, built here in Ottawa, and take a house that is built of cinder blocks with the necessary trimming and so on, to give some resistance to cold and some resistance to heat. Does your department make any study of the respective costs of those two houses?—A. Yes sir, we are generally aware of these things. But we do not have the people to spend all their time on the studying of housing costs. That is the sort of thing that is done by the Central Mortgage and Housing Corporation who are building houses every day, and who are in touch with the market and with the details, and who therefore know the costs in a very detailed way. So it is to them that we look whenever we need the costs of a special part of a house. But in a broad general way I think that everyone in the Division is aware in some measure of this, and is prepared to provide some answer to every specific question that comes up.

Q. We are not the only country faced with the high costs of home building. I take it that you people realise, let us say, that for a frame house so much goes into the framing of it, and so much for the rafters, and so much for the sheathing, and the studding, and probably two or three coats of paint, and insulation; and with respect to the inside there will be two or three coats of plaster as well as the laths; and in the case of a stucco house there will be the same things I have mentioned plus two or three coats of stucco, and then the paint and so on, and then the stripping and the insulation and the lathing and two or three coats of plaster and then the paint. It has always disturbed me that I have never been able to find out if there is any information or any study made of these main projects. And the same thing happens in the case of automobiles because, after all is said and done, take a frame house; could it not be made in sections, such as an eight foot section with the studding and the laths and the insulation in it, and on the inside the sheathing, and the regular material which is usually on the outside, and then the studding? Has there been any study made of this type of construction such as an eight foot panel because a house could be 16 feet to 24 feet wide, made up a multiple of the eight foot panels, with the windows or doors or openings in the different places? Have you come to any conclusion in that regard?—A. Yes sir. There has been a good deal of work done on that kind of study. In the first instance, houses must be acceptable and satisfactory and our job is to put an evaluation on these things. We do not have the people available to go out and make a study of the costs in housing, but we are very generally aware of this situation in the course of evaluating various constructions which are submitted to Central Mortgage and Housing Corporation and then referred by them to us. We go over these things again and again. We are in touch with organizations in the United States which are trying to promote panel construction and pre-fabricated housing, and we have visited factories where such operations are being carried on.

Q. They are doing a good deal of it in the United States, are they not? —A. I can say that none of these studies have any great advantage over the present methods used in house building in Canada, and in fact many of them do not offer any reduction in cost. There are some advantages in using some of these new methods, but there are also disadvantages.

Sometimes it is possible to make good use of pre-fabrication or panels or unitized construction, and one of the places where this is of most value is in the north, because of the need to ship in materials and to carry on construction over what actually is a two month period. Consequently it is very desirable to reduce the amount of on-site construction, and if these can be taken from a factory to the north, it would work out very well to build them in that way.

Q. We have building constructors in this country who still use old-fashioned methods in putting up studding, whereas a modern builder can use a different method even in putting up studding, and the same would apply to rafters?—A. The total on-site labour on a house is only 50 per cent of the total cost.

Q. Yes, but compare it to what it was 10 years ago? Have you got the figures?—A. The total on-site labour today is only 50 per cent of the total cost. We have no hope at all of reducing this very materially by another method.

In the meantime we are studying some of the materials, but the material costs are substantially the same whether we build the house in a factory or on site. Therefore even if we can reduce the total on-site labour to zero, we can only cut the cost of the house in half, but we can never approach this figure since in reducing labour on-site the cost is usually increased in some other way.

Q. You mentioned paint blistering. How is it that in the case of two houses, for instance, pain will blister on one house, and will not blister on the other. Is it a matter of insulation?—A. It might be. We cannot claim to know all these things as yet.

Q. Are not some builders allowing space for a little air to get in between the siding and the insulation?—A. That is right.

Q. Is that for the purpose of letting moisture out?—A. Yes, paint blistering, and is normally associated with water in the wood. The water content may be high behind the paint film for a variety of reasons. With improper control of vapour flow condensation occurs in the walls; water is thus deposited on the back of the sheathing and may wet the siding. A very high moisture content is developed under certain conditions.

Q. Do these apertures avoid that?—A. When the moisture comes along in the normal way, that is a way to divert it; but if the situation is one of rain entry—

Q. I don't mean that.—A. The paint does not care how the moisture gets in. In a great many cases it may be by rain penetration. One really does not know, at this point, how many cases are caused by the one thing and how many by the other. Humidity on the outside may be a factor and humidity on the inside may be a factor.

The CHAIRMAN: Is not the content of the paint also a factor?

Mr. MURPHY (*Lambton West*): I am, of course, referring to good quality paint.

The CHAIRMAN: Yes, but good quality paint can be made of different ingredients. Is the difficulty not caused by the application of a particular paint to a particular material to which it is not suited? In other words, you cannot put rubber base paints on some types of materials outdoors.

By Mr. Murphy (Lambton West):

Q. What I had reference to was the same type of construction, same type of siding, and I wondered whether or not these apertures which are coming into use now should be more universally utilized?—A. No.

By Mr. Stewart (Winnipeg North):

Q. Are there different kinds of paint more suitable to different regions in this country?—A. That is very possible, but I doubt if we know enough about the whole situation right at the moment to begin to mark these out.

By Mr. Murphy (Lambton West):

Q. You mentioned briefly about soil and foundation settling. Does that apply to any buildings here? For instance, the hospital or the National Museum?—A. Yes, sir. Some of the most serious house settling problems in Canada occurred in Ottawa.

Q. To public buildings?—A. The National Museum has been recognized for many years as a building in which serious settlement has occurred.

Q. What method do you use for stopping that sinking?—A. This is something about which one may or may not be able to do anything. In the case of the museum, repairs are being instituted, and we had an opportunity to get in and sample the soils so that we might be able to design better in some other case. We were not involved in deciding what the remedy might be.

Q. Is there a remedy?—A. It is not an easy one. You can change and rebuild the foundation, which is always very difficult.

Q. Is there a problem with the hospital?—A. In the matter of buildings built on clays, it is extremely difficult to avoid some settlement because when they carry a load the water is squeezed out of the clay and it settles.

Q. Are there any others besides the hospital and the museum?—A. I personally do not know of any other large buildings in Ottawa in which very serious settlements have taken place.

The CHAIRMAN: I am not aware of any others in Ottawa. Some house owners occasionally in this area keep up the moisture content of the clay so they will not have the settling in the very dry season in the summer. It is as simple as that, I think, with a small light house. If they water the lawn regularly the house will not have the severe settling that it sometimes has in an intensely dry building season.

By Mr. Murphy (Lambton West):

Q. Having reference to the House of Fine Arts in Mexico City, which has been sinking considerably due to the soil, I understand there they shove cement down under the foundation by pressure. I have been told that they have been doing it for years.—A. This would be something that one could try. I am not familiar with the details of that. It is, of course, a famous area for this very thing.

Q. You referred to heating in home construction. Can you elaborate on that?—A. Well, the heat pump is essentially refrigeration in reverse. That is, you use the refrigeration unit; you reverse the business and pump the heat from some outside source and heat the house in the winter. One can use the same unit, with modifications, for cooling in summer. One has to have in the order of at least a 2-horsepower compressor unit for cooling in summer.

Q. What would be the source of heat?—A. And a much larger one of 5-horsepower for heating in the winter. The source of heat can be from either the ground or water.

Q. You mean deep down in the ground?—A. No, sir. Bury coils in the ground about 5 or 6 feet over an area 50 by 100 feet. You can extract heat from the ground and pump it up to a temperature which enables it to be used.

Q. Would that project be satisfactory? Has it proven satisfactory without auxiliary heating?—A. Oh, yes. It is entirely possible to heat a house.

Q. How would the cost be as compared to oil or gas in the same area?—A. In general, it means fairly high first cost. Certainly, even in the United States, one could hardly contemplate putting in a unit for less than double the cost of a conventional heating system. The operating cost will depend entirely upon the cost of electric power. In some areas the cost of water plays a part, as it is involved in cooling the compressor in summer. This is a very critical business in the United States—the use of water for cooling in summer air-conditioning.

Q. You, no doubt, have done some work on the pump used in an ordinary heating system; that is the system which forces the water through much faster than it otherwise would go by reason of pressure from the boiler. Does it surprise you that most contractors do not use that method when it comes to using hot water? The point which I have in mind is, if that method of heating is feasible why should it not be used more in this country where heating is a problem?

Dr. E. W. R. STEACIE (*President, National Research Council*): You mean a circulating pump in a hot water system?

By Mr. Murphy (Lambton West):

Q. Yes.—A. The matter of the speed at which you circulate the water is a factor. This, of course, needs to be related to the output of the unit through which it is pumped. If the unit delivers the proper amount of heat with the water pumped slowly, there is no waste involved.

Q. The point I am driving at is that you can put that pump on a system and bring your water temperature up to 150 or 160 degrees and the pump immediately starts forcing the water through in a hurry, and you get hot water through the house much more quickly and the house is heated much more rapidly.—A. By far the larger proportion of hot water heating systems today are forced systems, but the hot water systems are not used in the majority of houses. The majority have forced warm air systems today.

Q. You said before that you were making some investigations and doing some research work on causes of fires and that the information which you had was most revealing. You did not elaborate. Could you give us some idea as to the information you received?—A. These are just the bare statistics based on collecting as much information as possible as to the time the fire occurs, which people are involved and trapped in the fire, which of the people die, the time of the year when the most fires occur, and the time of day when most fires occur. Information is also collected as far as possible on the construction of the house.

Q. And what was the cause of the fire?—A. Yes, and what caused the death of the person whose death was related to the fire.

Q. What proportion of the fires have been caused through poor wiring or overloading?—A. I would hesitate to give a figure on that. We are concerned with the fires which cause death. That is what we have picked out to start on. A very great job has to be done to extend this to other parts of Canada and all fires. At the moment we are studying only those fires in which death occurs and I cannot give you those figures; I do not know what the statistics show.

Dr. STEACIE: We could get that when we visit the laboratory.

By Mr. Murphy (Lambton West):

Q. What concerns me is the number of fires which seem to be caused through perhaps an old type of wiring in an old house and whether or not your proposed building code is going to eliminate a good portion of this particular fire cause. I think the committee will agree, Mr. Chairman, that many of these old houses are a menace to life and that many of them were constructed with wiring that is not sufficient for the load which may be carried today with probably heavy-wired stoves and everything else which is used as a household necessity today.—A. Would you like, sir, to ask Dr. Ballard that when you are at the laboratory? This unvolves the Canadian electrical code with which he is very familiar.

By Mr. Harrison:

Q. Dr. Hutcheon, you mentioned the research that is being done at Saskatoon on insulation, and particularly the effect of the air space. I wonder if you would care to commnet roughly on what your findings have been with respect to air space?—A. Yes. The over-all value of the air space as an insulator has been known for some time; it is not that which we have found reason to doubt. It was not so well known that the air circulating in the air space is able to separate out so that the air space is colder at the bottom than at the top. This may seem like a simple business but it has all sorts of implications. To carry this further; if one has several air spaces in the wall, due to the fact that the air circulates, and is coldest at the botom, it will flow from the bottom of the one space into another, and one ends up with the equivalent of only one space—the air actually circulates from one to the other. This emphasizes the importance of sealing off air spaces where one is relying on them and forcing them to act as individual and separate spaces in the wall. This is in essence a result of the work, and it is things of this kind which have given us great insight into the problem. It means that the fit of insulation is very important.

The CHAIRMAN: Mention was made a few moments ago of the "better building bulletins". Perhaps it would be useful if I indicated the subjects dealt with in the "better building bulletins" which have been published already. They are: condensation in the home; insulation of the home; concrete; permafrost and buildings; and winter construction. For instance, the one on concrete, in the publication itself, has a list of sources of information on concrete giving other publications to which reference may be had.

Mr. LOW: Where could we get copies of those?

Dr. STEACIE: Would you like to have these circulated to the committee?

Mr. LOW: I think they would be very useful.

The CHAIRMAN: I will have them circulated to the committee members.

By Mr. Murphy (Lambton West):

Q. In reference to winter construction, it is only in recent years that we in this country have attempted even to do brick work and stone work in the winter time, also plastering and such things. I am wondering if there has been sufficient worn done to warrant an opinion at this juncture as to a comparison, so far as the permanency is concerned, with summer construction; I am referring, of course, to brick, stone and mortar.—A. Winter construction has been brought forward as a very live topic recently in line with the general desire to decrease winter unemployment. We have been consulted, and we have a project involving study of winter construction methods. Generally speaking, it is possible to carry on all of these operations successfully in winter, but not, of course, in the same way that one carries them out in summer.

Q. That would mean a much higher cost of construction?—A. Not necessarily. One will have to pay more money for certain things. One has to build a shelter, for example, and spend money on heating. But it is also possible that one benefits from the much more firm site conditions for transportation; the frozen ground facilitates transportation frequently, although in certain cases also the snow may be a hindrance. One has usually a much better labour supply and there are many advantages which improve the situation in the winter. But it does not follow that one can carry out all summer operations under winter conditions in the same method and with the same results; far from it.

Q. The thing I have in mind is laying brick in an apartment house, or any building, when the mortar is being laid in a temperature of 20 or 30 degrees below zero.—A. There is no concrete evidence that mortar and plaster can be applied under freezing conditions and react satisfactorily. There are some bits of evidence which indicate this, but there is no concrete evidence.

Q. If they are laying brick with mortar in the winter time, will that be as effective or will it have the same durability?—A. No, sir. If it is not protected against freezing it will not.

Dr. STEACIE: They would have to put a shelter up and heat it.

By Mr. Murphy (Lambton West):

Q. You see apartments going up in the city in the winter time and they are laying brick. What disturbs me is the effectiveness and length of use they will get. If they are up 6 or 7 stories the mortar cannot be continually heated.—A. That is a very good question and a matter for concern. We have suddenly shifted to a period of wanting to allow these things to be done in contrast to the regulations which have been more or less accepted over the years which involve keeping these materials from freezing during the setting period.

By Mr. MacLean:

Q. Has any research been done into the possibility of devising some acceptable method, other than the use of water, which would be frostproof, or which in conjunction with water might be satisfactory as a mortar mix so that it could be used in low temperatures?—A. No. There is no possibility, as far as I know, of using any anti-freeze solution of any kind. The reaction one desires is the reaction of water with a low-cost material. If one turns to another liquid one might conceivably find some other reaction. You might find a liquid which did not freeze and which would give a cementing action with some other material, but it would not perhaps be competitive in price. It is not thought suitable to add large quantities of salt, for instance; this interferes with the basic reaction. One does add up to 2 per cent of calcium chloride, which is not for the purpose of making the water non-freezing, but is rather to accelerate the set; it results in a more rapid generation of heat and is, therefore, desirable from that point of view.

Mr. HARDIE: Do I take it that questions relating to permafrost are out of order today?

The CHAIRMAN: No. They are in order.

By Mr. Hardie:

Q. In the investigation that your department did at Aklavik upon the new townsite there, what would be the proportion or percentage of ice in the soil on the present location as compared to the old location? Would your department have that information available?—A. Not necessarily. We may have access to the information. We were engaged only in the original soil survey. Certainly the fine-grained soil at the old site had a very high water content, up to 100 per cent and in some cases more. At the new site, there was a great deal of gravel and this, of course, does not have ice interspersed through it in the same way that fine-grained silty soil does. Exploration subsequently has been carried out there with test pits by engineers, not by ourselves, but by the Department of Northern Affairs.

Q. I see in this National Research Council review that there were 24 test pits. As a matter of fact, I saw the test pits on the site in 1954. Since that time there has been, of course, a great deal of commotion up there among the people because some of the people working on that project have claimed that there is as much ice in the soil of the present site as there was in the old site.—A. Personnally I do not have knowledge of the facts in this regard. We could probably try to get that.

Q. Has your branch done any research on basements in permafrost?—A. Yes. One of the very early jobs, by the man now in charge of our permafrost section, before there was an actual section, was to make a survey of all buildings in the Mackenzie river valley and therefore we had an opportunity to observe different kinds of foundations. Where there was permafrost in finegrain soils there were very few basements in operation which were operating satisfactorily.

Q. So, I take it, as far as any research in that field is concerned it has been the conclusion then that basements cannot be put in in a soil containing a great percentage of ice as is the case of Aklavik?—A. I think that up to a certain point one does not have to do research to arrive at this conclusion. When you have fine grain soils and water present you almost always develop in the permanently frozen state a very high water content. The cause of this is a matter for conjecture, but the fact remains in most areas of fine grain soils permanently frozen that there is a high water content. If the soil never thaws down completely to provide drainage from underneath, the annual precipitation provides more water. If a structure begings to thaw this fine silty soil with a high water content, the basement will gradually settle and, the soil being depressed, the water comes to the top. I have seen several large buildings under which, through melting of the permafrost the soil had settled, forming a great lake under the building. When these are the conditions one does not have to do research to tell that you cannot heat the basement because it will thaw the ground, producing mud and the weight of the building will squeeze it out.

Q. My point was as to whether you had done research on insulation against the thawing of permafrost?—A. No, we have not. Here again one can go a long way in predicting what will happen. Insulation is never perfect. It never stops all of the heat. One merely puts off the eventual result. The real question is whether one puts it off one year of five years. This is, I believe, a matter which is going to be experimented on in the coming summer.

Mr. HARDIE: I have other questions, but I can ask them later.

The CHAIRMAN: You have other questions to ask?

Mr. HARDIE: I will ask them at the laboratory.

By Mr. Murphy (Lambton West):

Q. I wonder if Dr. Hutcheon is familiar with the building code which was suggested for the municipalities to adopt? In this country we are going to be faced with a problem in many municipalities where they do not have sewage disposal. I wonder if you have done any work in connection with a more efficient septic tank and drainage idea to eliminate the problems which we have faced in the past?—A. This is a matter of very great concern to us. It is not something on which, right at the moment, we are carrying out any laboratory work. This field is a most complicated one. The work in the field of public health is rather complicated and it is not therefore something which we can of our own volition decide we will work on. There are other things to be considered including municipal and provincial interests in such matters. The provincial sanitary people have the responsibility for the general regulations. Under the National Building Code there have been three advisory committees recently set up. One of these has to do with public health and it will now be a matter for this committee, which has on it many prominent people in this field, to bring these things under review and decide in what direction something might be done and to make suggestions, perhaps to ourselves or other agencies, as to how this could be carried out. We are in the meantime closely in touch with Central Mortgage and Housing Corporation and we realize, in several areas in Canada where land is generally scarce, that this is a very serious problem. We are keeping in touch with what literature there is available on other methods; but this is not something which we consider ourselves fully qualified, at the moment, to go into.

Q. Do you know of any other agency doing research of this nature?—A. There is work going on at Purdue University on a modification of the ordinary sewage disposal system which involves circulating air through the sewage and carrying out a somewhat different type of bacterial action than that which goes on in a septic tank. The result would be to produce a much less offensive effluent from the tank. There are some interesting developments but they are not at the stage where one can say they are the answer.

Q. Is any work being done on this here in Canada?—A. I know of no work being done in Canada.

By Mr. Hardie:

Q. Mr. Chairman, the Department of Northern Affairs has a Research Coordination Section and I wonder if the National Research Council cooperates with this Section, and if so what has been the research work which they are called upon to do?—A. We have frequent contacts with and references and questions from the Department of Northern Affairs, mainly in connection with northern building. We have one man who spends most of his time dealing with problems arising in the north and he keeps in contact with the various agencies. I do not recognize the committee which you mention. Normally we are in touch with them and they have referred a lot of problems to us.

Dr. STEACIE: There is an Advisory Committee on Northern Development of which I am a member, and then there are subcommittees.

Mr. HARDIE: This branch is a separate branch of Northern Affairs.

Dr. STEACIE: Is it the one in which Mr. Graham Rowley is the secretary?

Mr. HARDIE: Yes.

Dr. STEACIE: This is rather concerned with, I would say, research in general Arctic problems, in respect to exploration and things of that sort. It is not working on things like building and so forth. It is mainly concerned with coordination of scientific research in the north and is definitely concerned with all work that is done in the north and anyone sending parties to the north.

Mr. HARDIE: I wondered if your people cooperated with or were called upon to do any work for that particular section?

Dr. STEACIE: It is more coordination of what goes on. We have some connection with it. The Defence Research Board has quite a lot of connection.

By Mr. Hardie:

Q. A year ago in the Estimates Committee I asked a question on this particular thing and at that time I had the impression that you cooperated. That is to say, the research was on Eskimos and I thought perhaps you had one up here in a block of ice or some place.—A. We have been asked many questions about Eskimo houses. One of the difficulties is to get the right type of staff to put on this work. We have only one or two people available for such assignments. There are many things which we are not able to carry on simply because we have too few people in that particular field.

By Mr. Harrison:

Q. You mentioned pre-stressed concrete. Do you use light weight aggregates entirely in that?—A. It is usual to use much higher quality materials than in normal reinforced concrete. The concrete provides the means of carrying the compressive load and all tensile loads in a beam or column must be carried by steel in there. Concrete shrinks, and in addition in the area where the steel is, the concrete will frequently crack while allowing the steel to take the tensile load. In pre-stressed concrete, small high-strength steel wires are used as reinforcing. They are initially tensioned so that the concrete is put under a compression and does not have the opportunity to crack when the load is subsequently applied.

There are certain other advantages and certain problems in the use of this. It is one of these things, in the use of concrete and steel in combination, which usually involves using much higher quality materials and therefore one is able to operate at higher working stresses and come up with much smaller members.

Q. Do they find it desirable to use light weight aggregates, or does it just affect the weight if weight is a factor?—A. Many people are talking about using light weight aggregates now; but the concrete used must maintain the pre-stressed condition. If it backs away from the load through flow, or creep, then one has lost the advantage. The light weight concretes will generally have a greater tendency to creep and, therefore, while many people would propose to use them it is not at all clear that this is a good thing to try to do. In most cases up until now much better quality and stronger concrete has been used. It is something which may come, but only after we have been able to work out this business and when we know much more definitely what these light weight materials actually do in the way of performance under load.

By Mr. Murphy (Lambton West):

Q. Reverting back to this heating question. A problem which we will have to face is the cost of heating in a home, and it is a continuing problem. I am wondering about supplementary heating in a home, having in mind fireplaces. We build fireplaces for one purpose or another and within recent years we have had this Heat-o-lator idea, which gives more heat to the house than a fireplace built without the Heat-o-lator. What I would like to have you answer, if it is within your purview, is this: has any research work been done to enable a householder to get more heat out of the fireplace?—A. No, sir. The Heat-o-lator is the only device of which I know for this purpose. The only thing to do if you want efficient heating is to throw it out, unless you insist on having a fire to look at. A fireplace is a device which draws a lot of air into our houses. Our Canadian houses achieve their heating economy by a very careful control of the amount of air leakage allowed into them. A fireplace tends to draw a very large amount of air out of them and a corresponding amount of cold air in. It is not possible to do anything to a fireplace that converts it to a degree of efficiency comparable to that which we get in our ordinary closed stoves.

Dr. STEACIE: In England these days everyone is building stoves into their fireplaces. Wherever you go in England you find that in most fireplaces they have constructed a stove which they place on the hearth with the pipe up the chimney. The answer is that the English seem to be coming back to the conclusion that all their heat is going up the chimney.

The CHAIRMAN: We will meet on Thursday morning at 10.30 o'clock, when we will hear the director of the Division of Radio and Electrical Engineering.

Mr. MURPHY (*Lambton West*): Will the witness' brief be presented to the commitee before the meeting in order that the time need not be taken up in reading it? That would save time.

The CHAIRMAN: It will be available and will be distributed to you before Thursday morning.

HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 7

NATIONAL RESEARCH COUNCIL

THURSDAY, MAY 24, 1956

WITNESSES:

Dr. E. W. R. Steacie, President, National Research Council; Mr. B. G. Ballard, Vice-President, (Scientific); Mr. J. H. Parkin, Director, Mechanical Engineering.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956.

75090—1

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McIlraith, Esq.

and Messrs.

Bourget	Green	MacLean
Brooks	Hardie	Murphy (*Lambton West*)
Byrne	Harrison	Richardson
Coldwell	Hosking	Stewart (*Winnipeg North*)
Dickey	Leduc (*Verdun*)	Stick
Forgie	Low	Stuart (*Charlotte*)
		Weaver—(20).

(Quorum 9)

J. E. O'Connor,
Clerk of the Committee.

MINUTES OF PROCEEDINGS

THURSDAY, May 24, 1956.

The Special Committee on Research met this date at 10.30 o'clock. The Chairman, Mr. George J. McIlraith, presided.

Members present: Messrs. Brooks, Byrne, Forgie, Green, Hardie, Harrison, Hosking, Leduc (*Verdun*), MacLean, McIlraith, Murphy (*Lambton West*), Richardson, Stewart (*Winnipeg North*), Stick and Stuart (*Charlotte*).

In attendance: Dr. E. W. R. Steacie, O.B.E., Ph.D., D.Sc., F.R.S.C., F.R.S., President, National Research Council; Mr. G. G. Ballard, O.B.E., B.Sc., F.I.R.E., Director of the Division of Radio and Electrical Engineering; and Mr. J. H. Parkin, Director of the Division of Mechanical Engineering.

Mr. B. G. Ballard was called. He read a statement on research and development in the division of radio and electrical engineering, copies of which had been previously distributed to members.

Mr. Ballard was questioned at some considerable length.

At 10.45 a.m. Mr. Stick took the Chair.

Mr. Ballard's examination was concluded.

Mr. J. H. Parkin was called and introduced by Dr. Steacie. Copies of his prepared statement were tabled and distributed forthwith.

Mr. Parkin made introductory remarks on the work of the division of mechanical engineering. His statement was ordered incorporated in the evidence.

Before adjournment, Mr. Stick expressed the Committee's appreciation to Mr. Ballard and reminded the members of the Committee that it would visit the National Research Council Laboratories on the Montreal Road on Wednesday, May 30.

At 12.40 o'clock, the Acting Chairman still presiding and Mr. Parkin's examination still continuing, the Committee adjourned to the call of the Chair.

Antonio Plouffe,
Acting Clerk of the Committee.

75090—1½

EVIDENCE

THURSDAY, May 24, 1956.
10.30 a.m.

The CHAIRMAN: Gentlemen, I see a quorum. We have with us this morning Mr. Ballard, director of the Division of Radio and Electrical Engineering. I now call Mr. Ballard.

Mr. B. G. Ballard, O.B.E., B.Sc., F.I.R.E., F.A.I.E.E., Director of the Division of Radio and Electrical Engineering, called.

The CHAIRMAN: Would you mind first putting on the record your qualifications and your own personal association with the council?

The WITNESS: I have been with the council since 1930. At that time I entered the Electrical Engineering Laboratory which had a staff of one, and I was it. But it has developed since. Later it was amalgamated after the war with a separate radio section, and that group then became a separate division. I have been in charge of that division ever since, and more recently I was made vice-president, scientific, for the council. Is that satisfactory? Is that the information you seek?

The CHAIRMAN: Yes. You hold several degrees. Would you please indicate them for the record?

The WITNESS: Not several. I think all I have are already indicated on the record.

Mr. FORGIE: I think Dr. Ballard is to be congratulated upon his just having received a degree from Queen's.

The CHAIRMAN: And from a very good university, too.

Mr. STICK: I always though that it was second-rate!

The WITNESS: Mr. Chairman, I shall now read the brief which has been prepared.

Mr. MURPHY *(Lambton West):* Were we not to get copies of the brief and to have them filed?

The WITNESS: I left some 22 copies with the secretary of the committee.

The CHAIRMAN: The members have the brief. They were sent out by the clerk to the members.

Mr. STICK: When?

The CHAIRMAN: It was a thick envelope.

Mr. MURPHY *(Lambton West):* I have not had a chance to open them.

Mr. HOSKING: It was two days ago.

The CHAIRMAN: Yes; it was Tuesday, the 22nd, when they were distributed to the members.

The WITNESS: The Division of Radio and Electrical Engineering devotes its efforts mainly to applied research and development, adopting a rather liberal interpretation of the scope of radio and electrical engineering. However, it does devote, also, some attention to more fundamental studies, particularly in connection with electrical insulating materials, semi-conductor materials—which are becoming so important in the new field of transistors—meteors, the aurora, solar radiation and electromagnetic propagation. In many cases these more fundamental studies arise out of problems encountered in practical developments, and also because some equipment developed within the division lends itself specially to the pursuit of fundamental research. In this manner, a bond of interest between the applied and theoretical fiields is preserved.

The division evolved largely from a group which was assembled to meet the demand for the development of radar equipment in Canada during World War II. The staff acquired an extensive background in this particular field, and work on radar and associated problems has been pursued within the division ever since. Inevitably, the new techniques which were employed on radar development have been useful in other fields, particularly those involving microwave frequencies and which embrace that part of the electromagnetic spectrum between 1,000 megacycles and 60,000 megacycles. However, it is not implied that lower frequencies are ignored.

Because of this wartime background, the division has continued to devote an important part of its effort to radar development for defence purposes, mainly at the request of the Defence Research Board and the armed services. Altogether, about half the work in the division is of a defence nature and is classified.

In the civilian radar field, the division has developed marine radar equipment which is now being manufactured in Canada under licence, and which compares favourably with similar equipment manufactured elsewhere in the world. One firm in the United States has undertaken the manufacture of this equipment.

For several years, the division has cooperated with the Department of Transport in developing electronic aids-to-navigation other than radar, and to advanced surveying techniques. These developments include the so-called micro-wave lighthouse for coastal navigation, which enables ships or small boats to "home" on harbour beacons. The same device is used to enable fishing fleets or whaling fleets to "home" on mother ships. Similarly, microwave position-fixing systems, remotely controlled foghorns, light beacons operating in response to radio interrogation, etc., have been developed or are in progress. Underwater television equipment has been developed, and this has found extensive use both in Canada and the United States largely for studying fish in their natural habitat, but several other applications have been found.

Inevitably, in electronic development work the need for new and special electron tubes occurs frequently, and a separate section devotes its time to this problem. It should be understood, however, that the laboratory does not undertake the development of more conventional tubes, which are receiving adequate treatment in other laboratories throughout the world.

Studies on new types of antennas for all varieties of radio, radar, and television equipment are in progress, and the division has one of the best-equipped antenna laboratories on the North America continent, if not in the world. The work embraces the development of both radar and communication antennas for land-based, ship-borne and air-borne installations. More critical demands on antenna design, resulting from the increasing frequency range which communication systems employ and also the necessity for more precise directional performance, have promoted intensive development in this field.

Work is in progress on many devices which operate at relatively low power, and, in particular, mention should be made of equipment developed at the request of the Banting Institute to aid in the new hypothermia techniques for undertaking surgery at reduced body temperatures. Devices to correct fibrillation of the heart and restore a normal rhythmic beat have been developed and are in use in several hospitals. Also in the low power field are devices for detecting small flaws in high grade paper, and similar industrial control equipment.

Nor are cultural fields entirely neglected. One laboratory is devoting its time to the development of new electric musical instruments and systems for improving musical reproduction. This work has aroused a great deal of interest, and one firm has purchased an option for the United States rights for one of these developments.

In high-powered applications, an important part of the division's time has been devoted to high voltage studies, particularly those associated with the transmission of energy. Assistance is extended to industry in the development of their equipment, not only in connection with its ability to withstand the high electrical stresses imposed upon it, but also to overcome the problem of radio interference which high voltages so frequently create, and which prevents the satisfactory operation of essential communication services. Canada is confronted with unique problems in power transmission.

Mention was made earlier of more fundamental studies. In this field it is rarely possible to foresee the ultimate benefit which may arise from a particular project. We do not, in general, attempt to channel or guide the direction which the research shall follow, mainly because we feel that, by allowing complete freedom, better results are achieved and because almost any information acquired in this manner is likely to lead ultimately to useful results.

The need for investigating insulating materials is obvious, as is the investigation of semi-conductor materials which have assumed such an important position with respect to transistors, new types of rectifiers, and photo-electric cells. Perhaps the importance of rectifiers, for example, is not generally understood, but every plug-in radio, television, or electronic device of any kind employs one or more rectifiers. Silicon and germanium crystals are used extensively for some newer types of rectifier, and special furnaces have been constructed in the Division to produce high-purity silicon and germanium crystals.

The CHAIRMAN: Might I interrupt? I would like to ask Mr. Stick to take the chair for a few minutes.

(Mr. Leonard T. Stick assumed the chair.)

The WITNESS: The benefits resulting from an increased knowledge of the aurora and meteors may not be so obvious. It may appear that these are interesting phenomena about which we would like to know more. That is, of course, true, but it is highly probable that important consequences may arise from an improved knowledge. The aurora, for example, sometimes has an embarrassing and expensive effect on communication systems. There is no well-confirmed theory of the aurora, but the belief is held that it is caused by ionization resulting from high-speed particles emanating from the sun. These particles, on entering the earth's magnetic field, are, in general, concentrated into two polar rings normal to the earth's axes, giving rise to the two well-defined auroral regions in the north and south hemispheres. The more we know about the aurora, the better equipped we shall be to provide reliable communication service, and our studies are continuing.

Meteors present another challenge, and Drs. McKinley and Millman of the division have made very significant contributions in this field. Radar echoes have been obtained from meteors, and it thus becomes obvious that they may be used as a medium for reflecting long-range radio signals to receiving stations well beyond the line of sight. Such possibilities are being considered seriously, and they may well expand the horizon of our present communication systems. Furthermore, it is not impossible that meteors already play an important part in the progagation of some radio waves where they depend on what is known as "forward scatter".

I apologize for using some of these technical terms. "Scatter" is just a special case of reflection from relatively small-sized globs of atmosphere, and other particles.

A study of meteors enables us to learn many of the secrets of the upper atmosphere, such as its density, its temperature, its direction and velocity. While meteors, visible or otherwise, are always present in our solar system, there are periods of intense meteor concentration which are known as showers. These showers have been assigned names, and their recurrence can be predicted with close accuracy. There is a suggestion that the amount of rainfall may be associated with meteor intensity because the fine dust resulting from the destruction of meteors as they penetrate the earth's atmosphere may form the seed which induces rainfall. The interval between the meteor shower and the resulting rainfall is predicted to be about one month and, if this theory should be confirmed, it is possible that meteors may provide a means for long-range weather forecasting.

We have accumulated within the division the longest continuous reliable record of solar radiation in the 10cm. portion of the spectrum which is available in the world. When we recognize that the sun is the ultimate means of our survival, it is not surprising that we should want to know more about it and its effect on our everyday lives. We know that sun spot intensity varies in cycles and that certain terrestrial phenomena vary with sun spot intensity. Indeed, the whole field of radio astronomy opens interesting speculations because it enables us to detect phenomena that are not visible through optical telescopes.

It is not possible here to present more than a very general review of the division's activities, and it should not be assumed that the various projects mentioned constitute the entire work of the division. As indicated earlier, a very important segment of our activity is devoted to defence projects, and it is understood that these fall outside the terms of reference of the committee.

The ACTING CHAIRMAN: Are there any questions on the brief which has been submitted by Mr. Ballard?

By Mr. Murphy (Lambton West):

Q. Apparently since you became head of this division it has increased in personnel. I would say, speaking just offhand from the brief presented, that it must be a very interesting part of the National Research Council. What I want to ask you, Mr. Ballard, is in connection with—just for information—this antenna which you mentioned. It does not make any difference. It is for television, I assume?—A. Less for television than for other purposes. We have done some work on television antennae, but a good part of our work is in connection with radar antennae in which directional performance is extremely important if one is going to obtain an accurate bearing on a target, and also with communication antennae, because in an aircraft, for example, it is important that you do not waste energy by sending it out in all directions. You want to direct your energy into that region where you propose to use it.

If an aircraft is to communicate with a ground station, there is no reason to transmit energy above the aircraft because it would be wasted. And not only is the energy wasted but the equipment providing the wasted energy adds weight and the designer is hard pressed to keep the weight down in any event —also the superfluous transmission interferes with other communications so in those cases we direct the beams, from the various antennae to areas below the ship. The same is true with respect to naval vessels. We want to be certain that the energy is directed towards the target where it is going to be useful.

By Mr. Hosking:

Q. Can you give us some idea of the amount of horsepower required to work a radar in an aeroplane?—A. This ranges to a terrific horsepower. In terms of kilowatts, many of our radar stations momentarily broadcast two or three million watts. Momentarily you have this tremendous release of energy.

With the development of small civilian radar sets the average power will be in the order of from five to ten kilowatts, and of course larger sets go beyond that. We have some radar sets requiring one hundred horsepower in the way of power supply.

Q. How do you store this energy in order to release it so quickly?—A. It is usually stored in capacitors or condensers, and sometimes in inductances.

Q. That would be the heavy part of this equipment, for your aeroplane? —A. Not only are the energy storage devices very large and heavy—that is quite true; but you also must have heavy generators to provide that power.

Q. To create the storage?—A. Yes.

Q. The storage capacity would weigh even more than your equipment? —A. Yes.

Q. I am sorry to have interrupted.

By Mr. Murphy (Lambton West):

Q. On this question of antennae, for my own curiousity, I saw an antennae a few months ago which was in the shape of a windmill, the head of a windmill.—A. Yes.

Q. It seemed to be very effective and I was wondering if the man who had it had discussed it with you. He came to Ottawa and he was a scientist.. He could bring in twelve stations easily, whereas we get only four or five which are very good; but with this new type, do you know of any new types that are as effective as that?—A. I think in general there is one new type of television antenna introduced every day. We get quite a flood of them, but I am not familiar with this particular one. Some of them have merit, while a lot of them have no particular virtue. I cannot discuss the one you mention because it has not been brought to my attention, but there are quite a few antennae which look something like a windmill. Again some of them are good, while some of them are bad. But the general problem of antenna design is a complex one because not only have you to pick up the energy that is being directed towards you from the required source but you also have to eliminate as much as possible extraneous radiation from other sources. For this reason almost all receiving antennae become directional or are made directional so that they concentrate on the transmitting station as far as physically possible. Then there is another very great problem; you have to be able to accept quite a broad frequency range to obtain the intelligence you need. For example, in television sets there is a terrific amount of intelligence which you have to assemble to get a moving picture, and also the sound effect as well.

Q. Doctor, are there any new ones which will pick up stations more effectively, say, at 75 or 100 or 150 miles away?—A. In general, I would say that the answer to that is no.

Q. What is the range of the best ones?—A. Usually this becomes a matter of line of sight. You can pick it up at 75 miles if you can get a station where the two antennae can see each other. There are various devices to try to bend the waves around, but this usually means an intermediary station. As a general device for taking care of ordinary TV it is just impossible. In the United States, for example, they have seriously experimented with aircraft which pick up a signal from a ground station and then rebroadcast it. This aircraft is operated at 30,000 or 40,000 feet which means that is has a very long line of sight. One aircraft could cover a tremendous range of country, particularly if it is flat country, but it is largely a matter of physical conditions, rather than electrical. The propagation of these waves is affected very seriously by physical obstructions, not only because the obstructions interrupt it but they also reflect it; and signals may arrive from two sources, one which is direct and one which is reflected. The two do not arrive at quite the same time and you have a distorted picture, and a distorted sound effect.

Q. You have me confused. You say that these antennae have to see each other. What about the antennae which are just on the top of the set? I can understand what you mean if you have an antenna on the house.—A. I really was not thinking of optical vision; they do not see in the same sense that I can see you here. You have got to have some direct line between the two antennae. You can have some limited materials in between as long as they are not metallic.

Q. What about brick?—A. Brick gives you some reduction in signal strength, but not a serious one. The fact is that in most cities, where you have a high level of signal strength, you can use what is known as a rabbit ear antenna near or on top of the set. Obviously, it cannot physically see the receiving set, but it is not hidden, shall we say, by large ground masses that would either prevent any significant amount of energy getting through, or at least reflect it so that you would have a distorting effect.

By Mr. Hosking:

Q. You spoke about fog-horns. What is the system for them?—A. There are a number of schemes. Some of them are in use on the west coast, and in the main these are fog-horns which are located in isolated areas with no attendants, and they are controlled from a lighthouse several miles away. It is really radio control, except that we use a microwave frequency.

Q. Does a ship come into the beam and then the fog-horn blow?—A. No. In the case of the fog-horn, it is turned on by somebody in the lighthouse. It means that you can have a fog-horn on some isolated rock. I believe there is one on Holland rock on the west coast which is operated without having anyone in attendance there. That one, in particular, is a rather dismal spot in which to keep a man housed. It can be operated from a remote point.

By Mr. MacLean:

Q. Mr. Chairman, perhaps the doctor would say a few words about any research which is developed to discover relationships between weather cycles and sun spots in the aurora, if any is being done in this country?—A. Research of this kind is going on all the time, and is not confined to the National Research Council by any means. As I mentioned earlier, we have been studying solar radiation and the effect of sun spots on that radiation. There are other laboratories throughout the world doing similar work. We started this work very early and selected a particular part of the spectrum which seems to be leading to fruitful results. That information is correlated in other observatories all over the world and we are quite astonished at the fact that if our flow of information is interrupted we very soon hear about it from other parts of the world where they are using that information regularly. We cooperate very closely with the Dominion Observatory. They are correlating information on sun spots and sun spot activity with other natural phenomena to try to arrive at some natural coordination between them. It is going to require a good many years of effort yet, I believe, before we can arrive at any sound conclusion.

By Mr. Brooks:

Q. Mr. Ballard, I am sure, from your testing of this, it has been known for some time that the dust from meteors entering the atmosphere causes excessive rainfall sometimes and also, I suppose, snow. I was going to ask about these atomic bombs and hydrogen bombs that are being exploded and sending billions and billions of little particles of dust into the air all over the world. Is it logical and reasonable to expect that they will cause rainfall and snowfall and upset our weather to a great extent?—A. I would like to dodge that question because I do not know too much about the character of the dust clouds which these bombs produce.

Q. We know there are dust clouds, and I would think that it would work in the same way as dust from the meteors; the principle is the same thing. —A. I would expect that the dust coming from the meteors would be finer.

By the Acting Chairman:

Q. Would the dust clouds from a meteor being metallic make any difference?

Dr. E. W. R. STEACIE (*President, National Research Council*): There is one thing that is true; that is, that one is accustomed to think of an atomic bomb explosion as being a very large affair. It is true that it is large when compared with man-made phenomena. However, it really is an entirely insignificant phenomenon when you compare it with nature. The amount of energy released in an atomic bomb explosion compared with a small earthquake, or anything of that sort, is quite insignificant. I would feel that the total amount of dust released from these atomic bomb explosions is probably insignificant compared with the meteor activity, because you have meteors coming in all over the world all the time. It is true they are small, but there are immense numbers of them and I would feel, therefore, that the atomic bomb is a pretty small and insignificant phenomenon when you compare it with what nature can do. It is only when you compare it with man's effort that it is significant.

Mr. BROOKS: There is a lot of study being done on this?

Dr. STEACIE: Yes.

By Mr. Brooks:

Q. With reference to electronic aids to navigation, I heard criticism made not long ago in the house by one of our members who is greatly interested in the fishing industry on the eastern coast. He said that these are very expensive and that therefore the fishing boats could not make use of them. Have you any idea of the practical application?—A. When we developed this one device in particular, known as the microwave lighthouse—which is not an appropriate name—involving a relatively small portable unit which may be used in small boats or carried in the hand; and which is self-contained and has its own power in the form of batteries we are not unmindful of the fact that if it were to be successful it would have to be an economically built unit. But electronic equipment is never cheap. We expected that this could be produced for roughly around $200 a unit and we do not know how to make it any cheaper. We thought that that was a reasonable price. It is more expensive than a portable radio set, but is not outside the realm of reason.

Q. Is there quite a demand for it?—A. The demand has not been very high. A lot of fishing groups have been interested in it and we have demonstrated it on the Great Lakes, down the St. Lawrence and in Newfoundland, but there are problems which have to be settled; one is that you have got to have someone to provide the transmitting service. Either it must be by the Department of Transport or some private enterprise, perhaps some association of fishermen who would set it up. But I understand there is some objection to that sort of an arrangement because it has been done in connection with aircraft beacons and aircraft outside of the association begin to depend on it; and then, suddenly, the association finds that it does not need it for a particular period and it leaves the other aircraft in an unfortunate position. There is some reluctance to license private navigational aids for that reason, particularly when other groups could use them.

By Mr. Stewart (Winnipeg North):

Q. I would like to refer to another example of man-made phenomena. You mention that one laboratory is devoting its time to the development of new electronic musical instrument. Is that necessarily a contribution to a civilized society? In other words, what is the purpose of devoting time to the development of new electronic musical instruments?—A. Well, this is, at the moment, something which promises to be one of our more profitable undertakings. I do not know how to justify this, except to say that musical instruments, and electronics in that field, certainly interest a good proportion of our population.

Q. When you speak of instruments, do you mean, for instance, these organs which an amateur plays with chords; it sounds terrible to me.—A. We do not have in mind organs for the amateur but rather more sophisticated organs. We have now an organ which we believe is superior to any other electronic organ on the market. It is this organ which has excited the interest of an American group.

Q. What other musical instruments are being worked on?—A. There is another instrument which I hesitate to describe to you known as the "sackbut". I assume no responsibility for that particular name. However, this is an instrument which makes it possible to imitate almost any of the single toned instruments, including the bagpipes. I have a little bit of Scottish blood in me but perhaps not enough to really appreciate the bagpipes; however, I have heard it and it sounded like a very credible imitation of the bagpipes. That particular instrument will imitate almost any other single note instrument which you could think of—saxophones, clarinets, base violins, and violins.

By Mr. Hosking:

Q. Can the one instrument imitate several instruments at the same time? Could one instrument be a whole orchestra?—A. No. You have to content yourself with one instrument at a time with it. If you have enough of these things you can have a whole orchestra composed of any instruments which you like. Some of you may have heard this sackbut on the radio as a string quartet. There was only one instrument, but in this case the music was recorded on a magnetic tape and another instrument was superimposed on that and still a third one and a fourth. We had some musical experts and they could not quite make up their minds whether it was real or faked.

Q. What does Mr. James Petrillo think of it?—A. I do not think that he would like it, but he has not expressed an opinion on it yet; it is not that well known.

By Mr. Stewart (Winnipeg North):

Q. Is it not of importance that the day may come when we will not have any more symphonic orchestra and only electronic instruments?—A. I think we will always have people who are interested in music and who will amuse themselves playing instruments. On the professional scene I would hate to see professional musicians disappear, but it is possible, that the work going on at RCA Victor in the United States and at our own laboratories would make it possible for a composer to produce music which would never be played by a musician; that is, he would write the music just as though you were punching holes in a film on a player piano and by this means you can achieve results which no musician would ever achieve, because he has very definite physical limitations as to the speed at which he can move his fingers and the span that he can reach on a piano or organ. Most of our reproduced music written to date has been played by a musician on an instrument; but it is possible that this may disappear. I do not think that it would become general, but it does mean that a composer can put on some sort of film, or paper or magnetic tape, some selection which he has created and it will go into the reproduction immediately without ever having been played by a musician.

By Mr. Murphy (Lambton West):

Q. Coming back to the predicting of rainfall by meteors, could you give us some explanation of that?—A. In what respect?

Q. Is that a new field?—A. It is a relatively new field, and has developed mainly since the war, because we have learned more about meteors since the war than in the 100 years before the war, I would say. I do not want to suggest that it is a foregone conclusion that we will be able to predict rainfall through meteors. But it is a possibility and a very real possibility. To confirm a statement that Dr. Steacie made on the magnitude of these things, I think it is well to understand that the meteor showers which we think may be significant in creating rainfall, are really gigantic clouds of particles, and the earth, in its orbital journey, encounters that same cloud again and again. It has been doing this for 100 years and longer. A great many of the showers are at least 100 years old.

Q. These are from meteors and are dust particles?—A. Yes. The meteors themselves are not necessarily dust particles; they vary in size from the head of a pin to something the size of a marble. And then there are larger particles; but they are rarely encountered and they become meteorites because they penetrate the atmosphere and really strike the earth. Unfortunately, we have never yet observed a meteorite on radar equipment. That is sheer coincidence, I think. These meteors are destroyed when they encounter the atmosphere. It is from that source that the dust particles arise. The particles forming potential meteors are floating around in space and as far as we can determine they are all within our own solar system; they do not come from outside.

By Mr. Brooks:

Q. Do we know the origin of the meteor?—A. Well, there are several possibilities. Certainly asteroids and planets have disintegrated at one time or another and there have been collisions, and you get particles of different sizes. Some of the meteorites are fair-sized bodies, many tons in weight. We have comets flying around and there are dust particles in those.

By Mr. Forgie:

Q. There is a question which has been worrying us in our section of the country. The TV reception which we have in our part of the country is very poor. The contours are about the same and there is very little variation in the earth structure between our area and the west—we are talking now about Pembroke. We seem to be on the fringe, and I am wondering if there is any practical suggestion that you could make to improve the reception at that distance of 100 miles, or is that too far for projection at the moment?—A. You certainly can get television reception at 100-mile ranges, but it is not consistently good. You have to have very special ground contours, I think, to get it. I am not familiar with the particular problems in the area which you mentioned, but it is not unusual to find parts of the country that are naturally poor for radio reception. The area between Toronto and Ottawa is not good. We get very few Toronto radio stations in Ottawa. I am not thinking of television but rather radio now.

Q. In that case is it because the elevations vary?—A. In that case it is largely due to the ground conditions and the electrical conductivity of the earth.

Mr. MURPHY (*Lambton West*): That subject, I think, interests everybody. Down our way we figure that around 65 miles is about the limit.

By Mr. Forgie:

Q. That seems to be the limit for us. In the town of Pembroke itself the reception is inferior to the reception beyond the town.—A. Undoubtedly you get these varying conditions in the ground and the conductivity, although conductivity is not as important in television as in radio, but it has some effect..

By Mr. Murphy (Lambton West)*:*

Q. Can they put a booster on to send the signal out in one direction at greater strength?—A. Yes; but you are still confronted with the same problem of bouncing it off obstructions in between.

Q. If it is just a matter of distance—if you had to overcome the distance between 65 and 100 miles to get the signal into a certain specified area, can you put a booster on to send it in in that direction?—A. I do not think you could give an unqualified answer to that. It would depend upon conditions in general. The more power you put into a transmitter the greater range you get. However, the height has a very profound effect upon TV.

By Mr. Byrne:

Q. Supposing that the line of sight is perfect, is there any limitation on the distance for television outside of the atmosphere?—A. Yes. Even though you do have a great deal of reduction of loss, you can never get a beam that is completely parallel. It diverges a bit and as it diverges it shoots energy off into space and you cannot readily recover this and direct it towards an antenna which has a relatively small pick-up area. You are bound to lose signal strength with distance. There are practical limits beyond which you cannot go.

Q. I am interested in this because in my particular area, living in the mountains, we have no television as such. There are installations on the mountain tops in several of my communities where they set up a large television antenna and then pipe the television programs into the homes at a certain rate. I am wondering if they could improve on our reception if they had a more detailed study made, say, of the geophysical conditions between the stations? They are probably 125 or 150 miles from the station. I wonder if they had a study made of the maps of the area in between, if someone could make a study of that and give them some indication if they have the proper type of aerial or if they could improve on their aerial. At the present time, while they are astonishingly good, still the reception is snowy and, I would say, hard on the eyes.—A. Of course, I think that to expect consistently good television reception at 100 or 125 miles is asking quite a bit, with the present stage of development. I would guess also that most of the transmitters have already received a great deal of consideration. People erecting transmitters have a keen interest in obtaining the best site they can, if for no other reason than to increase the range, on the basis of which, they can collect revenue for their advertising.

Q. Of course the companies which have installed the reception stations there at the present time are receiving all of their television programs from the other side of the line. The station that is transmitting is not particularly interested in reception there; it is simply more or less a bootlegging operation. It is not economically sound broadcasting for the television station itself.—A. To answer your question directly, I would say that it is possible that a survey might reveal methods of improving it, but I would not expect any great increase in performance.

By Mr. Hosking:

Q. Why do these sun spots affect our communications so much? We hear about it in the paper.—A. Sun spots really are a sort of gigantic radio transmitting set, so to speak. The sun is an immense source of radio energy and we are getting signals from it all the time. If you have a constant and steady signal strength you do not worry about it too much; but if this thing varies as it does with sun spots—and bear in mind that a sun spot is a gigantic form of explosion—it will extend for thousands and thousands of miles out in space, and this does affect our communication systems. Also arising out of these sun spots we have the particles which I mentioned earlier which we think cause our aurora. The aurora has a very profound effect upon communications. Anything the sun spots do is going to affect both the direct radiation and also our aurora.

Q. A moment ago there was some mention made of the atomic bomb being small compared to earthquakes—I believe Dr. Steacie mentioned that. Would one of the more recent hydrogen bombs, exploded under water, create quite a tidal wave similar to an earthquake?—A. I would suggest that you ask the people at Chalk river that question.

Dr. STEACIE: The point which I was making is that as compared with natural phenomena this is not such a very big thing. Compared with man-made things it is very big.

Mr. HOSKING: It would not cause a tidal wave, whereas most earthquakes do.

Dr. STEACIE: I think that you could get a quantitative answer on that from Chalk river. However, I think we have a tendency to think it is enormous; but when you take things like climate and the things involved, these are little pinpricks.

Mr. STEWART (*Winnipeg North*): Could I revert to the line of questioning which we had earlier in connection with this sackbut? What does the instrument look like?

Dr. STEACIE: Is it still intact?

The WITNESS: Yes.

Dr. STEACIE: Could we show it to you?

By Mr. Stewart (Winnipeg North):

Q. If you would?—A. If I had to describe it, I could say that it looks like nothing on earth.

Q. Have you considered what it would cost as a commercial possibility? —A. No; I do not know. I would guess that it would be well under $1,000.

Q. Apparently you could form a whole orchestra out of sackbut instruments?—A. Yes.

Q. Are you going to go ahead with this line of endeavour?—A. We are going to complete a sackbut and let the musical people take over from there.

Q. Perhaps we may have an opportunity to see it?

Dr. STEACIE: I think it would be very interesting to you.

The WITNESS: You might be interested also in the organ because it has some unique features. For those who really appreciate organ music, we think this would be very interesting because you can obtain on this electronic organ control which is impossible on a conventional organ, whether a conventional pipe organ or electronic.

Q. How far can you go below sixteen cycles?—A. At the moment you cannot, but there is no real practical limit to the bottom of this.

Q. Sixteen sounds horrible.—A. Even the Duke of Edinburgh has played this sackbut.

By Mr. Leduc (Verdun):

Q. Are you talking about a new electronic organ which is not on the market yet?—A. Which is not on the market yet.

Q. I would be very much interested in this.

By Mr. Hosking:

Q. Are these instruments still as difficult to learn to play as, for instance, a piano? Do you require practice and skill?—A. Yes. We are not undertaking to make music simpler for the amateur. We are trying to make better music.

By Mr. Stewart (Winnipeg North):

Q. How much does the sackbut weigh?—A. Less than 100 pounds. The sackbut is played like a small organ; it has a keyboard like an organ. This organlike keyboard enables you to imitate a slide trombone and to obtain sound with a continuously changing pitch. This is possible because the control has one additional degree of freedom—you can wiggle the keys sideways.

By Mr. Brooks:

Q. With reference to radar equipment, I understand you to say one-half of the work you are doing in radar is for defence?—A. May I correct that. I said that one-half of our work is for defence—not necessarily radar work. A significant part of that work is in the radar field.

Q. The question I wish to ask is this: you know that all the NATO nations would be working in unison in the matter of defence, and does each nation work in the general field of radar and other defence equipment, or is there a particular branch of it assigned to each nation? Would we be working in the genearl field or do we have some particular branch assigned to us in defence matters?—A. In general, the NATO nations endeavour to cooperate and each nation does what it is best fitted for. It so happens that Canada has a fair reputation in the radar field. One of the best radar sets which was used in the war—and this was anti-aircraft radar—was of Canadian origin. That, by the way, has been modified since and it is being used by the NATO countries and is being manufactured in Canada to a large extent.

By Mr. Hosking:

Q. Was it developed by the National Research Council?—A. Yes, and manufactured by what is now Canadian Arsenals.

By Mr. Brooks:

Q. The development of radar in the first instance was in Great Britain?—A. I am afraid you would find a lot of controversial views on that.

Q. I have read some of them in the American papers.—A. I think it is fair to say that Great Britain contributed enormously to the development of radar. It was really in Great Britain that the scientific plans involved were first put together in an effective radar. I should qualify that by saying that very early, the United States was doing some work on radar, even well before the war; but I think that the major impetus for radar was in Great Britain.

Q. The NATO nations are all working together on this and there is no withholding of information one from the other?—A. This is something with which we have nothing to do. We just do work for the Department of National Defence and if they want the work classified it is classified. It is none of our business.

By Mr. Murphy (Lambton West):

Q. Is that the type of work that Sir Robert Watson Watt was interested in?—A. He was given credit for the early development of radar.

Q. He was given something else besides credit, was he not?—A. Yes. I am told that some monetary reward followed.

By Mr. Hosking:

Q. Is there any truth to the stories which we heard in England that they could bend the beams that the German planes were flying on so that they dropped their bombs in the sea? The rumour among the troops was that you could have the planes flying on one directional beam, and when they came into the other they would drop their bombs. Was there any truth to the story that they could bend them and put them out in the North Sea?—A. They did not really bend them, but you can produce some information of your own, and they sometimes accept the wrong information.

Q. That is what I wanted to know. We actually do not bend them.—A. That is right.

Q. I wondered. If that could be done, as suggested, why can't you bend these radar and television beams?—A. Perhaps I should explain that, given enough money, you can do almost anything. You can even bend television beams, but the amount of energy you would have to put in mainly in the form of heat to get the various strata at a different density of atmosphere would be a tricky job to operate. But you could do it if you had to. We get these varied effects accidentally and sometimes they cause us embarrassment. We have radar sets in marine service, and there are some areas in which you get the bending effect mainly because there are different layers at different temperatures in the atmosphere; they have the effect of bending or refracting the electro-magnetic propogation. A lot of our great lakes skippers discovered that they could see enormous distances with their radar sets and they began to expect this as normal, and they complained when they could only see a normal distance. We had to spend some time to show them that you cannot expect to see beyond the horizon normally. But if you got this sort of stratified atmosphere, then you would have those bending effects.

By Mr. Murphy (Lambton West):

Q. Is that the reason that occasionally a person can pick up a station which is 400 or 500 miles away?—A. What are you referring to now?

Q. Television.—A. It is perhaps not so likely to be that as some reflection you may get off the ionosphere. This is particularly true in the lower frequency communication systems such as the ordinary broadcast radio, and then you get magnified distances specially in the winter.

By Mr. Hosking:

Q. What is the ionosphere?—A. It is the ionized layer above us some 70 odd miles or so. It varies, and there are different layers.

Q. You are saying that radar bounces down again?—A. When radar does that you cannot make use of the information because the beam is so widely dispersed. But that is not so true with ordinary radio programs, because you do not have to worry about a sharp beam. However, in radar if you do not have a sharp beam, the information does not mean very much to you. You cannot locate the position of the target. With a lower frequency transmission system, the signal may bounce off the ionosphere. And use is made of this principle in communicating across the Atlantic. The height of the ionosphere varies from hour to hour. In fact, the Bell Telephone people will tell you that they vary the frequency on which they carry their messages overseas and adjust it to the particular height of the ionosphere at any given time.

Q. I am one who believes that hydro has not been a good public utility because they have forced the people to use 25 cycles, whereas if there had been competition we would have had 60 cycles because of the economics. I wonder if the Bell Telephone Company which is a monopoly is doing as much development work with its system as should be done? They are not in competition with anybody, and they do not have to be.

Mr. Brooks: It is only backward Ontario that you are talking about.

Mr. Hosking: Ontario may do some things backward but it still leads the Dominion of Canada.

Mr. Byrne: That is only a supposition.

The Acting Chairman: We had better stick to asking questions of the doctor.

By Mr. Hosking:

Q. Is there any danger of our missing something because we are giving a monopoly to them? I am not being critical; I was just joking, but is there any danger in your department of not doing enough of the work that we are doing, and doing the best job in communications, because I suppose there is more money spent on these things as a luxury or as part of business than on anything else in the country?—A. It is not fair to say at the outset that it is practically a monopoly because, while they may have a monopoly in a particular area such as this area, nevertheless they still must compete with the service and performance which is given by a good many private companies elsewhere. There are dozens of private telephone companies in Canada as well as in the United States and we do know that we are getting comparable services from all of these firms. They are really in competition although that may not be so in a particular local area. But in the broad field they are, and we know the sort of telephone service provided by the British Post Office, and in my opinion we are getting better telephone service in Canada than they are in Great Britain.

Q. I agree with you.

Mr. Forgie: You can say that again!

The WITNESS: Independent telephone companies are installing equipment which is manufactured by firms not connected with the Bell Telephone Company. I think that the Bell Telephone Company in the United States and its associated companies have one of the most outstanding laboratories that you will find, and they are doing a tremendous amount of work. My personal feeling is that we are not suffering because they have a local monopoly. I am not arguing for or against monopolies, but that seems to me to be the case.

By Mr. Hosking:

Q. Perhaps I should not have posed my question in that way.

Mr. BYRNE: I think it was a good idea!

By Mr. Hosking:

Q. These telephone companies all have their own areas or spheres of influence. They do not actually have to compete or do a competitive job on each other, and because of that would you say that some of them do not carry on as much investigation or development as they should?—A. I think they are; I think they are really competitive. You may get better service and at a lower rate for that service, let us say, in the province of Manitoba than we are getting here. People know about this, they travel back and forth, and they say: "why are we paying the money we do for this sort of service when they are getting better service elsewhere?"

Q. If there is enough research being done by these companies, are you convinced then that there would be no reason for our government to spend more money than we are spending for that purpose?—A. I personally do not feel that we would be justified in spending money on the development of telephone service.

By Mr. Murphy (Lambton West):

Q. Is it a fact that Bell Telephone is within the first ten major industries in its program so far as the amount of money is concerned which is spent for research?—A. That is about true. I could not be precise and say that they are among the first ten, but they are well up.

Dr. STEACIE: It is the Bell system, not the Bell Telephone Company. The work is done by the Bell Laboratory which is part of the Bell system. None of the individual Bell units do research at all. It is all done by the Bell system.

Mr. MURPHY (*Lambton West*): A certain amount is set aside for research work which is done on the other side, in the Bell laboratory?

Dr. STEACIE: Yes.

Mr. BROOKS: It was only about a week ago that I read in the *Montreal Gazette* where the different telephone companies, through their research work, had improved their system so much that it was only a matter of seconds now to get from—when you make a call—the person making the call to the recipient—it was only a matter of seconds anywhere in Canada, or it would be as soon as they all had their apparatus installed.

Dr. STEACIE: I think everybody would agree that the Bell laboratory is an outstanding laboratory and has been a very enterprising one. They have a tremendous reputation scientifically.

By Mr. Hosking:

Q. You would not hesitate to say then that there would be no useful purpose in our spending more money on communications, and you would say that the job was being well done by industry?—A. As far as telephones are concerned, I would say so, yes.

Q. In other fields—we have to accept these telephones, and once you get to the place where you accept something, that is it, and you do not do much work on it. But have we not progressed in the last fifty years to where there is something better than stringing wires across? Is research not being done in order to do away with our present communication system?—A. I do not think you could say that the telephone systems have been static. They have been far from that. When you put through a long distance call now the chances are that your information is being carried by a radio link at some place or other in the system. After all, the Bell Telephone Companies have radio links all over the country which are carrying television programs and long distance calls. As I mentioned earlier, there are changes taking place all the time. The automatic exchange is a change which has taken place within the last two decades, and that is going to continue to grow as I mentioned. Ultimately we will have automatic long distance service from subscriber to subscriber. It will go through an exchange but you would not call the exchange first and put an order in for a long distance call; you will be able to call somebody, let us say, in Toronto directly by dialing and thereby reduce the time very substantially. These are developments which are in progress and I think it is fair to say that we are getting very satisfactory service. Then again we are going to have a trans-Atlantic cable.

The ACTING CHAIRMAN: We have already got it because I was at the launching of it last year.

The WITNESS: Yes, but it is not yet in operation. This will be the first time that voices will have been communicated over such a long cable. It is true that we have plenty of cables with repeaters here and there; but in the case of the trans-Atlantic cable they have put repeaters into the cable all the way along.

The ACTING CHAIRMAN: Every forty miles.

By Mr. Hosking:

Q. You have not yet come out and said that you feel that this job is being so well done by free enterprise that we should not spend more money than we are spending to investigate it.—A. That is true, in my opinion, for telephones.

By Mr. Byrne:

Q. Is it true that the Trans-Canada micro-wave will carry over a thousand communications at one time?—A. That is right.

Dr. STEACIE: We should emphasize also that whether we should have public or private ownership, or competition, is obviously out of our field.

Mr. HOSKING: I simply introduced it to put my thinking across.

The ACTING CHAIRMAN: I have one question which interests us very much down in Newfoundland. We have a tremendous potential of hydro electric power in Labrador. I have been told that it is not economical to transmit electrical energy over 400 miles. But Sweden has done it for up to 600 miles. Would you comment on that? What research have you been doing in regard to the transmission of electrical energy over longer distances? Grand Falls in Labrador has the highest electrical potential in the world at the present time. But we are about 1,000 miles away from the industrial centres of Ontario and Quebec. Would you like to comment on the transmission of electrical energy, and what has been done in that field?

The WITNESS: This whole Hamilton river development has interested us very considerably. But there are differences between the situation in Sweden and that in Canada. For one thing, the Swedish transmission line runs the whole length of the country virtually, and they have lines or loads which are sprinkled along that line, whereas the Hamilton development would mean mainly the carrying of that power in one block from Labrador to the more highly settled areas in Canada. Certainly some thought has been given; we have given a fair amount of thought to it, and one possibility—I am not going to make any definite prediction about this—but one possibility is the use of direct current rather than alternating current. It so happens that the development from Labrador down to the more highly populated areas lends itself to direct current transmission more than does any other area in the world. I mentioned in the brief that Canada does have unique energy transmission problems and that is one of them. That is something we are studying now, perhaps not at as high a rate as we should, but with the maximum effort our man power will permit. We have discussed this with Swedish engineers, and we invited two of them to visit us this autumn in order to discuss further this very subject. It is hard to say what is going to emerge from this.

In the United States they rather frown upon the use of direct current, not, I think, because they feel that it is completely impracticable but because they have had such pronounced success with alternating current. But they have not been confronted with the same sort of problems that we have in the Labrador area; and they are reluctant to spend the money necessary to develop that special form of direct current transmission. Direct current transmission has been backward for a long time. It has some theoretical advantages.

In Sweden they installed a short direct current transmission line. It reaches an island off the mainland, but its operating voltage is so low that it does not provide good experimental data. There is no direct current transmission that we know of at the moment that is handling a problem comparable to that in Canada. During the war the Germans started development of a direct current transmission system which would operate at something like 2,000,000 volts, and that was an interesting development. But unfortunately it was lost because the armies moved in at the end of the war. The Russian armies occupied the area in which it was located, and there has been no significant report on it since that time.

In our laboratory we have a sample of the cable that they were proposing to use, but which was never really installed. However they did have a station which was being set up for the purpose. We talked to their engineers about it, but in any event if the new system is to become practicable and an economic success it will involve a large amount of development.

That same system might be useful on the west coast where we have a large potential of hydro areas, and we are looking at it very carefully and we are studying it with every effort we can bring to bear on it. I do not think I can say much more about it.

It is true that with the potential capacity in the Hamilton river area we can expect from 4 million to 6 million horsepower.

The ACTING CHAIRMAN: Up to 10 million horsepower.

The WITNESS: Depending on how much money you are prepared to spend on the hydraulic end to divert water to some more economical site.

The ACTING CHAIRMAN: There is no possibility of changing alternating current to direct current? That has never been done?

The WITNESS: Oh yes, and that is the way it will be done. We have never learned how to generate direct current power in large quantities at high voltage. The general practice would be to use generators which are very similar to the generators we have now; then this current would be rectified. And by the way, before it is rectified it is stepped up in voltage by means of transformers, and then rectified and converted into direct current; and at the other end of the line it must be reconverted to alternating current again, because direct current is intractable for distribution purposes and for use in homes. However for transmission purposes it definitely has some advantages, and it will be reconverted into alternating current again at the receiving end, but that is tricky business. It will use electronic equipment, and the development of that equipment will require the greatest part of our effort. Once it is reconverted into alternating current, it is a simple matter to step it down in voltage to make it useable in industry and in our homes.

By Mr. Green:

Q. We have a very important question coming up in British Columbia in regard to the transmission of power from Mica Creek dam site on the Columbia river down to the lower mainland. Are the developments and the technical improvements such that it would now be possible to transmit that power for that distance immediately? And the same question by the way arises in connection with the transmission of power from the possible power site on the Taku river area in that district, and to transmit power from there to the head of the Portland canal at Stewart, which I think is over 300 miles? What is the situation technically with respect to the transmission of power for that distance?—A. I am afraid I cannot touch on that question because after all, that falls into the field of the utilities, and they have devoted a good deal of attention to it. We, in the laboratory, have not studied the economics of that particular development. Even if we did so, we could not come up with a complete answer because we do not know as much about the economics of power transmission as do the utilities. All we endeavour to do is to advance the scientific possibilities so those utilities may use them. We are not experts on the economic end of it. I am certain however that this is receiving a great deal of attention. I have discussed it with some other people, but I do not profess to be able to answer questions about it. I can say that we hope to be able to make some small contribution which will assist it, but I cannot guarantee anything.

Q. Would it be possible to transmit that power from the Mica Creek dam site to the lower mainland area as a technical consideration, and not whether it would be economical?—A. We can do almost anything if we have enough money!

By Mr. Brooks:

Q. In connection with the development of hydro, is your department conducting any research at all regarding the development of hydro electric power by harnessing the tides? I refer particularly to the tides at the Bay of Fundy.

The ACTING CHAIRMAN: That is a hardy annual!

The WITNESS: Well, the answer is no, but we have followed with considerable interest the proposals made to develop the tidal project on the east coast. Of course in France they have developed a number of tidal projects. However again you cannot give unqualified answers to a lot of these things. For example, in France they have a close network or system and they can afford to pump power into that system at a propitious period in the tidal cycle. When the tide is out, they can forget about it, and they can pump power into the system from some other source. They are considering a series of tidal plants around the coast which will collectively supply a relatively constant amount of power. Our east coast presents a very different problem. To put in a system there, which would use effectively the tidal energy, would involve a tremendous investment. I do not know if you have examined the reports, but they propose to build dams from island to island. I am not a specialist in construction or in economics but just looking at it from the outside, it looks like an ambitious undertaking.

Q. Now about the Severn river in England?—A. They have a tidal project on the Severn, but I do not know how successful they have been as yet. I think it has been two years since I discussed it with Mr. Marshall, their deputy chief engineer, and he did not seem to be too hopeful that they were really going to produce something which would be useful as tidal power.

Q. But they are making a special study of it now?—A. Yes.

Q. Not only in the United States but in Canada as well.—A. There has been a number of reports issued there.

Q. I have seen some of them.

By Mr. Hosking:

Q. Has any effort been given to methods of storing gas for these off-peak hours?—A. They have proposed to use some of the holes in the ground in the Niagara region, but I do not know how they will store it otherwise economically.

By Mr. Forgie:

Q. Will the Hydro Electric Power Corporation be engaged in storing gas so that it may be distributed to the Toronto area? Are they working on it?—A. Yes, but again this is largely a question of economics. If you spend more money on the transmission line, you can thereby reduce the loss.

Q. The loss is about 10 per cent now.—A. It is about that order, but you could cut it in half if you wanted to spend the money on the transmission line.

The ACTING CHAIRMAN: Are there any further questions? If not, we have with us Mr. Parkin who is the director of the Division of mechanical engineering, and if it is acceptable to the committee I shall now call on Mr. Parkin.

J. H. Parkin, (Director of the Division of Mechanical Engineering), called.

The ACTING CHAIRMAN: Perhaps Dr. Steacie would be good enough to introduce Mr. Parkin.

Dr. STEACIE: Mr. Parkin is one of the pioneers in aeronautical engineering, particularly in this country. He came to the Council in the days when the laboratory first started. The division of aeronautical engineering was established there before the war, and it is concerned with problems for the Canadian Air Force. In addition to that, the division roughly covers a wide variety of other things. I can say that Mr. Parkin has had a very large share in the development of Canadian aeronautical engineering, and that he has developed, starting from nothing, what is a large aeronautical establishment on the Montreal Road.

The ACTING CHAIRMAN: All right, Mr. Parkin.

The WITNESS: Gentlemen, I appreciate the fact that this committee is concerned with non-military research, but I will refer briefly to certain military work going on in the division because of its bearing on future civilian development. The military development of today is generally applied to civilian work tomorrow as in the case of the jet engine which was applied during the war to military aircraft but which is now being used for civil aircraft.

As Dr. Steacie mentioned, the scope of the division of mechanical engineering embraces several branches of aeronautical engineering and certain phases of hydraulic engineering and naval architecture as well as mechanical engineering.

While a large part of the work of the division continues to be related to defence, work for industry is increasing year by year. The division is being called upon more and more by firms for assistance in the solution of problems. In addition to the aircraft industry, the division is working with the shipbuilding, pulp and paper and chemical industry as well as heavy and light manufacturing.

The setup of the Council has, in two respects, proved an advantage in its work with industry. One is its flexibility. Flexibility is an essential characteristic of any research organization and is very important when dealing with industry because of the manoeuvrability it provides. The other is its advisory character. The Council must be asked to advise, and its sole responsibility is that the advice shall be sound. It has no responsibility for implementing the recommendations.

An important aspect of our work with the aircraft industry is the library service provided. The Council library possesses the largest collection of aeronautical literature in Canada, totalling over 100,000 documents. Loans to industry in 1955 totalled nearly 6,000 out of a total circulation of over 26,000.

Work is also done for government departments, particularly the Departments of Public Works, and of Mines and Technical Surveys.

In the defence field, while most of the work has been for the RCAF and the aircraft industry, a large amount has been done for the RCN and shipbuilding industry. The division has participated in the construction programme of the navy by testing models of ships and boats, assisting in seagoing trials of completed vessels and in special projects. Most of our work for the army has been concerned with aspects of arctic warfare and vehicle development.

The work of the division includes basic researches, applied investigations, developments, and tests. It should not be inferred from the foregoing that all the work of the division is for outside bodies. Projects are inititaed in the division and the outside work often points up the need for investigations. For example, some work done for a paper firm led to our undertaking a study of the characteristics of fibre suspensions in water. However, the demands for outside and applied work are such that internal and fundamental researches are limited.

Examples of applied investigations include the icing of helicopters for the navy, studies of silting in the St. Charles river estuary for the D.P.W., and a study to remedy unsatisfactory conditions in a catalyzer for a chemical firm. Developments undertaken have included a de-icing system for aircraft, a gear for operating the rods in a nuclear reactor, and an amphibious vehicle for the army. A limited amount of routine testing is undertaken for government agencies. Tests are only made for industry if faciltie for making the tests are not available in commercial laboratories. Examples include acceptance tests on aviation fuel and qualification tests on equipment and instruments being produced in Canada, for the RCAF, low temperature tests on equipment for the army, and calibrations of current meters and anemometers for industry.

The work of the division lies in four fields of science: aerodynamics, hydrodynamics, thermodynamics, and mechanics.

Aerodynamics is dealt with in the low and high speed aerodynamics laboratories and the flight research section.

The large wind tunnel of the low speed laboratory has a working section about 6 x 10 ft., a maximum speed of 350 m.p.h. and is driven by a 2000-hp. motor. It is thus the largest wind tunnel in Canada. The tunnel is presently operating a large part of the time on two shifts a day on projects for Canadian aircraft firms. One of these is a new twin engined cargo aircraft being designed by De Havilland for north country service.

The two small supersonic tunnels of the high speed laboratory, one 10 x 10 in. with a maximum Mach number of about 4·5 and the other 16 x 30 in. with a maximum Mach number of about 2·0 are practically wholly engaged on fighter aircraft and missile projects.

The flight research section at Uplands, operated with the cooperation of the RCAF, which supplies and flies the aircraft used, undertakes any work required to be done in flight. It is largely occupied at present with the improvement of the aerodynamic performance of high speed fighters. Another project of considerable interest is an attempt to develop a "crash position indicator" which will automatically signal the location of a disabled or crashed aircraft and thus avoid costly searches.

There are two hydrodynamics laboratories. Almost the whole effort of the hydraulics laboratory is being devoted to the St. Lawrence Seaway project. Two large models of reaches of the river are in operation investigating the effects of modifications on navigation and power development, and a second lock model is being built to study features of design.

To cope with the work in the ship laboratory in recent years, staff increases and improvements in equipment have been necessary. Models of a large variety of ships and boats have been tested for the RCN, naval architects, and ship builders, including escort vessels (*St. Laurent*), ice breakers (*Labrador* and *d'Iberville*), car ferries, mine sweepers, lake freighters, tankers, and barges.

The thermodynamics group comprises four laboratories.

The gas dynamics laboratory is concerned with gas turbine power plants, both aircraft and industrial, combustion and certain aspects of nuclear reactors. The altitude exhauster plant of the laboratory, the second largest in the Commonwealth, permits the testing of combustion chambers under high altitude conditions. The combustion chamber of the new gas turbine being developed by Orenda Engines Limited was recently tested in the laboratory.

Gas turbine blading subjected to combustion gases from Leduc bunker fuel for 1000 hours at 700°C. has confirmed that Alberta crudes are unusually low in harmful sodium and vanadium salts and hence particularly suitable for gas turbine use.

An assessment of the practicability of the gas turbine locomotive in Canada is being made.

The facilities of the engine laboratory permit the testing of full scale aircraft engines and turbines under a variety of conditions. Work is presently concentrated on the development of a reheat system for aircraft turbines to boost the thrust in climb or combat.

The low temperature laboratory is equipped with cold chambers, the largest capable of accommodating an army tank, in which temperatures as low as −85°F. can be attained and a refrigerated wind tunnel with a working section 4½ x 4½ ft. in which a minimum temperature of −4°F. at 200 m.p.h. can be attained. Problems related to the icing of aircraft are studied in the tunnel and military equipment, guns, vehicles, etc., are tested in the chambers.

The fuels and lubricants laboratory is engaged on investigations related to aviation fuels, oils, greases, and hydraulic fluids used by the services, and acceptance tests of these materials.

Structures, instrument and a general engineering laboratory comprise the mechanics group.

The structures laboratory is equipped to test full size aircraft and components, and other structures under both static and dynamic conditions. The investigation of failures of aircraft components, and of aircraft accidents due to structural failure, is part of the work of the laboratory. Fatigue, of increasing importance as aircraft speeds increase, is being studied. A study of propellers for ice breakers is presently in progress.

The instrument laboratory is responsible for the design and construction of a wide range of special instruments required in the laboratories and, on occasion, for outside bodies. These include such items as water level indicators, trace recorders for flight research, cloud droplet camera, and automatic controls for aircraft de-icing systems.

The engineering section undertakes design, development, and test projects such as the development of a dust collector of high efficiency, an electric drive for a wheel chair for quadriplegics, and the design of a machine to cut ship and other models.

That, briefly, gentlemen, summarizes the range of activities of the division of mechanical engineering. I have not attempted to touch on the facilities, the staff, and the equipment, because I hope you may have an opportunity of seeing these when you visit our laboratories.

The ACTING CHAIRMAN: Are there any questions, gentlemen?

By Mr. Hardie:

Q. I think your branch has done some work on the design of a spar for the Beaver aircraft. I was working in conjunction with De Haviland some years ago. Since that time the Otter has come out and I understand that the recent crash of Otter aircraft gave indications of metal fatigue in certain of the Otter aircraft. Is that true?—A. I have no direct knowledge, sir of the actual conditions of the Otter crash. We were asked to do some incidental testing in trying to find the cause of that crash. There has been a second crash since then of the same type in Labrador and in both cases the wing failed under a down load, and there is some suspicion that it was due to flap movement. We were asked to determine the resistance of some fragments of the first Otter to permit a reconstruction of the sequence of the break-up, in the air. This method has been used in investigating other crashes and has now been handed over to the air force to use. It is a method of trying to determine the cause of the accident and where a machine disintegrates in the air. It involves the picking up of fragments from the ground and plotting their trajectories. To do so one has to know the resistance of each fragment of the aircraft and this we measured in the case of the first Otter crash.

By Mr. Hosking:

Q. Speaking of de-icing equipment, the British use some kind of anti-freeze and they squeeze it out in order to stop ice from forming?—A. They have tried it, but I think the general consensus is that it is not very effective. When there is any rain it is washed away and it has a very limited life. In some cases it actually seems to favour the adhesion of ice on the wing.

Q. Do the British still use it?—A. Some may be using it, but I think the trend is now towards the use of electric heating.

Q. What experimenting would you be doing with it on helicopters?—A. There was no need until quite recently to provide de-icing for helicopters because they were not flying blind; they made no attempt to fly in the clouds. But now that is being done and the British have organized an anti-submarine helicopter patrol which means that they must operate in fog over the English channel. This means that they must have icing protection. We have set up at Uplands a rig for producing an artificial icing cloud. Navy pilots have been flying helicopters in the cloud so produced. We have found, with certain helicopters that the slightest amount of ice on the motor blades will force the helicopter down, so it is imperative that some means of protection be provided.

Q. It changes the pitch of the blade?—A. It changes the shape. The blade is so narrow that a very little ice will change it radically.

By Mr. Forgie:

Q. You are engaged in research on north country aircraft. Would you enlarge on that?—A. We have co-operated with De Havilland in the development of a successor for the Otter. They have produced numbers of Beavers and Otters. They are now going to a larger twin-engine aircraft and we are assisting in its development.

By Mr. Hosking:

Q. Continuing with the problem— —A. We are planning to use a type of protection for the helicopter blade, in which an electrically heated pad is applied which takes current through slip rings from a generator. The heat of the pad loosens the ice, and centrifugal force throws it off. We have had some difficulty getting the pads made. We took delivery recently of two experimental pads but they are defective.

The ACTING CHAIRMAN: Are you finished Mr. Forgie?

By Mr. Hosking:

Q. It is not so important as the damage which is done to the change of the pitch of the blade. Another question I have is this; you were talking about different types of automotive power, as I gathered from your remarks. —A. Mostly we have been concerned with aircraft engines. But we have done some work on small diesel powered units. Some few years ago some of the marine engine manufacturers on the east coast asked for help in the development of a small semi diesel for inshore fishing boats. We produced a five horsepower semi-diesel engine for them, and I believe that a firm is now manufacturing them in the United Kingdom.

Q. Do you know of any work being done by automotive manufacturers to get away from the conventional form of engine and to make use of diesels? —A. Not officially. I have read about it in the technical press.

Q. But you have not done anything on it. There has been experimental work done at McGill on powdered coal.—A. No, but we know about it. That work was supported at one time by D.R.B. but it is now supported by the Mines Branch.

Q. Could you hazard any opinion as to why automobile manufacturers are going to such high horsepower engines in their automobiles?—A. It is a matter of pleasing people, I would think. I personally do not see any need for it. It certainly is not economical to use 100 to 120 horsepower to move one person around.

Mr. MURPHY *(Lambton West)*: Why not use a bicycle?

By Mr. Byrne:

Q. How far on have you got in the investigation of these crash position indicators? Is that something which will soon be in general use?—A. We hope it will be soon. But it will not be easy. If an aircraft is travelling at, let us say, 300 miles an hour strikes a mountain there is terrific deceleration and to get the transmitter out of the aircraft without damage—and the crash may be followed by fire—and in condition to send out automatically signals, is not easy. But we have some ideas and we think that we can come up with an answer.

Q. I was wondering if you were thinking of some little arrangement which would be released by the pilot at the moment of crash.—A. The pilot will be too busy doing other things if he is aware of the impending crash and he may not be aware. It has got to be completely automatic.

Q. It might take place without the pilot knowing anything about it.

By Mr. Murphy (Lambton West):

Q. Could radar take part in that?—A. No, it would be an automatic transmitter sending out signals.

By Mr. Byrne:

Q. Would the scheduled airlines be interested?—A. Oh definitely. For some years I have had requirements from TCA. They know what they want, but the difficulty is to satisfy them.

Q. With respect to the question of errosion in the development of gas turbine engines, has there been any consideration given to the type of turbine that is being developed by Dr. Mordel for use with gas or oil as fuel? Apparently Dr. Mordel's experiment makes use of heat exchangers, and in that way it uses fresh air that is free from contamination and combustion in any way.—A. In my opinion that is the only way to proceed with a coal burning gas turbine. If you try to put flue gas through a turbine, the fly ash is extremenly abrasive and it will erode the blades, so you must transfer the heat to another material such as uncontaminated air.

Q. I am aware of that fact, but I wonder why it would not be possible to develop a more efficient turbine for fuel using the same principle as the heat enchanger.—A. I suppose one could, but with Leduc crudes you do not need to do so, because they are very low in metallic oxides, which are abrasive, and there is little blade erosion. We have run blades for many hundreds of hours on Leduc crude without any appreciable erosion.

Q. What is Dr. Mordel's greatest difficulty now? Is it a question of the air, and the matter of erosion, or is it a question of getting sufficient energy or knowledge of how to use this heat exchanger principle, where your gas comes in at low temperature and goes out with sufficient pressure to drive a turbine?—A. I have not been closely in touch with his work sir. The idea of a coal fired gas turbine has been very attractive down through the years and a great deal of energy and money has been put into it in the United States without any great success.

Q. Have they been mostly truck turbines?—A. They started that way. The project was started shortly after the war subsidized by two or three railroads. I talked with the director of that work, and he thought that he was on the way. But again he was "scuppered" by the fly ash. What advance Mordel has made I do not know.

By Mr. Hosking:

Q. What is the size of the unit in horsepower?—A. I do not know the size of Mr. Mordel's model, but it would require to be 1,000 horsepower or so for a locomotive.

By Mr. Byrne:

Q. He expected to derive sufficient power out of one unit to equal that of two diesel units—that is from a direct gas turbine unit using fuel or gas from a combustion unit, requiring as much as one using a heat exchanger.—A. There is a certain loss in the heat exchanger in transferring the heat.

Q. Would the overall size of the plant be much larger with Mordel's type using a heat exchanger? Would it be a larger unit than one using fuel combustion gases directly?—A. Oh yes, I would think so. The heat exchanger generally is very large, but he is using a rotary type of heat exchanger which is fairly compact.

By Mr. Green:

Q. You mentioned having set up a model in your division of the St. Charles river at Quebec. Are you doing any other work of that kind?—A. We did not use a model in the case of the St. Charles river. In that case we actually went to the St. Charles river and traced the movement of the silt and tried to locate where it was coming from. That was the problem, because there is a bank at the east of where the river comes into the St. Lawrence which silts up and requires dredging.

Q. Are you using models for any other things?—A. We did a good deal of work some years ago on the silting of the Fraser. We constructed a model of the lower reaches of the Fraser, which is now being operated by the university of British Columbia and the department of public works.

Q. What about Vancouver harbour?—A. We made an investigation of Vancouver harbour too.

Q. Are you now studying the Port aux Basques harbour?—A. Yes.

Q. And you have a model of that harbour?—A. We are just getting a model into operation.

Q. Are you doing anything in connection with the ports which would be affected by the opening of the St. Lawrence Seaway?—A. No, I think that is an economic question.

Q. But you did refer to some work in connection with the St. Lawrence Seaway. Could you give the committee more details on what that is?—A. We have three models at the moment in operation; one is what we call the Cornwall model covering about ten miles of the St. Lawrence from the power plant down. There are two channels there. The Canadian channel is on the north of Cornwall island and the American channel is on the south. The seaway, the actual navigation channel, is on the American side.

We have been studying different methods of excavating the navigation channel as proposed by the Authority. The model is used to determine the effects of the excavations because it is not easy to predict them theoretically.

Q. You are doing that work for the St. Lawrence Seaway authority?—A. And for Hydro, yes. Hydro is interested in every inch of head they can get because it means many thousands of horsepower. So we are asked to check the effect of different schemes on the tail-race level.

The ACTING CHAIRMAN: You have a model of this at the Montreal Road plant and we will be able to see it when we visit your laboratories.

By Mr. Green:

Q. Are you doing a model of the Port aux Basques harbour for the Department of Public Works?—A. Yes.

Q. And you actually have that model set up at the Montreal Road plant?—A. That is right.

The ACTING CHAIRMAN: You will be able to see it on Wednesday. It is now twenty minutes to one. I regret to say that the chairman found it unable to return. There are one or things we have to do before we adjourn.

Our next meeting was arranged for Tuesday but there seems to be some doubt with regard to the gentlemen from the National Research Council being able to be here on that day. Would it be agreeable to the committee to leave the date for the next meeting at the call of the chair?

Mr. GREEN: What about having it on Monday?

The ACTING CHAIRMAN: If you will leave it to the call of the chair, we would consider the possibility of having a meeting on Monday. According to the notes I have it was set down for Tuesday but there seems to be some doubt as to our being able to have Dr. Steacie on Tuesday. So I suggest we leave the time of the next meeting to the call of the chair, with the idea that we would have one on Monday if it is convenient.

May I remind the committee that should we visit the NRC. plant we have to leave here by 9.30 in order to go to the Montreal Road Laboratories of the National Research Council. You will be informed.

May I say on behalf of the committee that while we did not pass a vote of thanks to Mr. Ballard for his submission here this morning, I feel that he has given us a very good submission and has answered most of our questions satisfactorily. Will somebody move the adjournment?

Mr. GREEN: May I just ask one question of Mr. Parkin. You said there might be some difficulty with the Otter. Have you been asked by De Haviland to do any work on the Otter?

The WITNESS: Not since the crash, except as mentioned earlier.

HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 8

NATIONAL RESEARCH COUNCIL

TUESDAY, MAY 29, 1956

WITNESSES:

Dr. E. R. Birchard, Vice-President (Administration); Dr. L. E. Howlett, Director, Division of Applied Physics; Dr. W. H. Cook, Director, Division of Applied Biology; Mr. J. H. Parkin, Director, Division of Mechanical Engineering.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956.

75144—1

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McIlraith, Esq.
and Messrs.

Bourget
Brooks
Byrne
Coldwell
Dickey
Forgie
Green
Hardie
Harrison
Hosking
Leduc (*Verdun*)
Low
MacLean
Murphy (*Lambton West*)
Richardson
Stewart (*Winnipeg North*)
Stick
Stuart (*Charlotte*)
Weaver—(20).

(Quorum 9)

J. E. O'Connor,
Clerk of the Committee.

MINUTES OF PROCEEDINGS

TUESDAY, May 29, 1956.

The Standing Committee on Research met this day at 10.30 a.m.

In the unavoidable absence of the Chairman and the Vice-Chairman, the clerk attended to the election of an Acting Chairman.

On motion of Mr. Hosking, Mr. Stick was elected Acting Chairman.

Members present: Messrs. Brooks, Byrne, Dickey, Forgie, Hardie, Hosking, MacLean, McIlraith, Murphy (*Lambton West*), Richardson, Stewart (*Winnipeg North*), Stick and Stuart (*Charlotte*).

In attendance: Dr. E. R. Birchard, O.B.E., B.A.Sc., Vice-President (Administration), National Research Council; Dr. L. E. Howlett, Director, Division of Applied Physics; Dr. W. H. Cook, Director, Division of Applied Biology; and Mr. J. H. Parkin, Director, Division of Mechanical Engineering.

Dr. Birchard, with the consent of the Committee, made corrections in Mr. Ballard's evidence of Thursday, May 24 last. (*See this day's evidence.*)

Mr. Parkin was called and his examination concluded.

Dr. Howlett was called and introduced by Dr. Birchard.

Dr. Howlett read a statement on the work of his division and his examination was also concluded.

At 12.20 p.m., before going into an executive session, the Acting Chairman thanked both Mr. Parkin and Dr. Howlett for their presentations.

Mr. McIlraith took the Chair.

It was then tentatively agreed as follows:

1. To visit the National Research Council Laboratories on the Montreal Road on Thursday, May 31st.

2. To hear Mr. W. J. Bennett, O.B.E., LL.D., President and Managing Director, Eldorado Mining and Refining Limited, and President, Atomic Energy of Canada Limited, on Tuesday, June 5th and Thursday, June 7th next.

3. To visit the Atomic Energy Plant at Chalk River on Monday, June 11 and Tuesday, June 12 next.

At 12.30 p.m. the Committee adjourned to the call of the Chair.

Antonio Plouffe,
Acting Clerk of the Committee.

75144—1½

EVIDENCE

May, 29, 1956
10.30 a.m.

Mr. HOSKING: I move that Mr. Stick preside as acting chairman of this committee.

The Clerk of the COMMITTEE: You have heard the motion, all those in favour? Carried.

(Mr. Stick took the chair as acting chairman)

The Acting CHAIRMAN: May I first thank the members of the committee for placing me in this chair this morning I understand that the chairman, Mr. McIlraith, will be here later on. We shall carry on with the business of the committee. When we adjourned at the last meeting Mr. Parkin was the witness. He submitted a brief. Mr. Parkin is now available for questions. You all have copies of his brief and you have had time to look at it and study it. Are there any questions?

Mr. J. H. Parkin, Director Mechanical Engineering, National Research Council, called:

Dr. E. R. BIRCHARD (Vice-President, Administration): May I say that Mr. Ballard was giving evidence at the last meeting and in reviewing his evidence there were two questions which he did not understand and to which he gave wrong answers. If you will turn to page 13 of the transcript of evidence you will see that Mr. Hosking asked a question about storage capacity as follows:

By Mr. Hosking:

Q. The storage capacity would weigh even more than your equipment?

And Mr. Ballard answered: "Yes", but his answer should have been "No" because he misunderstood the question. And then again on page 63 of the transcript of evidence Mr. Forgie asked a question:

> Will the Hydro Electric Power Corporation be engaged in the storing of gas so that it may be distributed in the Toronto area? Are they working on it?

Mr. Ballard thought the question related to power and his answer should have been "I do not know".

Mr. FORGIE: I do not think that question should have been attributed to me.

Mr. HOSKING: I think I was the one who asked that question.

Mr. BYRNE: He is always asking questions!

Mr. MURPHY *(Lambton West):* Who is the witness today?

The Acting CHAIRMAN: Mr. Parkin.

Mr. MURPHY *(Lambton West):* On what subject?

The Acting CHAIRMAN: On mechanical engineering and you have his brief, which was recorded in the evidence, on "the division of mechanical engineering".

Mr. MURPHY *(Lambton West)*: Have you any spare copies?

The Acting CHAIRMAN: Yes. Give this copy to Mr. Murphy.

By Mr. Murphy (Lambton West):

Q. When we go out to the Montreal Road laboratory are there not some features in connection with this department which we shall be seeing there? —A. Any which you wish to see. I believe it was mentioned at the last meeting that you might see the model of the Port aux Basques harbour.

The Acting CHAIRMAN: There are two or three models of harbours which will be on exhibit, and one is of Port aux Basques.

The WITNESS: The Port aux Basques model, two models of reaches of the St. Lauwrence, and a model of one of the navigation locks in connection with the Seaway will be available.

Mr. MURPHY *(Lambton West)*: Who presented the brief?

The Acting CHAIRMAN: Mr. Parkin.

By Mr. Byrne:

Q. Did you do any work on Ripple Rock in British Columbia?—A. There was a committee of the Council set up to examine the situation at Ripple Rock and recommend ways for its removal. A report was submitted to the government and I believe it is now being implemented.

Q. Was there no model?—A. We had a model or two of the rock itself just to see its shape, and we may have done some very simple tests on the flow around it, but nothing at all thorough. The other piece of work done on Ripple Rock was test boring which the committee arranged for in order to ascertain the condition of the rock under the channel, whether it was fissured and whether it would be possible to tunnel through it in order to reach the rock. That has been the method adopted.

By Mr. Murphy (Lambton West):

Q. With respect to your second paragraph I think we would be interested in knowing the type of work you are doing for industry.—A. I could list a number of examples. One of the most recent was a request we received from a locomotive builder in Ontario for help in solving difficulty that was being experienced with the failure of pistons in diesel locomotives.

Q. Would that be a London firm?—A. No, it was from Kingston, sir.

Q. Is that a follow up? They had difficulty and called you in? Is that the idea?—A. Yes.

Q. And did you follow it through?—A. In this case we did some experimental work trying to find some explanation for the failure and we are still working on it. We have put in some interim reports and suggestions for trials and we have done service trials with some pistons which they lent us. It is not finished, but we are working very closely with them.

Q. The work you are doing would be of interest to other diesel engine manufacturers as well, I presume?—A. Possibly, if they are having the same trouble with pistons. It was not quite clear at the beginning whether it was a fatigue or a thermal problem, or just what it was.

By Mr. Byrne:

Q. Were the pistons cracking?—A. Yes, the pistons were cracking, through the crowns.

By Mr. Murphy (Lambton West):

Q. What other types of operation could you list?—A. In another case a chemical firm using a catalytic process was having difficulty with a catalyzer, because the gas entering it disturbed the catalyst which was in granular form, and they wished us to try to develop means of getting the gas in at high speed without disturbing the catalyst.

Q. Would that be a normal experiment?—A. No. In that case we were able to produce an arrangement which seemed to work, and the company, I think, have asked that it be patented, as a matter of fact.

By Mr. Dickey:

Q. Was it in your division that the work was done on the sodium clock?—A. No, sir; that was done by the applied chemistry division.

By Mr. Murphy (Lambton West):

Q. Have you any other examples? I think this is rather interesting.—A. Well, I think I mentioned the work we are doing with the ship building industry, not only for the government but also for ship builders and for naval architects. We do a great deal of work for them because the National Research Council has the only model basin for testing designs in the country, and it is customary in ship design to have a model tested. The problem could come to us in either of two ways: a naval architect may want to know a for hull design the power which he will need to instal in order to get a given speed; or alternatively he may plan to install an engine of certain power and want to know what speed will be attained.

Q. You mentioned a while ago that some firm patented an idea. Where does the National Research Council come in if you do some work on it?—A. If the idea is developed or originated in our laboratory, it would be handed over to Canadian Patents for patenting. From there on the Canadian Patent Corporation handles the whole situation. Sometimes, as in this case, we may not have any idea of patenting but the firm may think it would be desirable to have it patented. In another case we have been working with a pulp and paper firm helping them to devise an improved head box for paper machines. The results were interesting and the firm suggested that we publish a paper on it, and we are proposing to do so. The firm itself will, I think, present a paper at a forthcoming meeting of the Pulp and Paper Association.

Q. I wonder if you could give us some idea of the type of work you are doing. You mentioned the St. Lawrence Seaway and I am interested in it because it is an international project. Does Canada's partner in this project, the Americans, recognise the value, and do they make, shall we say, the necessary contribution in connection with your Seaway work?—A. That work is being done for two organizations; first, for the Seaway authority, and second, on the power aspects, for the Hydro Electric Power Commission. One of the two models I mentioned is of the reaches immediately below the power plant, what we call the Cornwall model and about ten miles of the river is represented on the model at a scale of 500 to 1; that is, one foot on the model represents 500 feet of river.

The work, as I explained, is of two types; one is for the hydro in trying to get an absolute minimum of tail water level below the power plant, because every inch by which it can be lowered means a very large increase in power development. The hydro engineers have proposed different plans for excavation below the power plant. We have been trying in the model to indicate to the hydro electric engineers the relative merits of the different suggestions, but the question is partly an economic one, involving a comparison of the cost of rock excavation against capital cost and against power developed. As a result of that work we may come up with a suggestion of our own for improvements in the project; and the same thing is being done on the navigation side.

The navigation channel at the Cornwall power plant is on the American side. There are two channels around Cornwall Island, the American channel to the south and the Canadian channel to the north. One complexity of the situation is that apparently it is required to maintain the percentage of distribution of flow in the two channels exactly the same after these alterations as at the present time; it involves a rather tricky adjustment of the flows. The two channels diverge at the west of Cornwall Island in a channel known as Polly's Gut. The Gut is a very critical channel because it affects the tail water level at the power plant which is just above it; and furthermore, if the flow through Polly's Gut is not controlled, it will make it very difficult for shipping to get into the lock at the power plant. The current out of the Gut will cut across the navigation channel and skippers will have difficulty in getting their ships through.

We have been trying out different proposals, which have been put up to us by the engineers, for modifying the flow out of the Gut by use of retaining walls and so on. We are also working at the moment on the north channel for the Seaway authority in trying to keep the velocities down to a reasonable limit in the north channel so that Canada will not be handicapped in the future should she wish to build her own canal. Does that answer your question?

Q. Yes, I think so. I was wondering about the diversion of water. You have done some work for navigational purposes. Is that done by jettying, by a concrete jetty?—A. Partly: Where the flow from Polly's Gut cuts through the American channel, a combination of excavation and dykes may be used.

By Mr. Hosking:

Q. Are they experimenting with running propellers for water wheels under a vacuum on this project?—A. We are not doing any experiments of this land but the turbine builders may be.

Q. Yes.—A. The turbines will discharge into draft tubes and draft tubes are always in a vacuum.

Q. Have they got around the trouble that they had at the Dnieper Dam when the Russians wanted to have the British engineers shot?—A. I have not read about that.

Q. Dean Lawson told us that when they expanded at the Dnieper Dam, in order to slow down the velocity—you may remember the time in 1933 when there was a row between the British government and the Russians over the fitting of these propellers; and when you spoke about getting a lower head and getting a maximum head at a lower tail velocity of the water, I asked if they had got around that difficulty now.—A. I think so. There is always a possibility of cavitation pitting of the runners of turbines. The same thing may occur with the propellers on ships. Cavitation may occur unless the design is properly worked out. But I do not think it results from a draft tube effect particularly. I think it is largely a matter of design of the blade itself.

Q. Have you discovered what causes it?—A. I think it is pretty well understood. If a design is such that there is a low pressure region any where on the blade—a region of high vacuum—there, will be cavitation and pitting.

Q. What causes it? Do the particles fly out? At the time it happened they did not know why.—A. I think that hydraulic engineers understand it pretty well now.

By Mr. Brooks:

Q. I have a question with reference to the production of pulp. We are now manufacturing pulp practically 100 per cent from soft woods. But recently we heard they were experimenting with hard wood, and that they can possibly produce pulp from hard wood. Have you done any experimenting with that, and if so what success are you having?—A. We have not experimented with the actual pulp production. The only work we are doing with pulp firms is the working out of a head box for the paper making machine and arising out of that we have started a basic investigation of the mechanical properties of fiber suspensions in water, what the scientists call "non-neutownian fluids". We do not know much about how they behave in pipes and that sort of thing. We have obtained a supply of pulp from a paper company and we are pumping it through transparent pipes. You may see that being done when you visit our laboratory.

Q. You say you are not experimenting with hard wood pulp in order to see if paper can be manufactured therefrom?—A. No. I think that would lie in the applied chemical field.

Q. But not in the research department?—A. It is likely being studied by the Pulp and Paper Association which has an excellent research laboratory of its own in Montreal. We have not been asked to do work in that field.

By Mr. Dickey:

Q. Is your division doing any experimental work in connection with the control of sound in paper machines?—A. No sir. Dr. Howlett will be able to tell you what the division of physics is doing. However we have a sound problem on our hands of our own making in the testing of jet engines which is most unpopular with our neighbours.

The Acting CHAIRMAN: You were speaking about the winter propellers of ships regarding ice. That is a very live problem with us down east. What work have you done on that? I understand that when ships are made ready for winter they change their propellers. I understand you have done some work on ice propellers. Would you mind commenting?

The WITNESS: Yes. There is an investigation of the design of ice breaker propellers going on in the division which arose out of the work we did in connection with screws for the *Labrador*. On its first trip in Arctic waters, the *Labrador* was accompanied by an American ice-breaker, and the *Labrador* went through the whole operation without damage to its propellers, whereas the American ship lost at least one propeller in the ice. No one seems to know how to design a propeller for work in arctic waters.

At the moment we have two large models—I think they are quarter-scale models—of a blade, of two designs; one a Canadian designed blade and the other an American designed blade and we are testing them in different ways to find how best to design a propeller to work in ice—to stand up to impact.

By Mr. Murphy (Lambton West):

Q. In your pulp and paper work, with the amount of research that has been going on in that particular industry—I do not know if it comes within your sphere or not—but is there any standard or limitation for the sale of paper with respect to the amount of moisture there would be in it?—A. I am afraid I cannot answer your question because I do not know. The chemists or physisists might be able to answer you.

Dr. BIRCHARD: That problem is being worked on by the physics division.

By Mr. Murphy (Lambton West):

Q. With reference to your scale model of Port aux Basques—I do not mean any political implication in this but there has been some argument whether the ship was too big for the harbour or the harbour not big enough for the ship. When you entered the picture was that when they first considered the development of that particular harbour, and you went down there and had your men make a scale model of it?—A. No. We came into it after the ship was built and after some work had been done in the harbour. We were asked by the Department of Public Works to build a model of the harbour in which the waves and the channels and the harbour in general could be studied. A model has been built of the harbour itself and part of the open sea, and a wave maker has been installed with which we can reproduce waves of different types and intensity coming from different directions so that we can get a complete picture of the way in which the waves are distributed and act in the harbour. That work is just starting.

At the same time we will be able to determine the effect of breakwaters or any other work that may be thought desirable or necessary. As a matter of fact, we tested a model of the ship itself for its designers.

Q. Is there any question of silt coming into that area?—A. No. It is all rock!

The Acting CHAIRMAN: Yes, it is all rock.

By Mr. MacLean:

Q. Can you say a word as to the division of responsibility from the research angle in the Seaway development? I think there is someone in the United States doing research along lines similar to the work you are doing in connection with the Seaway. What liaison exists between you and your opposite member in the United States regarding Seaway research? I take it that if the Seaway authority or the Ontario Hydro Commission have a problem, they give it to you. But at the same time similar problems might arise from the United States side or point of view out of work on the Seaway. What means are taken to prevent duplication of effort on the part of the agency in the United States which is responsible?—A. The agency in the United States that is responsible for this work is the United States Army Corps of Engineers, and I think that the St. Lawrence comes within the jurisdiction of the Buffalo office of the Corps of Engineers. They visit us frequently to see what we are doing. About a year ago they decided to build their own model and test it, as well as ours, and that is being done by the U. S. Corps of Engineers at their laboratory at Vicksburg, Mississippi. We have been there, and there is quite a close interchange. We have to agree on our results and make them match. It is very desirable that this should be so and that there should be a cross-check between the two countries. The International Joint Commission is involved as well. There is duplication—and duplication is necessary because each country has to see to it that the results are correct. At the moment we are getting somewhat different results from the Americans, but we think we are right, and we think we can convince them that we are right. Then it will be all right.

Q. You mean that you would come to the same conclusion in the end?—A. Yes.

By Mr. Brooks:

Q. Suppose some inventor produces something which he believes to be satisfactory as an invention along certain lines, and it is brought to Ottawa. Does your department try to work out the practicability, or it is left to someone else?—A. No sir. This is one of the crosses which we have to bear. Inventions come in to us at least once a week; sometimes we may have more than one in a week.

Q. I would like to ask about a particular one. I saw a letter which was sent to one of the members regarding these crash position indicators. A man in Victoria named George Clayton claimed that he had been working on it for seven years and that he had perfected it to a certain degree, and then it was found that it was taken or stolen from him by the United States. I wondered if your department had any evidence at all that the man in Victoria was working along this line, as well as of the work that was being done here in the research department?—A. I could not state offhand because, as I have indicated, we are continually having inventions submitted to us by inventors from all over the country. They seem to increase from the western provinces in wintertime for some strange reason.

Q. No wheat!—A. Invariably after a major crash ideas come in to us for preventing crashes.

Q. How far advanced are we on that? Do you feel we are anywhere near preventing them with this protective device that it speaks of here?—A. I would not like to promise a successful solution. We have been in touch with the Americans and we know just where they are. They have their sights set somewhat lower than we have in that they are prepared to rule out and not try to cope with a certain type of crash; whereas at the moment we are trying to develop a device which will function in, let us say, 99 per cent of possible types of crash.

Q. In the Science Digest for March 1953 there is an article called "Robot calls rescue planes". This article said that in another two or two and a half years they would have it completed. That would make it 1956, this year. Have you any ambitious idea such as that?—A. No, not on this development. I would not like to set a date, because it is an extremely difficult problem to produce a device to be used in an aircraft, operating speeds of several hundred miles an hour. The aircraft may run into a mountain, dive into dense bush, fall into a swamp, or after impact catch fire and in all cases, the device will be projected out of the aircraft and land in such a way that it can send out a radio signal for a period of two or three days.

Q. That is the general problem.—A. With a range of two or three hundred mile. That is the soft of thing we are trying to do, but it is extremely difficult. There are other limitations as well. One obvious solution would be to discharge the device from a sort of cannon in the opposite direction to that in which the aircraft is moving but operators of civil aircraft dislike the idea of having explosives of any kind in such aeroplanes and, so that idea is automatically ruled out.

Q. If a pilot expects to crash, he could release it himself, could he not?—A. Yes, but we have ruled out any participation by the pilot in such a case because if he is aware of an impending crash, he is going to be too busy trying to do something about it to bother about trying to get a device of that kind out.

By Mr. Stewart (Winnipeg North):

Q. What happens in the case of some person in the west who has spent long winter nights conceiving an idea and he comes to you with that idea which is perfectly workable? Do you encourage him or tell him what further steps he should take? What is the policy?—A. We try to encourage him, even if we know the idea is worthless. We give it serious consideration and point out wherein it is defective, impractical or anticipated. I dealt with a letter just the other day from an old chap who had invented a hydraulic transmission on his own, but unfortunately it was invented by someone else about fifty years ago. However, I complimented him on what he had done on his own, because apparently he was entirely on his own, informed him of the actual facts as gently as I could, and I expressed the hope that he would not be discouraged, and that he should keep on "bothering" me.

By Mr. MacLean:

Q. I suppose in most cases when people come up with ideas which they think are original, and they are investigated, it is found that there is almost nothing new under the sun, and that the idea in question was developed by somebody else long ago in most cases, and if there is something practical, can we say that possibly one in one hundred is something new?—A. Yes.

By Mr. Murphy (Lambton West):

Q. In your department have you had anything to do with any equipment or machines for grinding out gun bores without taking the guns off the ships?—A. Not yet, sir; that has not yet been put up to us.

Q. Some years ago when they wanted to grind out a bore they had to take the gun off the ship and take it to a machine shop.—A. I understand that was the procedure.

Q. But now that work is done right on the ship. Is that a correct understanding?—A. I could not tell you.

Q. Are there not patents registered in Canada now for that purpose?—A. There might be but patents for defence may be kept on a secret list.

Q. I do not think this is a secret because the same idea has been applied to automobiles.—A. I have no knowledge of the device of which you speak, but I think it would be quite reasonable. With modern development in grinding machine tools there would be no reason that a tool could not be designed to do what you say.

Q. It used to be that with automobiles they would have to remove the motor off and take it to a machine shop. I wondered if there was not a more recent means of machining them that you would know of.—A. I have no knowledge of that particular tool.

Q. In your second paragraph on page 5 you say "an assessment of the practicability of the gas turbine locomotive in Canada is being made." Just how far have you gone along with that work?—A. We are proposing to build a small turbine drive in order to get some first hand information about its operation. We have already designed and built two gas turbines in our laboratory, one of one thousand horse power and the other of two thousand horse power in order to become familiar with their design and manufacture. We also propose to use them in our gas turbine work as a piece of laboratory equipment for very high speed drives for testing other equipment and to obtain low temperature conditions by expanding air through them to a lower temperature and pressure for stimulating altitude conditions. We are in touch with both the Canadian railways in this connection. Our people are in discussion with them and they have helped us by giving us records of draw-bar pull of locomotives on different types of run, and we expect to be able to build a small gas turbine drive for a locomotive employing a non-electric transmission.

By Mr. Murphy (Lambton West):

Q. I wish you would expand the idea of this turbine a little more. Will it be applicable, let us say, to an automobile?—A. Gas turbine drives have been developed already for automobiles in one or two cases, but the question of economics enters into it whether or not a small gas turbine for motor car use would be economical. There is no technical reason why a gas turbine should not be applied to a motor car, but normally they are rather expensive.

Q. Do you mean expensive to build or to operate?—A. Expensive to build.

Q. If there is mass production, then what?—A. Then they would be cheaper, because the cost would come down; but at present they are quite expensive. The gas turbines that are being built for aircraft use are very expensive. For example the cost of each blade, and there are hundreds of blades, is high. A particular feature of the gas turbine of interest from the standpoint of Canadian conditions is the fact that in winter time a steam locomotive loses through heat loss about 25 per cent of its power, whereas a gas turbine locomotive, will develop 25 per cent more power under winter conditions than under summer conditions because of the greater density of the air which is used in the burning of fuel.

Q. What fuel is used?—A. I think I mentioned at the last meeting that we were looking into bunker fuel from the Leduc field which is peculiarly suitable for gas turbine use. We are trying working with bunker fuel and are trying to get away from high cost refined fuels.

By Mr. MacLean:

Q. I suppose there is considerable liaison between the work of Dr. Mordel in connection with the development of a coal burning turbine for research use? —A. We know of the work of Dr. Mordel. We are leaving the coal burning field to him, and are working with oil fuel. There are difficulties in connection with coal fired gas turbines. If one attempts to pass combustion gas through a turbine, the fly-ash will erode the blades. I think that Dr. Mordel is now working on the idea of interposing a heat exchanger and passing hot air through the turbine in order to avoid the fly ash.

By Mr. Brooks:

Q. On page 2 you speak about investigation in the development of amphibious vehicles for the army.—A. They came to us. They wanted a vehicle for a special requirement. At the Lake St. Peter heavy artillery range on the lower St. Lawrence dud shells occasionally fall on the ice. They had been in the practice of sending a couple of soldiers out in a jeep to de-vitalize the duds so there would be no danger of their going off when they should not go off.

Q. Are you investigating the possibility of a vehicle which could be used on air, land and sea? Is not such a vehicle being developed in the United States?—A. Oh yes, but this was a one-off development for this particular range in seeking the dud—so that if they happened to go over a place where the ice was thin from a previous burst, and they went through, the vehicle would float. Apparently the soldiers tired of getting wet and wanted something that would float. We designed this new vehicle around a Volkswagon chassis and they were quite happy.

Q. That is an accomplishment—to make the army happy.

The Acting CHAIRMAN: Are there any further questions gentlemen? If not, we have with us Dr. Howlett, who is director of the division of applied physics and, if it is your pleasure, we shall hear Dr. Howlett now.

Dr. Birchard, would you introduce Dr. Howlett and give the committee some idea of his work?

Dr. BIRCHARD: Would you like me to read the degrees which he holds?

The Acting CHAIRMAN: Do you think that is necessary? It is just as well to have it on record, I suppose.

Dr. BIRCHARD: Well, Dr. Leslie E. Howlett, M.B.E., B.A., M.A., Ph.D., F.R.S.C., Director of the Division of Applied Physics, is an authority on optics, especially air photography. He was awarded the M.B.E. in 1943 for his service in developing the optical instrument industry in Canada during the war, particularly in Research Enterprises Limited. Up to that time, Canada had no optical instrument industry to speak of and had to rely on imports.

Dr. Howlett joined NRC in 1931. He became assistant director of the Division of Physics in 1948, associate director in 1949, co-director in 1950, and in 1955 became the Director of the Divison of Applied Physics.

The Acting CHAIRMAN: I am sorry, gentlemen, but Dr. Howlett has not got any copies of his statement, but if he will read it you can take notes and ask questions afterwards.

Dr. Leslie E. Howlett, Director of the Division of Applied Physics, called.

The WITNESS: The division of applied physics is concerned with two types of work which are really different aspects of the overall purpose of the division. This purpose is to ensure that physics contributes as fully as possible to the development of the Canadian economy.

One type of work is the undertaking of research problems likely to contribute significantly to the development of industry or natural resources. Emphasis is placed on the tackling of problems of broad significance and usually of considerable difficulty. A limited number of these is studied rather than a multiplicity of smaller ones. More importance is attached to problems of an industry-wide nature than to those of individual companies. In the course of these investigations a good deal of fundamental physical research is done. Research projects of this kind arise in two ways. Some are suggestions direct from industry and others are suggested by members of the staff of the division from their knowledge of requirements in particular fields. To help maintain a realistic programme there is a deliberate cultivation of co-operation with industry.

An example of what is involved in this kind of research work is well exemplified by two problems that are currently studied at the request of the Canadian Pulp and Paper Association for the benefit of the whole paper industry. One of them, on noise abatement, is being brought to a satisfactory conclusion and the results are being rapidly put to practical use. The importance of the solution of this problem to the efficiency and the physical welfare of the workers in the industry needs no stressing. The problem of noise abatement in the pulp and paper industry has been attacked without success in a number of laboratories in other countries over the last fifteen years. A by-product of this research was a new type of ear defender which is based on acoustic principles not previously applied in this way. It surpasses in performance by a large margin all present types of ear defenders. It has been patented and is being exploited commercially. There is very wide interest in it both in Canada and abroad.

A second project of the same type involves the investigation of the physical factors affecting the uniformity of drying of newsprint. This is in a relatively early stage but already useful information has been established by laboratory experiments and it seems certain that it will be possible to define precisely the measures that must be taken to ensure uniformity of drying.

There is a further purpose behind the solving of these problems of the pulp and paper industry. It is not the intention that part of the divisional work should be indefinitely devoted to them. Particular attention is being paid to them at the present time because of a conviction that physical research could contribute very much more to the development and efficiency of industry than it has been allowed to do up-to-date. By demonstrating the power of physical research for the solution of a few important problems the division hopes to convince management in the industry that physical research should be done within the industry itself and that it should be placed in a sufficiently senior and authoritative position within a company or organization to do an effective job.

One section of the division is concerned with the problem of mapping generally, and very specifically with the development of new photogrammetric methods peculiarly adapted to Canadian requirements. One of the latter is a method to extend mapping controls without the use, or with the limited use of ground parties. The cost of the latter is very great in rough northern territories. An entirely novel photogrammetric method of air triangulation has been developed to meet this need. It successfully combines the use of air photographs, a radar device and an electronic computer. It will probably have extended application outside Canada judging by American interest.

The other main aspect of the division's work is the development and maintenance of fundamental physical standards such as the units of length, mass, luminous intensity, electricity, etc. Precision standards developed with imagination and originality on the basis of the latest knowledge and techniques are fundamental to all research problems where measurement is involved and they form the basis on which calibrated standards and instruments can be provided to industry. They are the base on which rests the validity of the work of the Standards Branch of the Department of Trade and Commerce in enforcing weights and measures legislation and the controlling of the sale of electric power, etc. Developments in the standards field are much more rapid, challenging and significant than is ordinarily thought. In many cases developments made in the course of the work can be applied in a number of other fields.

As an example, a novel idea was developed by one of the laboratories which greatly facilitated the calibrating of thermocouples and which was copied by other national standardizing laboratories. The basic idea involved in the development promises to be of great value in observing temperature conditions in rivers above power plants in order to get advance information on ice formation during the winter season. It also promises to have an important application in oceanography for measuring the temperature of the ocean at various depths more rapidly and more accurately than current equipment permits.

In connection with the maintenance of the standard of length, the Canadian Yard, extensive researches have been carried out in interferometry to prepare the way for basing length measurements on a wavelength of light instead of a physical prototype. The importance of this from the point of view of indestructibility and reproducibility needs no stressing. A new type of interferometer of greatly increased accuracy and convenience has come out of these researches. It has many applications as a powerful tool in fundamental research as well as in improving greatly the ease and accuracy of calibrating Johansson gauge blocks for industry. Work on standards is closely coordinated with that of other countries through one of the staff who is a member of the International Committee of Weights and Measures.

Similar examples of the work of the division could be found in any of its seven sections:

1. Acoustics.
2. Electricity and Mechanics.
3. Heat and Solid State Physics.
4. Interferometry.
5. Photogrammetric Research.
6. Photometry and Optical Instruments.
7. X-rays and Nuclear Radiations.

By Mr. Murphy (Lambton West):

Q. Does your department have anything to do with the observatory and the instruments they use?—A. In the astronomical sense, no. We do have close contact with them in connection with standards of frequency; standards of frequency are intimately related to astronomical time, and in that respect the observatory provides the time in order to get frequency.

Q. But no one in your department has anything to do with the invention or supervision of the equipment being used there or elsewhere?—A. No.

Q. Who would do that?—A. You mean telescopes and things of that sort? There are commercial firms who do that. There are Chance Brothers & Cook, Tronghton & Sims in England; Bausch & Lombe in the United States, and similar firms in France and Germany.

The Acting CHAIRMAN: I was rather interested in what was said regarding the elimination of noise. If we could have a noiseless—

Mr. MURPHY (*Lambton West*): House of Commons? Do you mean that?

The Acting CHAIRMAN: Well, yes, that would be acceptable just now, but I was thinking more in terms of aeroplanes than of the House of Commons at the moment. I know I cannot speak from hte standpoint of the army or of the other services, but from the standpoint of civilians who live near airports and flying fields there is a good deal to be said. I do not know whether there is any possibility of developing a noiseless aeroplane but since, in your brief, you mentioned noiseless engines, would you tell us what are the possibilities of our producing a noiseless aeroplane engine?

The WITNESS: I think you misunderstood me sir; I did not speak of noiseless engines. Ours is a problem of the pulp and paper industry concerning the newsprint machines. Where the wet pulp comes out of the head vox it first goes over a wire and then over a drum in which there are a number of holes drilled, with a suction box behind. This draws the major part of the water out of the pulp. As these holes get back to atmospheric pressure air rushes in and there is a terrific howl. This noise reaches an intensity of the order of 140 decibels at the wet end of the machine. You can see the seriousness of this when you consider that continuous exposure to noise at the level of 90 decibels will cause permanent ear damage.

We were presented with this problem and our acoustic section has produced three distinct methods of dealing with it, all of which are being taken up by industry at the present time and put into current practice.

By Mr. Brooks:

Q. Do they decrease the noise, or are you turning out some apparatus for use in the ear?—A. Speaking generally, there are two approaches to this. You can redesign the couch, so that it does not make such a noise as the current ones make. This is done by ceasing to place the holes in rectilinear pattern and by theory, producing an arrangement of these holes which will result in what is, in effect, a destructive interference of the noise. The second approach has been to treat those couch boxes which are now in existence. A special type of silencer has been devised with this aim in view—a devise which, in effect, lets the air into the holes to just the right extent to fill them, but no more; most of the noise is produced by air overfilling the holes in the first place and then underfilling them, thus producing an oscillation which produces the howl I have mentioned.

By Mr. Richardson:

Q. Some years ago a very distinguished professor from Yale university expressed a theory that during the winter you might heat the water of the St. Lawrence. Has your branch continued to examine any such project?—A. No, I am sure we have no undertaking as ambitious as that on hand.

An Hon. MEMBER: Leave it alone—it might take the Maritime ports away from us!

By Mr. Byrne:

Q. What have you done with regard to eliminating frazzle ice?—A. Nothing at all. The problem on this mentioned in my brief comes from a power company in Alberta. We are very interested in this problem and have become involved because of the requirement they have for very accurately measuring the temperature of the water above their dams so that they can be warned when dangerous freezing conditions are impending.

By Mr. Murphy (Lambton West):

Q. Do other industries have the same problem as far as noise is concerned?—A. Yes, we are interested in extending our activities in this field; we feel it to be very important, from the point of view of the efficiency and well being of the workers.

Q. What type of thing have you in mind?—A. Already we have had some contacts with the chemical industry. Columbia Cellulose, in the prairies, had some problems with vibrating compressors and ventilating equipment and the head of our acoustic section paid a visit there while in the West for other reasons. He was able to give advice which has considerably improved the situation.

Q. Are you also studying the problem of vibration in industry?—A. We have made some studies, but our major difficulty is that our acoustic section is small; at the moment it consists of three scientists and we must be careful not to undertake so many different tasks that nothing gets finished. I think the fact that the work has been confined, within the last four or five years, to two or three problems is one reason why they have been rather successful.

Q. What industries in Canada are working with you, generally?—A. In connection with noise it has been the Canada Pulp and Paper Association. We have had very good cooperation with them; we contribute the specialized knowledge in physics and laboratory work and they provide the rather expensive contribution of actual mill trials. That cooperation has in the last two years been extremely fruitful.

By Mr. MacLean:

Q. I suppose you are not responsible for research into the effect of noise on the workers? I am not thinking of damage to the hearing organs so much as of the tiring effect it might have.—A. No, we have done no specific work along that line; we naturally keep in close touch with conclusions which are being reached as to the effects of this sort of thing.

Q. But you have done work on ear protectors?—A. On the physical side.

Q. Would you care to expand on that? What industries might be most interested—where would the most general uses be found?—A. This subject is interesting because it illustrates the second method of taking up the problem of more abutment. This ear defender developed from a proposal from two members of the staff for a better ear defender than those already available without any particular inquiries having been made from outside. These two scientists became interested in the problem, did some very worthwhile thinking about it, and then examined those ear defenders which were already available on the commercial market. They found that in general they were not particularly effective—in fact there were some that were not much better than nothing at all, and in certain regions of the sound spectrum they were worse than if you were using no ear defender at all. With basic new principles they devised an ear defender which is effective throughout the audible range. One aspect which is particularly gratifying is that it is effective in the low frequency range which is a very hard region in which to provide adequate protection. They made several experimental models and these were tested by physical methods for effectiveness. Finally a patent was written—it has been applied for, and currently licensed by Canada Patents and Development Ltd. A canadian firm is at the point of going into full production; the development period is over.

This defender will be of considerable interest to people in the pulp and paper industry; there are many places already where they are being applied, where the circumstances are noisy. The ear defenders will have an application in areas where people test jet planes, for example, and we can see that they may become a substitute for existing types of protection for pilots and so on; you can go on almost indefinitely because there are a great variety of industrial operations where this development will find a very good use.

Q. That would include I suppose protection against sounds of such high level as not to be within the audible range?—A. Yes, but that is not too serious a problem, because it is very difficult to get sufficient energy into the ultra sonic range to do damage; you have to go to special lengths to get that amount of output. The serious region is probably from 600 cycles to 2,000 or 3,000 cycles.

By Mr. Murphy (Lambton West):

Q. How long has the pulp and paper industry been using the ideas you have already produced?—A. The problem started two years ago and the first experimental model, or a newsprint machine, went into the Gatineau mill of the Canadian International Paper Company about a year ago. Currently, the Beloit Iron Works in the United States which is one of the biggest builders of newsprint machines, is making a new newsprint machine for Canadian International Paper at La Tuque and this device will be installed there. Dominion Engineering is making two more which will go into the Three Rivers mill of the same company. Dominion Engineering is also building one for Abitibi, for the Port Arthur mill and other newsprint manufacturers will be following suit.

Q. They are not in operation yet?—A. Gatineau Mill is in operation. The other ones will be so shortly.

By Mr. Brooks:

Q. Does it mean that they have to install a complete new set of machinery?—A. There are two ways of coping with the problem. With an existing couch we put on a silencer; where a new machine is being installed we would recommend it as preferable to drill a special pattern on the couch which would make it less noisy than the earlier pattern.

By Mr. MacLean:

Q. You mentioned that there was photo-grammetery research being done.—A. Yes.

Q. Would you care to expand on that. In that connection I saw a news item the other day to the effect that either the Defence Research Board or the Department of Defence Production—I believe the latter—had recently let a contract for some work in mapping, for some special reason, to a commercial firm. My understanding was that previously to that time most of the mapping by aircraft in Canada was done by the air force, the actual photographing, and I was wondering if there was some reason for special mapping procedure such as a more accurate kind, as distinct from the method developed by the air section.—A. The operation which we have going on in photo-grammetery research is a very interesting one. It is rather unique to Canada. In all other countries the operational people—that is the people who are actually making the maps, attempt to do a little research at the same time. But that is not generally very effective, and some five years ago we had a discussion with the Department of Mines and Technical Services and with the army mapping services to devise a plan whereby we in Canada could have an effective research unit which would concern itself entirely with problems which are local to us. There are serious problems involved in the mapping of our extensive northern territory where the terrain is very rough and difficult.

You must keep in mind in mapping that you must have certain fixed points called "control points" to which you tie the rest of the details. You formerly did this by sending in a field party. This was very costly and slow. This was one of the reasons we established this research unit in my division. It works very closely with mapping agencies in the other government departments as well as with provincial government departments and with two or three commercial companies interested in this field.

The largest problem presented to us was to try to extend control into unknown territory from known territory by means of aerial photographs alone. This problem is extremely important to Canada for the reasons I have outlined. It is also of very considerable importance to mapping areas such as India, South America, and most under-developed countries where maps are so seriously needed.

After five years our rather small group—composed of three scientists—has come up with what looks to be an excellent solution to this problem in addition to the ordinary vertical photograph from which a map is made—they take an infra-red photograph looking ahead which extends a straight line into unknown territory. With successive pictures taken as the aircraft proceeds you can extend the straight line for considerable distances into country where you have no controls.

A second development is the use of a radar altimometer which continually records the height of the aircraft above the terrain beneath. This enables you to control the scale of the photograps. A combination of the three now enables us to triangulate by purely aerial methods over a distance of from 200 to 250 miles with an accuracy which has surprised many people who have come to visit us.

The United States army has been very interested in this recently, as well as the United States navy. In fact we have had representatives from both of these departments spend something like two months each in our photogrammetery research section studying these methods. That is a typical sample of the work we do.

By Mr. Murphy (Lambton West):

Q. What about the topography and the height of land and mountains?—A. That is obtained by vertical photographs which are taken in overlapping pairs. A stereographic model is made by them and you are able to take the details from this to map sheets which have control points, established by aerial triangulation. This speeds up the whole mapping process very considerably.

By Mr. Brooks:

Q. In your mapping development, do you determine the physical features, do you try to discover where minerals are located at certain places?—A. Here I should point out that in straight mapping the work we do is entirely associated with doing research projects. We test methods and that sort of thing. The function of mapping itself rests with other government departments. The mapping we do is restricted to the purpose of testing methods devised by our researchers and which we hope are suitable to our conditions.

Q. Do you try to devise methods which will determine not only the physical features but also indicate what minerals there might be in any locality?—A.

That is a job for a particular specialist. I think we often hear a lot of unreasonable things about photo interpretation. Many people talk about it as if it was rather a mysterious new science, whereas in point of fact you simply take your photographs to people who know the kind of things you want to look for in that photograph. For example, if you want to ascertain the geology of an area, the person you get to look at your photograph is a geologist and so with other fields of knowledge such as forestry, soil studies, etc.

By Mr. Hosking:

Q. Have you done any research with respect to different types of dust and the problem of hay fever?—A. No, we have not been in that field at all.

Q. What should be done is to get some interest taken in it because there are so many people today who suffer from hay fever. As yet there seems to be no cure. Is it not a field in which you should be interested?—A. Yes, but I think it probably lies more in the medical field than in that of physics, except in so far as it is a question of collecting dust samples.

Q. It would be strictly a mechanical process as far as finding out the number of particles in the air that bother people. How should we go about having something done to start research on this subject?—A. I think that the problem involved here is not so much one of collecting samples, which is relatively easy. There are well established techniques for collecting dust samples from the air. I think the basic problem is one of having medical research done on the allergy side. Would that not be true?

Q. I happen to be one of the sufferers. I have a device in my home which is supposed to do a pretty good job in collecting dust but it does not seem to be very effective. I wondered if there wasn't something we were missing in this sort of thing. I know that doctors are doing some medical research on it; but I wonder if there wasn't something we couldn't find out. It is very annoying and there are so many people now who have it. I know there are hundreds of thousands of people who would appreciate something being done in that field. I think it is one of the most important fields, and it would seem to me that the National Research Council should do something about this situation. It is not a nasty job, and I recommend that a start be made on it in conjunction with whatever doctors are required.—A. You can devise methods for taking out almost any size of smallness of particles that you care to take out of the air; but the smaller and smaller the size, so the methods become more cumbersome and more costly.

Q. Has there been any research done on it at all? Just what do we need to make conditions where hay fever won't exist? I think that one of the greatest services that could be done for humanity by the Dominion of Canada would be to see if you can develop, or at least improve, or make one room in your house where you may go and not have hay fever. I am sure that the average sufferer from hay fever spends $100 a year, and with the thousands of sufferers there are, that is a very formidable amount of money. In order to get some relief I think they would spend much more than that, if they were sure of getting relief. It is a terrible affliction and one which a great many people who do not suffer from it do not realize just how bad it is.

I strongly recommend to the Research Council that they make some study of it and try to find out if they can create a room in which a person subject to hay fever may go, and he will know that in that room he will not have hay fever.—A. I think the probable answer to the question you are asking as far as my own division is concerned lies in the fact that so far we have not been approached by any body of medical opinion to cooperate with them on a problem of this sort. Where you have medicine involved with physics, it is practically essential that the medical profession be included in it at a very early stage and as the senior poster if you are going to get somewhere.

Q. It is most regrettable that they do not realize that if they asked for your services, they would be available. I think some publicity should be given with a view to seeking out a group which would be interested in cooperating with you on this thing.—A. We would be very glad to consider giving assistance to any group of medical researchers who were concerned with this problem.

By Mr. MacLean:

Q. I think a much simpler solution would be to come down to my province, Prince Edward Island, for your vacation in the summertime because nobody there suffers from hay fever. But I wanted to ask a question with regard to aerial mapping. I am under the impression that Canada is looked upon as a country that perhaps has established itself as being very competent in aerial mapping generally, and I understand that commercial firms—Canadian commercial firms have done considerable mapping in South America for exploration companies of various kinds, and that Canada has also contributed under the Colombo Plan towards helping to map Pakistan and some other countries which are badly in need of accurate maps. In these cases is it only the established methods that are now in common use in those countries, or have you done research into the particular problems of these countries so that more advanced methods could be used? For instance, have any problems come up in Pakistan which have been referred to you for solution?—A. No, not directly, sir. We have dealt only with problems which have been brought to us by our own Department of Mines and Technical Surveys, and by the armed services. Our solution to some of these problems are applicable to the under developed countries. One of these is the modern method of aerial triangulation which was developed in our division and is being adopted by both the Department of Mines and Technical Surveys and by the army mapping services for actual routine use. That is the kind of thing that pleases us, when it happens.

By Mr. Richardson:

Q. Would Dr. Howlett express an opinion as to the optical industry in Canada, and as to how it compares with that of some of the countries of Europe?—A. I am afraid that the optical industry is always an extremely difficult industry in any country; it is an unsatisfactory one because the demand for its products is usually relatively small. I think it is safe to say that in no country has it ever reached a high pitch of excellence without government support being advanced through contracts. You see this in England, West Germany, France and the United States, and I am afraid that for the foreseeable future this is the only way to develop an optical industry.

Q. Is Dr. Howlett of the view that we should have a good optical industry in Canada?—A. That is a very difficult question to answer directly because it depends on how much you are prepared to pay for it and that gets us into the field of government policy. I think it is safe to say that you cannot have a well developed optical industry without giving it some sort of financial support by one technique or another from the government. That is a fact which has been proved in all countries, and whether we should have it in Canada and to what extent seems to be a matter for the government to decide.

By Mr. Brooks:

Q. Have we an optical industry at the present time which is sufficient for our needs?—A. It is very small, almost vanishingly small, and it would be extremely difficult to give effective competition against large American, English, or European firms which are covering the world market.

By Mr. MacLean:

Q. These large firms, I take it from your earlier remarks, are in fact subsidized by defence contracts?—A. By one technique or another, yes.

Q. From one viewpoint we might say that these optical products are brought into this country from West Germany and various other places and are, in a way, subsidized; and from one point of view you might say that the effect is that of dumping.—A. I do not think I would go quite that far. Optical instrumentation is a difficult field. The initial subsidy is generally required back at the optical glass stage. It is very difficult to conceive how optical glass could be produced in good quantity and of good quality without some subsidy because it is a very costly operation and actually not very large quantities are used in any given instrument such as a camera and so on. That is one place where the difficulty arises.

By Mr. Richardson:

Q. Would Dr. Howlett be prepared to say that we have an adequate number of technicians in the optical field in Canada at the present stage?—A. At the present stage I would say that we have perhaps half a dozen competent optical technicians in the sense of those who can do precision operations, and most of these are in my division.

Q. Should we have some more?—A. We demonstrated in the last war that we can very quickly develop a first class optical industry. There was nothing that the Research Enterprises Ltd. could not make, once it had become established for a year or so. But things are changing. Even in the optical industry until 1940 it was very much an art. People had traditions about German workers and continental workers. But the necessities of the last war taught everybody that working with optical glass is strictly parallel to working with metal, and that it is not an art. It is a straightforward scientific piece of manufacturing, and if we had to do so, we could do it again in very short order.

By Mr. Brooks:

Q. Where do our people gain their training now?—A. We have in the small optical shop in my division five people at the present time. We have to take people who have had no previous experience whatsoever. We generally like to get someone who has had experience in the processing of metals, because that gives him a good ground work on which to begin his training; but his training as an optical mechanic is done entirely in our optical shop.

Q. There is no school anywhere in the world to send them?—A. No. There are places outside the country where an informal sort of training can be obtained. We have sent some of our people down to the United States to certain specialized optical shops, but that is not done in the sense of formal training. It is a question of sending a man to some expert in the business who is prepared to give some extra know-how.

By Mr. MacLean:

Q. There is no possibility of finding a cheaper or easier method of producing a lens from some substance other than optical glass?—A. The thought that you have in mind, I presume, is plastics?

Q. Yes.—A. I do not think I can answer your question any better than by repeating an answer which was given once by Dr. C. K. Mees, Vice-

President in charge of research at the Eastman Kodak Company, who said that glass is the best plastic for optical parts.

The Acting CHAIRMAN: Are there any more questions?

Mr. HOSKING: I move we adjourn.

The Acting CHAIRMAN: I see that our chairman is now here and I invite him to take the chair.

Mr. McILRAITH: No, please continue as chairman. Perhaps the committee might remain in order to discuss future plans.

The Acting CHAIRMAN: I wish to thank Mr. Parkin and Dr. Howlett for their evidence.

Is it the wish of the committee that we now suspend taking evidence.

Agreed.

HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 9

NATIONAL RESEARCH COUNCIL

ATOMIC ENERGY OF CANADA LIMITED

ELDORADO MINING AND REFINING LIMITED

TUESDAY, JUNE 5, 1956

Statement by W. J. Bennett, President, Atomic Energy of Canada Limited, President, Eldorado Mining and Refining Limited.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956

75394—1

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McIlraith, Esq.
and Messrs.

Bourget	Hardie	Richardson
Brooks	Harrison	Stewart (*Winnipeg North*)
Byrne	Hosking	Stick
Coldwell	Leduc (*Verdun*)	Stuart (*Charlotte*)
Dickey	Low	Weaver—(20).
Forgie	MacLean	
Green	Murphy (*Lambton West*)	

(Quorum 9)

J. E. O'Connor,
Clerk of the Committee.

MINUTES OF PROCEEDINGS

TUESDAY, June 5, 1956.

The Special Committee on Research met this day at 11.45 a.m. The Chairman, Mr. George J. McIlraith, presided.

Members present: Messrs. Byrne, Dickey, Forgie, Green, Hardie, Hosking, Leduc (*Verdun*), McIlraith, Richardson, Stick, and Weaver.—(11).

In attendance: Mr. W. J. Bennett, O.B.E., B.A., President, Atomic Energy of Canada Limited, President, Eldorado Mining and Refining Limited; Mr. D. Watson, Secretary, Atomic Energy of Canada Limited.

The Chairman, in calling the meeting to order, referred to the visit by members of the Committee to National Research Council facilities off the Montreal Road. By leave of the committee it was ordered that a note of the visit be recorded in the Minutes of Proceedings this day.

VISIT BY MEMBERS TO NATIONAL RESEARCH COUNCIL INSTALLATIONS—MONTREAL ROAD

THURSDAY, May 31, 1956.

The following Members met this day at 9.30 a.m. for the purpose of visiting certain installations of the National Research Council: Messrs. Brooks, Forgie, Hosking, MacLean, McIlraith, Murphy, and Stick.

Members of the Committee were welcomed by Officers of the National Research Council including Dr. E. W. R. Steacie, President, Dr. E. R. Birchard, Vice-President (Administration), and Mr. B. G. Ballard, Vice-President (Scientific), and conducted on a tour of the following centres of interest:

1. Hydraulic Laboratories of the Division of Mechanical Engineering;
2. Division of Building Research;
3. Microwave Section of the Division of Radio and Electrical Engineering.

Following a luncheon tendered by National Research Council, the Chairman, Mr. G. J. McIlraith, expressed, on behalf of Members of the Committee, gratitude to the Officers of the National Research Council for a most interesting and informative tour and for the excellent co-operation offered by all the Officers participating.

Messrs. Bennett and Watson were introduced to Members of the Committee by the Chairman who then called upon Mr. Bennett to give evidence.

Mr. Bennett, in his statement, dealt with the responsibilities of Atomic Energy of Canada Limited and the operations of Eldorado Mining and Refining Limited. He also referred to certain aspects of research and development in the peaceful application of atomic energy and the production of uranium in Canada.

75394—1½

By leave of the Committee, it was ordered that the following documents be printed as appendices to the Committee's Minutes of Proceedings and Evidence of this day:

Appendix I—Why Heavy Water?
II—Canadian Industry and Atomic Energy.
III—Physics Division.
IV—Reactor Research and Development Division.
V—Chemistry and Metallurgy Division.
VI—Biology Division.
VII—Operations Division.
VIII—Engineering Development and Special Projects Division.
IX—Engineering Services Division.
X—Medical Division.
XI—Administration Division.
XII—Commercial Products Division.
XIII—Public Relations Office.
XIV—Canada's First Atomic Power Plant.

The following documents were filed with the Committee and copies distributed to Members:

1.—An Economic Forecast of the Role of Nuclear Power in Canada.
2.—Some Economic Aspects of Nuclear Fuel Cycles.
3.—Organization Chart—Atomic Energy of Canada Limited.

The Committee agreed to postpone to a further date the questioning of the witness and at 12.45 p.m. adjourned to meet again at 10.30 a.m., Thursday, June 7, 1956.

J. E. O'Connor,
Clerk of the Committee.

EVIDENCE

June 5, 1956.
11.45 a.m.

The CHAIRMAN: Gentlemen, I see a quorum.

On Thursday of last week the members of the committee visited the National Research Council. If it meets with your pleasure, we will have a note of that visit to the National Research Council laboratories made in the minutes of this meeting.

Agreed.

In accordance with our earlier understanding, we have with us today Mr. W. J. Bennett, president of Atomic Energy of Canada Limited and president of Eldorado Mining and Refining Limited. We also have with us Mr. D. Watson, secretary of Atomic Energy of Canada Limited.

If it meets with your pleasure, I will now call on Mr. Bennett to start his evidence.

W. J. Bennett, O.B.E., B.A., President, Atomic Energy of Canada Limited; President, Eldorado Mining and Refining Limited, called.

The WITNESS: Gentlemen, I have prepared a brief which I would like to submit to you. It occurs to me that I have copies of this brief and you might like to follow it as it is being presented. I would ask Mr. Watson to distribute copies.

I propose to discuss the Canadian program in atomic energy under two headings—research and development directed towards the peaceful application of atomic energy, which is the responsibility of Atomic Energy of Canada Limited, and raw materials, or the production of uranium, which is under the direction of Eldorado Mining and Refining Limited.

The subject is a large one and in many respects highly technical. For this reason it seems to me that you will be best able to assess the significance of the atomic energy program within the context of a general statement as to its nature and scope, its organization, the manner of its execution, its objectives, and its present and future implications for our economy. Therefore, my remarks will be directed to this end. I hope that they will provide an adequate preparation for the more detailed description which will follow my presentation. In the case of the research and development program, this detailed description will be given on the occasion of the committee's visit to Chalk River. May I suggest that the papers to be presented at Chalk River be printed in the record of today's proceedings as an appendix to my general statement. Such an arrangement would, I think, facilitate greatly the discussions of the committee at Chalk River.

The CHAIRMAN: Is that procedure agreeable?

Agreed.

(See Appendix "A".)

In addition to the Chalk River visit, I would recommend strongly, subject to the convenience of the members of the committee, that a visit be made to the commercial products division of Atomic Energy of Canada Limited in Ottawa, to the Blind River uranium mining field, and to the Eldorado uranium refinery at Port Hope, Ontario. I am sure that such visits would contribute much to your understanding of these particular aspects of the program.

Let us look first at the research and development program directed towards the peaceful application of atomic energy. I suppose there is no subject which has excited more interest in recent years and no subject about which there is more confusion. The interest is readily understood. Atomic energy has momentous implications for the future of mankind. Used for war, it can bring upon the world a devastation frightful to contemplate. Used for peace, it can bring untold benefits to the world, since it provides a new and tremendous source of energy at a time when acute shortages of energy already exist in many parts of the world and when we are able to forecast an almost universal shortage by the end of the century. Perhaps I can indicate the true significance of these two possibilities by reminding you that a large hydrogen bomb has an explosive power equivalent to 15 million tons of TNT and that a ton of natural uranium used as a fuel has a heat potential equivalent to 2,600,000 tons of coal. The energy content of the known reserves of economically recoverably uranium in the free world is already considerably larger than the energy content of the known reserves of fossil fuels. I believe the confusion about atomic energy can be attributed to two causes. The first cause can, I think, be properly described as historical, since, while it contributed to the public confusion which still prevails, it has now largely been removed. I refer to the security regulations which during the war years and in the immediate post-war years prevented the full disclosure of information about atomic energy programs. You will recall that the publis was told nothing about the atomic energy program until the first atomic bomb was dropped on Hiroshima in 1945. While security regulations were relaxed somewhat during the post-war years, information was still released in a piecemeal fashion, which made it exceedingly difficult for the layman to grasp the full implications of this new science. It may be of interest at this point if I tell you how information is declassified. Declassification is the responsibility of a tripartite committee on which the United States, the United Kingdom and Canada are represented. The criteria which this committee uses are based on the proposition that any information which can contribute to weapon technology should not be given public distribution. The application of this criteria has been exceedingly difficult, since much of the information in both the fundamental and applied fields is common to military and civil programs in atomic energy. Recognition of this fact prompted the decision to declassify for the Geneva Conference large areas of information which had previously been classified. As a result of this action—and this is a point to which I should like to give particular emphasis—sufficient information is now available to permit any country to undertake a program of research and development, assuming that it has the required scientific, engineering and industrial competence. The problem which faces us today in the field of information is not one of scarcity of information but rather one of interpretation and evaluation, which brings me to the second cause of the confusion in the public mind. The language of this new science is frightening to the layman. Since I happen to be in that category, I have adopted the philosophy that it is sufficient to accept the facts which the scientists have given us without understanding fully the steps by which those facts have been discovered.

The first basic fact about atomic energy is that a nuclear fission produces large amounts of energy in the form of heat. A ton of natural uranium has an energy potential of 20 billion kilowatt hours—which, as I have already mentioned, is roughly equivalent to the heat potential of 2,600,000 tons of coal. We must find a way of using this heat, and the most likely use appears to be for the production of steam to drive a turbine in a power plant. A second basic fact about atomic energy is that when a nuclear fission occurs, certain new elements can be produced in the uranium fuel. One of them—plutonium—is itself fissionable and can, therefore, be used as fuel in a reactor. A third basic fact is that when fission occurs, the fissionable material breaks down into what are known as fission products. It seems probable that certain of these fission products may also have useful applications. For example, experiments are now under way involving the use of one of them—Caesium 137—as a food preservative. The fourth basic fact about atomic energy is that certain materials when irradiated in a reactor take on new properties—that is to say, these materials themselves become radioactive. The radioactive materials are called radioisotopes. Radioisotopes are now being used widely in industry, medicine and research. I do not suggest that our knowledge of these four basic facts about atomic energy gives us at once a full understanding of all of their implications, but it does provide a good starting point from which to consider the research and development program.

The broad objectives of this program are twofold—to develop the economic use of atomic energy as a source of electric energy and to produce radioactive isotopes for use in medicine, industry and research.

How are we trying to reach the first of these objectives? We are doing three things. First, we are carrying on fundamental research in physics, chemistry, biology, physical metallurgy, and associated sciences. Second, we are testing materials and components in the NRX reactor. Third, we are undertaking design and feasibility studies, with the required engineering development, for power reactors. I should point out at once that, while I have described these three activities separately, they are in fact very closely related. Although sufficient scientific data are now available to permit the engineer to make a beginning in the applied field, the boundaries of scientific knowledge have by no means been pushed to their limit. Our present advanced position in atomic energy can be attributed largely to the emphasis we have put on fundamental research. To be more specific, it is now commonly agreed that Canada must be included with those countries which are in the forefront in the development of nuclear science. This emphasis on fundamental research must continue, if we are to maintain our position. In a science that is moving and changing as rapidly as this one, there can be no static position. The first role of the research scientist is to provide the scientific data on which the design of the future and possibly the ideal reactor will be based. His second role is to act as a consultant to the engineer as the work of reactor design proceeds, since there are as yet no handbooks containing full information on the design of reactors. While Chalk River is the centre of such fundamental research, a number of the universities are also making valuable contributions. Chalk River maintains close relations with the universities—an arrangement which includes, amongst other things, the participation of university staff in the technical conferences which are held quite frequently and summer training courses for postgraduate students.

The testing of materials and components is also an essential part of power reactor development. This we are able to do in experimental reactors such as the NRX reactor, because we can simulate conditions such as irradiation and temperature which are likely to be encountered in the operation of a power reactor. As it happens, the NRX reactor, because of its high flux and its size, still provides facilities for experiment and testing which do not exist elsewhere in the free world. This will explain why it has been used so extensively in the United States and United Kingdom programs, as well as in our own program.

In this connection the committee may be interested in an excerpt from a statement made by Dr. Lawrence Hafstad, the former director of the reactor program of the United States Atomic Energy Commission. In an appeal to American industry to participate more actively in the development of suitable fuel elements for power reactors, Dr. Hafstad had this to say:

> In order to do this, one of the tools you ought to have is what we would call a fuel element testing reactor. It is pretty generally known in the business that we have an excellent research reactor in the materials testing reactor (MTR). In order to get the very high flux that reactor has, it was so designed that none of the holes available for testing samples is large enough to accommodate a full-sized fuel element. We have been depending upon the good nature of our northern neighbor, Canada, to test full-scale elements in her NRX reactor. This has been going on for years.

I might mention a project of current interest. The United States Atomic Energy Commission is now building a large demonstration power reactor known as the PWR. The selection of specific fuels for this reactor has been made as the result of experimental work carried out in the NRX reactor. The NRU reactor, which is expected to come into operation at the end of the year, will have a power rating and a flux approximately five times as great as NRX. This reactor is a triple-purpose reactor: it will produce substantial quantities of plutonium which will be sold under contract to the United States Atomic Energy Commission: it will produce large quantities of radioisotopes—notably $Cobalt^{60}$: and it will provide larger and improved research, experimental and testing facilities. Because of the high flux of the reactor and its size, these research and experimental facilities should be the finest in the world.

Design and feasibility studies with supporting engineering development are also necessary if the results of research and experiment are to be given a useful application. Or, to put it another way, there comes a time in every research and development program when it is necessary to demonstrate feasibility—both engineering and economic. In the case of a nuclear power research and development program, this can only be done by designing and building a power reactor.

Our first design and feasibility study began early in 1954. From it came the outline specification for the demonstration power reactor, known as the NPD, which we are now building in association with Ontario Hydro and the Canadian General Electric Company. This reactor will be designed to produce steam sufficient to generate 20,000 kilowatts electric. It will use heavy water as a moderator and as a primary coolant. The heavy water will be pressurized and will raise steam from ordinary water in a heat exchanger. The nuclear fuel will be, in the main, natural uranium, but some enriched fuel may be used in order to reduce the physical size of the reactor. The uranium fuel will be in the form of uranium oxide pellets clad in zirconium alloy. Mr. Ian McRae, general manager of the civilian atomic power department, Canadian General Electric Company, will present a paper on the NPD reactor during the committee's visit to Chalk river. The NPD will not produce power at competitive costs. However, it will demonstrate the feasibility of producing electric energy from atomic energy, and it is expected to provide valuable information on fuel element design and performance. The arrangements for the carrying out of the project are as follows. Atomic Energy of Canada Limited will supply the nuclear specifications and pay for the cost of the reactor part of the station, less the amount which is being contributed by the contractor, the Canadian General Electric Company. This company will contribute up to $2,000,000 towards the cost of design and engineering development. Ontario Hydro will furnish the specifications for the conventional part of the plant, will pay for its cost, and will operate the station when it is completed. The NPD reactor is expected to come into operation early in 1959. The estimated total cost—and this is a present estimate—is $14,500,000, which will be allocated as follows:

Atomic Energy of Canada Limited	$ 9,000,000
Ontario Hydro	3,500,000
Canadian General Electric	2,000,000

While the design, construction and operation of demonstration power reactors such as the NPD is a necessary step in the power reactor development program, such reactors will not provide final information either with respect to design or capital costs. To be more specific, the design of a small power reactor such as the NPD cannot be blown up for the design of a large central power station. Consequently, we also have under way a preliminary design and feasibility study, with associated development programs, for a large power reactor—in the range of 100-200 megawatts. This preliminary design study will consist of feasibility studies similar to that on which the specifications of the NPD reactor are based. The preliminary design work will consist of three phases—first, general studies comprising reactor designs, reactor cores, heat transport and transfer arrangements, plant layouts and steam cycles; second, specific designs based on the information derived from the general studies; third, estimates of operating and capital costs for the specific designs. It may be anticipated that the final report of the preliminary design study will call for further detailed studies which will include in certain cases experimental and engineering development projects. Some of these projects will be carried out at Chalk river—notably those concerned with fuel element design and testing and reactor core design. Others will be carried out by manufacturers. Broadly speaking, the policy will be to use those manufacturers which are best equipped to undertake a specific engineering development project. In addition, we are considering design studies for other types of reactors which we consider may have a useful place in the Canadian economy—for example, a dual-purpose reactor which will provide power and process steam for the pulp and paper industry and a small reactor which will provide power and heating in remote areas of northern Canada where the cost of conventional thermal fuels is excessive.

I am frequently asked whether our program in power reactor development provides for the participation of Canadian industry.

I will first answer this question in a general way by stating that from the inception of the program we have recognized two basic principles—first, that nuclear power plants will be operated by the utilities and, second, that these plants and their components will be designed and built by manufacturers. These principles have determined the manner in which we are trying to carry out the program.

As a first step, we decided that the utilities should be fully informed about the program in Canada and elsewhere. This we are accomplishing in two ways—first, through the medium of an advisory Committee on atomic power on which the utilities are represented, and second, through the nuclear power branch which is located at Chalk River and the personnel of which has been recruited mainly from the utilities. These arrangements with the utilities serve a dual purpose. First, they enable the utilities to evaluate the economic importance of nuclear power in terms of their respective future power requirements. It was such an evaluation which prompted Ontario Hydro to join with us in the demonstration power reactor project. While Ontario Hydro is the only utility participating financially in this project, the information obtained will be made available to all members of the advisory Committee. Second, the arrangement provides the kind of economic yardstick which is essential to the proper planning of the Chalk River program. To be more specific, the information about future power requirements which we are able to obtain from the advisory committee permits us to give our applied program the shape and direction which is best suited to the particular needs of the Canadian economy.

We have also thought it most desirable that the manufacturer should participate in the program on the broadest possible basis. This participation can involve two stages. First, the manufacturer must have sufficient information about power reactor development to enable him to determine what part, if any, his company can play in that development. Second, the manufacturer can undertake the design and fabrication of power reactors and their components. With regard to information, much of this is now available in the published literature, and particularly in the published proceedings of the Geneva conference. I might add here that included in the Canadian delegation to the conference was a group of Canadian manufacturers. We have also found that it is very useful to have manufacturers visit Chalk River. Over the past few years representatives of every major industry in Canada have made such visits. For example, a few weeks ago senior representatives of the pulp and paper industry attended a two-day conference at Chalk River. Recently we have established an industrial assistance office. This office will handle inquiries from the manufacturer and will also seek to encourage visits and discussions. The participation of industry in the design and fabrication of reactor components is the second stage and obviously the most important stage in our partnership with the manufacturer. This participation began in a major way on the NRU project. More than 100 Canadian companies have been engaged on the fabrication of parts for this reactor, involving special designs outside of normal manufacturing experience. I have already made reference to the Canadian General Electric Company which has the contract for the design, fabrication and erection of the NPD reactor. A contract has been placed with Canadair Limited for the design and construction of a research reactor of the swimming-pool type, and with the Canadian Westinghouse Company for the design and manufacturer of a loop system for the NRU reactor. It has been, and will be, our policy to invite proposals from Canadian manufacturers for projects of this kind. Perhaps I might cite two current examples. We are now inviting bids for the fabrication and erection of the experimental reactor of the NRX type which we are building in India under the Columbo plan. We have also invited proposals for the supply of the fuel elements for the NRU and NRX reactors. Bearing in mind our large supplies of uranium, we think there is a real future in the fuel element business. All reactors require fuel elements, regardless of their type. We think it makes good sense to aim at a situation where at least some of our uranium will be exported in the form of fuel elements. We would anticipate that the company which takes on the job of fabricating the NRU fuel elements will in due course build up its own design and development organization and thus be in a position to exploit the domestic and export markets.

While these are only a few of the items covered in our program of participation by the Canadian manufacturer, I believe they serve to point up the present and future respective roles of Chalk River and the manufacturer. Chalk River will continue to have the major responsibility for carrying out fundamental research and for undertaking those phases of the development program which require the use of reactors. It will be the responsibility of the manufacturers to translate the data supplied by Chalk River into useful and economic applications. This will not be an easy task, since power reactors and their components do not lie within the normal design and fabricating experience of the Canadian manufacturer. This means simply that a large and costly engineering development effort is required in many cases before a practical manufacturing specification can be established. This subject will be covered in some detail in a paper to be presented by J. L. Gray, which is included among the papers which I suggest should be attached as an appendix to my statement.

Where does Canada stand in power reactor development in relation to other countries?

So far as fundamental research is concerned, I think we can claim that our program compares very favourably with the programs under way elsewhere. In comparing the Canadian program in the applied field with the programs under way in the United States and in the United Kingdom, the following points should be noted.

First, the three countries are now designing and building demonstration power reactors and in each case the type of reactor is based on the technology with which the country is most familiar. For example, the design of the Canadian demonstration reactor provides for the use of heavy water as a moderator and coolant and natural uranium as a fuel. This is the technology which we pioneered with the NRX reactor. In the United Kingdom, on the other hand, the first demonstration power reactor—that at Calder Hall—will use graphite as a moderator and gas as a coolant. This is a technology which has been highly developed in the United Kingdom. The first demonstration reactor in the United States, the PWR, uses graphite as a moderator and light water under pressure as a coolant. Here again, the technology was first developed in the United States. The important point is that there is no duplication of effort as regards the basic design of these several demonstration reactors. No one can say at this time which type or types of power reactors will prove to be the most economic. My own guess is that there will be several desirable types.

Second, the applied programs differ in size and variety and for very obvious reasons. For example, the United States has under way demonstration reactors of five different types and several others are being considered. Our resources place some limit on our ability to undertake a highly diversified program. We think it best to do one job well rather than to do several jobs poorly. While this policy has some disadvantages, these should not be exaggerated. There are many features common to all types of power reactors. Consequently, any program in power reactor development is bound to produce valuable information, regardless of what the ultimate choice of reactor or reactor types may be. Power reactor technology is still very much in a fluid state. Consequently, it is most desirable that there be a constant inter-play of ideas as between different reactor development groups. With this comment on the difference between the Canadian and the United States and United Kingdom reactor programs, I should point out at once that we have every confidence that our particular technology will produce a power reactor which will be competitive. At a later stage in our presentation you will hear a paper in support of this opinion.

Third, the programs in Canada, the United States and the United Kingdom have this common feature—namely, that in the early stages of the development of power reactors (and this includes the design and construction of demonstration power reactors) the main burden of the cost is being borne by the respective atomic energy authorities. However, the three programs provide for the participation of the utilities and the manufacturers on the broadest possible basis. Normally there is a time-lag between scientific discoveries and their practical application on any substantial scale. This means that the cost of research and the cost of applied work (design, engineering development and fabrication) are usually spread over a considerable period. In the case of atomic energy, this time-lag has been reduced to the barest minimum. In fact, we have a somewhat unique situation in that a large scale research program and a large scale applied program are being carried on simultaneously. This procedure is bound to be costly. The scale of the expenditure required, particularly in research and development, is undoubtedly beyond the financial ability of Canadian industry, and to a large extent the same may be said of industry in the United Kingdom and the United States. It is impossible to make any comparison of the programs in the three countries in terms of dollar expenditure, for the simple reason that a major part of the atomic energy budgets in the United States and in the United Kingdom is devoted to military applications whereas in Canada our expenditures are exclusively for the civil program.

Fourth, in comparing programs in power reactor development, it must be borne in mind also that the degree of economic compulsion which prevails in a particular country has a considerable bearing on its program. For example, in the United Kingdom the cost of power generated from conventional thermal stations has now reached the point where nuclear power, even at 9 or 10 mills per kilowatt hour, is attractive. Obviously on this continent nuclear power at these costs offers no competition to conventional thermal power except in remote areas. This will explain why the United Kingdom is able to embark on a large-scale nuclear power program at this early stage in the development of power reactors.

This fourth point brings me to a consideration of the economic context into which our program of power reactor development must be fitted.

Or, to put it another way, is there a need for nuclear power in Canada?

This subject has been covered in some detail in papers delivered at the Geneva conference by Dr. John Davis of the Department of Trade and Commerce, who is economic consultant to Atomic Energy of Canada Limited, and Dr. W. B. Lewis, vice-president in charge of research and development at Chalk River. Since I have asked the secretary of the committee to distribute to the members copies of these papers, I will content myself with summarizing the conclusions contained in them.

The CHAIRMAN: If it is agreeable to the committee, these papers now being distributed will merely be tabled and referred to, but not printed.

Mr. GREEN: The trouble is that, then, no one else will know anything about them.

The CHAIRMAN: A summary will be given in the course of the evidence now being given. I do not think is any need to print them.

Agreed.

The WITNESS:

It is estimated that the annual increase in power demand for the country as a whole over the next twenty-five years is likely to continue at the rate of about 5 per cent per annum. On this basis, the total installed capacity in 1966 (10 years from now) will be 28,000,000 kilowatts and the total installed capacity in 1981 (25 years from now) will be 48,000,000 kilowatts, as compared with a present installed capacity of 16,000,000 kilowatts. Since Canada has large untapped hydro resources and an abundance of cheap conventional fuels in some regions, a substantial part of the future power demand will be supplied by new hydro stations or thermal stations using conventional fuels. There follows a table which shows the total installed capacity at the end of each five-year period beginning with 1956 and ending with 1981, and the estimated respective contributions which hydro, conventional thermal, and nuclear power stations will make to the total installed capacity. The role assigned to nuclear stations is based on the assumption that it will be possible to produce nuclear power at a cost not higher than the cost of producing power in a conventional thermal station using coal at $8 per ton or at a cost of not more than 6 mills. To the extent that the cost of nuclear power can be produced below this target, there should be an increase in the percentage of new power which will be supplied by nuclear stations and a corresponding decrease in the percentage of new power which will be supplied by conventional thermal stations.

INSTALLED CAPACITY IN MILLIONS OF KILOWATTS

Date	Total	Hydro	Other		
			Total	Coal, Oil, Gas	Nuclear
1956	16·0	14·0	2·0	2·0	Nil
1961	22·5	20·0	2·5	2·4—2·3	0·1—0·2
1966	28·0	24·5	3·9	3·7—2·9	0·2—1·0
1941	34·0	27·4	6·6	6·0—4·9	0·6—1·7
1976	41·0	30·2	10·8	8·8—7·5	2·0—3·3
1981	48·0	33·0	15·0	11·0—8·0	4·0—7·0

The figures shown in the table indicate that nuclear energy will play a quite modest part in supplying power demands up until 1971. During the 1970's it is probable that several millions of kilowatts of nuclear capacity will be installed. By 1981, nuclear power plants may conceivably account for as much as 10 per cent—15 per cent of the total generating capacity in this country and beyond that period this percentage will increase. In considering the estimate as to the future role of nuclear power in the Canadian economy, one might draw the conclusion that there is no great urgency about the power reactor development program. Lest we become too complacent, I would remind you that there are many problems to be solved before we reach our target of 6 mills. On the basis of our present experience, a period of about 7 years is required to demonstrate the engineering and economic feasibility of a particular reactor type. This period may be broken down roughly as follows—2 years for preliminary design studies with supporting development, 3 years for detailed design and construction, and 2 years for operation.

As one might expect, there is a wide variation from region to region, both with respect to the rate of the demand for new power and the availability of hydro resources and cheap conventional fuels to meet this demand. This means simply that nuclear power will be used much sooner in some regions than in others. It will be used first in those regions which have exhausted their hydro resources and which do not have available cheap supplies of conventional thermal fuels. Southern Ontario is such a region. It is estimated that the power growth rate in southern Ontario over the next twenty-five years will be at the rate of 6 per cent per annum. Consequently, southern Ontario will require additional power in the amount of 5,000,000 kilowatts in the period between 1960 and 1975. Since southern Ontario will have exhausted its hydro resources with the completion of the St. Lawrence seaway, the bulk of this power must be generated from thermal stations. Moreover, since southern Ontario has no indigenous supplies of conventional fuels, we would expect that beginning in the mid-sixties nuclear power would fill some part of this future power requirement. I have used the situation in southern Ontario to illustrate my point that nuclear power will supplement rather than displace existing sources of power. Where similar situations exist in other parts of the country, nuclear power should also play this supplementary role.

How soon do we expect to be able to produce nuclear power at a cost of 6 mills?

The answer to this question depends on how soon we will be able to solve a wide range of problems which, for the most part, lie in the engineering field. We have already demonstrated that a controlled nuclear reaction is possible—that is to say, we have built and operated reactors. However, all of the reactors built to date have been designed for the production of plutonium for the military program or for experimental purposes. The heat produced in these reactors is exhausted in their coolants as a waste product. Moreover, the capital cost of these reactors has been exceedingly high. Amongst other things, the advantage of an atomic power station as compared with a conventional thermal power station is the low annual fuel cost. However, the capital cost of an atomic station will undoubtedly exceed the capital cost of a conventional thermal station. The capital cost of the first round of demonstration reactors—that is, the demonstration reactors which will come into operation in the next two or three years—ranges from $500 per kilowatt to $600 per kilowatt. This cost must be reduced very greatly—a probable target would be $250 per kilowatt—if the benefits of lower fuel costs are not to be offset by higher capital charges. The engineer, therefore, has a twofold task. He must design a reactor which will be both a reliable and a cheap source of heat for a power plant. You will hear something of the problems involved in this undertaking in the papers to be presented at Chalk River. In the demonstration power reactors which will come into operation in the period from 1958 to 1961, the emphasis is on the first of these objectives—reliability of operation. There are varying opinions as to how soon the second objective—low capital cost—will be reached. Some of the experts believe that the second-stage power reactors, which may be expected to come into operation in the period from 1961 to 1965, will produce power at competitive costs. Others are less optimistic. When one lives with the problems, their difficulties are likely to be exaggerated. In my own case, I try to temper such pessimism by recalling that only a few years ago no one believed that we would have competitive nuclear power for at least twenty-five years. In fact, as recently as 1938, Rutherford, one of the great pioneers in the development of nuclear science, stated that he did not believe that a controlled nuclear reaction would be possible. I believe it is a safe prediction that competitive power will be produced on this continent not later than 1965.

I will now discuss the second objective of the Chalk River program, the production of radioisotopes. As I have already mentioned, a radioisotope is produced when certain materials are irradiated in a reactor. Radioisotopes have been produced in the NRX reactor since it went into operation in 1947, and the NRU reactor will also be used for this purpose.

Radioisotopes have already found a wide use in industry, research and medicine, and it can be anticipated that the current applications will be increased and that new applications will be found.

The uses of radioisotopes can be conveniently divided into three main categories—namely, the effect of radiation on materials, the effect of materials on radiation, and radiation tracers.

In the first of these, one or more of the alpha, beta or gamma radiations given off by the isotope is used to produce some change in the target material. A good example of this is the therapeutic application of gamma rays when $Cobalt^{60}$, the radioactive isotope of cobalt, is used for the treatment of cancer. Canada pioneered this particular use. Therapy units designed and built in Canada are now in operation in Canada, France, Italy, Brazil, Switzerland, New Zealand, the United States and the United Kingdom, and there are two on order for Australia. When the committee visits the commercial products division we will show you the three models of therapy units which are now being marketed. Radiation can also be used to induce certain chemical and physical reactions such as polymerization. Applications in this branch of the chemical industry are still in the experimental stage, but the prospects are encouraging. Since radiation produces a lethal effect upon the cells of living organisms, it can obviously be used in certain cold sterilization processes. Much experimental work has already been done on the sterilization of medical supplies, pharmaceuticals and food products, and again the prospects of successful application are encouraging. Radioisotopes are also used as a means of eliminating static because of their ability to ionize the atmosphere. This application is particularly effective in certain types of manufacturing operation such as printing, where static is a problem.

Uses resulting from the effect of materials on radiation include the radiography of castings, where the casting selectively absorbs the gamma radiation. The shadow which is cast on photographic film indicates thicker and thinner sections and, as a result, flaws in the casting. Thickness, density and liquid level gauges all fall into this group of uses. The isotope chosen naturally depends upon the particular problem to be solved. For example, a thickness gauge to be used in the automatic control of paper stock would make use of a beta emitting isotope with a medium-to-low energy, whereas a density gauge to be used in connection with thick sections of material might well select a gamma emitting isotope with a high energy. One of the present large uses of radioisotopes is for neutron well logging. In this case, the isotope is mixed with beryllium to emit neutrons. The penetrating characteristics of these neutrons make possible the underground logging of petroleum bore-holes, thus providing much useful data.

The radiation emitted by radioisotopes can be measured in extremely small quantities and consequently there are a great many uses of radioisotopes as tracers in various research and production processes. The radioisotope is incorporated into a material and its subsequent movement can be traced through the flow sheet of a chemical process. One of the significant uses of radioisotopes as a tracer is in fertilizers. Large quantities of phosphate fertilizers are used annually in the United States and Canada. Not all of the phosphorus contained in the fertilizer is taken up by the crops. There is, therefore, much room for detailed study of the types of fertilizers and the conditions under which these should be applied in order to obtain the most efficient use of fertilizer optimum. Conditions of application are not the same for all crops nor are they by any means the same in all areas. The radioisotope Phosphorus 32 provides a very effective tracer tool for these studies. Experimental phosphates tagged with Phosphorus 32 provide information as to the best method of applying fertilizer and the most suitable season for its application. At the same time, they provide a means of discriminating between uptake of phosphorus from applied fertilizer and uptake from phosphorus already existing in the soil. Sometimes the application of fertilizer stimulates the uptake of phosphorus already in the soil. The implications of this research are obvious—it is now possible to calculate the optimum rate and time for the application of commercial fertilizers. Dr. J. W. T. Spinks of the University of Saskatchewan has made a major contribution to this particular research project.

It is difficult to assess accurately the present and probable value of isotopes in the national economy. If one simply looks at the value of the sales of isotopes—that is, the income which is derived by the commercial products division of Atomic Energy of Canada Limited and other similar sales agencies—the dollar figures are not large. For example, the revenue of Atomic Energy of Canada Limited from the sale of isotopes in the present year is expected to be about $1,500,000. This represents shipments of more than 50,000 curies—an amount probably in excess of the total curies of activity sold by the United States Atomic Energy Commission and the United Kingdom Atomic Energy

Authority. It is estimated that gross sales may reach $5,000,000 per annum in about three years. The value of the use of isotopes to the national economy is obviously of a quite different order of magnitude. Here, we must take into account the savings which result from the use of isotopes in industry and in agriculture and the benefits which accrue from their use in medicine. I need hardly say that it is difficult to express these values in terms of dollars. Dr. W. Libby, one of the members of the United States Atomic Energy Commission, has recently stated that the use of radioisotopes in the United States, other than therapeutic uses, has resulted in estimated annual savings as follows—for industry $200,000,000, for agriculture $210,000,000. It would be interesting to develop similar figures for the savings to the Canadian economy resulting from the use of isotopes.

The commercial products division of Atomic Energy of Canada Limited has a twofold function. It is responsible for marketing isotopes and for developing new uses for isotopes. A major part of the division's sales is to foreign markets. While we have enjoyed certain advantages in these markets because of the special characteristics of certain of the isotopes produced at Chalk River—notably Cobalt^{60}—by and large competition is stiff. As in so many cases, volume is the important factor in costs, or, to put it another way, we can do a better job cost-wise for Canadian users if we are able to maintain a high level of sales in foreign markets. The commercial products division is pursuing this objective vigorously and at the present time has sales arrangements covering forty countries.

I have left my comment on the organization of Atomic Energy of Canada Limited until this point in my presentation, since it is my experience that the reason for a particular kind of organization is better understood when its purpose has been defined. Atomic Energy of Canada Limited, like other corporations, has a board of directors. The names of these Directors and their occupations are as follows:

D. W. Ambridge	President Abitibi Power & Paper Company Limited Toronto, Ontario
E. R. Birchard	Vice-President (Administration) National Research Council Ottawa, Ontario
G. A. Gaherty	President Calgary Power Company Montreal, P.Q.
Dr. A. R. Gordon	Dean of the Graduate School and Head of the Department of Chemistry University of Toronto Toronto, Ontario
R. L. Hearn	Chairman Hydro-Electric Power Commission of Ontario Toronto, Ontario
Huet Massue	Manager, Economics & Statistics Department Shawinigan Water & Power Company Montreal, P.Q.

V. W. Scully ....Vice-President and General Manager
The Steel Company of Canada
Hamilton, Ontario

F. C. Wallace ....President
Canadian Pittsburgh Industries Limited
Toronto, Ontario

W. J. Bennett ....President
Atomic Energy of Canada Limited
Ottawa, Ontario

It will be noted that in the composition of the board there are represented the several segments of our economy which have a particular interest in the development of the peaceful uses of atomic energy. The board is responsible for recommending to the government the broad lines of policy which govern our operations at Chalk River. This includes, amongst other things, the approval of budgets—both capital and operating.

At Chalk River we have two main divisions—research and development under the direction of Dr. W. B. Lewis, and operations and administration under the direction of J. L. Gray. I have asked the secretary to distribute to you a chart showing what is comprised in these two divisions.

The total number of employees of Atomic Energy of Canada Limited is 2,206, including the employees of the commercial products division. Of these, 1,133 are salaried employees and 1,073 are hourly-rated employees. In all, there are 356 professionals employed by the company.

May I give you in summarized form the objectives of our program at Chalk River. These objectives may be described as follows:

(a) To contribute to the development of economic nuclear power in order that nuclear power may be available for use in Canada in those regions where conventional methods of developing power are no longer economic. Since the ultimate responsibility for building and operating nuclear power stations on a commercial scale must rest with the present producers of power, it is obvious that the program must be carried out in close cooperation with the utilities. This basic principle makes possible a closer definition of the activities of Atomic Energy of Canada Limited as they relate to the future power requirements of Canada.

First, Atomic Energy of Canada Limited must be in a position to assist the utilities in evaluating the economic importance of nuclear power in their respective systems.

Second, Atomic Energy of Canada Limited should endeavour to develop the type of reactor which will best meet the requirements of those utilities which have decided to embark on nuclear power programs.

Third, Atomic Energy of Canada Limited must be prepared to supply technical advice and experimental and testing services when one or more of the utilities decides to build nuclear power stations.

(b) To carry out the power reactor development program in such a manner as to ensure that the Canadian manufacturer will be in a position to design, fabricate and construct power reactors and their components for the domestic and the foreign market. While this can be accomplised, in part, by keeping the manufacturer informed of general developments in the nuclear power field, it must be recognized that this is no substitute for design, development, fabrication and construction experience. It is now clear that the capital cost of nuclear power stations will be the major factor in determining their use as a source of electric energy. Capital cost will depend largely on design, development and manufacturing costs. Consequently, experience in design, development and manufacturing is essential if the Canadian manufacturer is to be in a position to compete for the domestic and foreign power reactor market.

(c) The production and marketing of radioisotopes for use in medicine, industry and research, and the development of new uses for these isotopes.

The conference which was held at Geneva last August and the recent negotiations concerning the establishment of an international agency for atomic energy have emphasized the importance of international co-operation in the field of atomic energy. Assistance provided under any plan of international cooperation can take the form of technical information and training, equipment such as reactors and their components, or fissionable or fertile materials for fuelling research, experimental and power reactors. The kind and degree of such assistance will depend in large part on the scientific, engineering and manufacturing competence of the receiving country. For example, a country which has highly developed scientific, engineering and manufacturing resources will be primarily interested in obtaining technical information. It may also be interested in obtaining supplies of fissionable or fertile materials, if it does not have these materials within its own borders. On the other hand, such a country will be quite capable of designing and manufacturing its own reactors and their components. The requirements of the so-called underdeveloped countries will include all the forms of assistance I have mentioned, although it seems probable that in the early stages of any nuclear program these countries may undertake, the pressing need will be for trained personnel. International cooperation is not exactly a new idea in Canada. For many years we have had very close relations with the United Kingdom Atomic Energy Authority. This has taken several forms—for example, the exchange of information and personnel and the common use of research facilities. Every year a U.K.-Canadian technical conference is held, at which time there is a full and free discussion of our common problems. Last June we entered into a bilateral agreement with the United States which now provides for collaboration on a scale similar to that which we have enjoyed with the United Kingdom. We also have under consideration arrangements for cooperation with other countries. This does not mean that thus far we have closed the door on such cooperation. During the past year we have had over 1700 visitors at Chalk River and among these were technical teams from Australia, New Zealand, Belgium, Norway, Sweden, France, Switzerland, Portugal, India, Burma, Japan, Southern Rhodesia, Egypt, Brazil and Peru. In addition, we have followed the policy for some years of exchanging technical reports and technical literature with accredited scientific institutions in various parts of the world. Perhaps Canada's most significant contribution in the international field has been the decision to build a research reactor of the NRX type in India. This, as you are aware, will be a part of our contribution to the Colombo plan. India has a very large population and rather meagre energy sources. Consequently, it is one of the countries where nuclear power can make a real contribution to the improvement of living standards. While the NRX reactor will not produce power, it will provide the kind of training that is essential if India is to embark on a nuclear power programme. I think we can take some pride in the fact that this is the first major project in the atomic energy field which has been launched by any of the countries which are well advanced in the science.

Our approach to the problem of international co-operation is based on certain convictions. First, we believe it is essential that a way must be found to share with others the peaceful benefits of atomic energy. This will explain our active participation in the discussions concerning the establishment of the international agency for atomic energy. We would hope that the agency would provide the kind of international framework which would make for the most effective kind of co-operation. Second, we think it unlikely that knowledge in this new field will be the monopoly of a single nation or a single group of nations. We find support for this view in the long history of scientific discovery which took place in many countries prior to the war and without which our present advanced position would not have been possible. It is true that some of us have made more rapid strides than others. Because of this, we may for a time expect to give more than we receive. However, if the past means anything, it is improbable that this condition will prevail indefinitely. He would be rash indeed who would attempt to predict in what country or countries the significant developments of the future will take place.

The CHAIRMAN: Mr. Bennett is available for questioning. Is it your wish that we start the questioning now or would you prefer to wait until Thursday morning?

Some Hon. MEMBERS: Thursday morning.

The CHAIRMAN: Could we have a motion to adjourn?

Mr. RICHARDSON: In the meantime Mr. Chairman, I wonder if I might just refer, with your permission, to page 23 of Mr. Bennett's very excellent memorandum. Almost at the end of that page he said, "It would be interesting to develop similar figures for the savings to the Canadian economy resulting from the use of isotopes." Would that, perhaps, be given some consideration for Thursday morning?

The WITNESS: Actually, I believe in the paper on the commercial products division, which will be attached as an appendix, there is a figure given. I think that figure is $25 million, but I cannot remember exactly.

This, of course, is not an easy thing to do. In regard to the figures that I quoted for the U.S., I do not know on what basis Dr. Libby made his calculation. Personally I doubt whether you can get the sort of statistical information that would be needed to make this sort of an estimate.

Mr. FORGIE: Is there not a plant in operation now at Oakville, Ontario?

The WITNESS: There is a company called Isotope Products Limited which is marketing isotopes, but they are not producing isotopes.

The CHAIRMAN: A motion to adjourn would be in order.

Some Hon. MEMBERS: Agreed.

The CHAIRMAN: We shall meet Thursday morning at 10.30 o'clock.

APPENDICES

APPENDIX I

WHY HEAVY WATER?

by

W. B. Lewis

2.1 *Introduction*

An economic survey in Canada of the electric-power situation by the Economics Branch of the Department of Trade and Commerce has shown that the demand for power is increasing and will exceed that available economically from water power. In some regions this limit will soon be reached. In Southern Ontario, for example, there will be need for other large sources of power within ten years and already large coal-fired generating stations are in operation at Toronto and Windsor, burning imported coal. In other areas water-power development is far from complete now, but in a time possibly as short as 30 years, even Quebec may require thermal generating stations using coal, oil or uranium.

The Canadian industrial economy is based on low-cost electric power, and the demand for atomic power would become large only if its cost could be brought below 6 mills per kilowatt-hour.

There is no reason to doubt that the heavy-water reactor will provide such low-cost power, but it is necessary first to devote quite a costly effort to engineering development of the reactors required.

Our confidence in the outcome is based firmly on practical experiments conducted over many years in the NRX experimental reactor at Chalk River. Our confidence is shared by those concerned with heavy-water reactor development at the Argonne National Laboratory at Chicago. It appears also that the U.S.S.R. has confidence in the heavy-water reactor for economic power.

Even when compared with any of the other types of reactor under development, and there are many, the heavy-water reactor is seen to hold an outstanding position in this particular field of low-cost power generation in large power systems.

Our case, then, for choosing heavy water rests on two factors, its promise of low-cost atomic power and our confidence that the technology is within our grasp.

2.2 *Technical Background*

Since 1950 at Chalk River we have had a programme of collaboration with the U.S.A.E.C. and the Westinghouse Atomic Power Division (U.S.) under which we have irradiated, in the NRX reactor, uranium fuel assemblies from which the heat is carried away by very hot water under pressure. The temperature and pressure have been about the optimum for a heavy-water power reactor, to raise steam to drive the generators.

In these experiments we have deliberately provoked many kinds of breakdown, and found out how to recover from such situations. We can think up some awkward cases but are growing more and more confident that these can be made extremely unlikely, but, if they occur, the power reactor will not be out of commission for very long. It took us a year and we employed a large number of people to rebuild the NRX reactor after its accident in 1952, but NRX had not been designed for such operations and in any future reactor even a breakdown as extensive as that should be cleared in a few months.

That breakdown of NRX, incidentally, postponed a little demonstration we had planned. We were going to run a steam engine of 15 horsepower from the heat from one of these irradiation "loop" experiments, as they are called, in NRX. We have now abandoned this, because the time for such demonstrations has passed; so many water-cooled reactors have been applied to generate electricity in the U.S.A. and U.S.S.R. We are moving ahead on the much larger project of developing 27,000 horsepower or 20,000 kilowatts of electricity from the Nuclear Power Demonstration (NPD) reactor.

We have also demonstrated in these high-temperature systems in the NRX reactor how to extract enough power from the uranium to make the unit cost significantly less than that from coal. Some time ago we appreciated this was possible from results obtained in the ordinary uranium fuel in NRX, but this was not at the operating conditions for a power reactor. Only in the last year we have found it easily possible to extract the required amount of energy in a practical way from uranium oxide. This we will demonstrate on a significant scale in operating the NPD reactor.

2.3 *Cost Comparisons*

To appreciate the anticipated costs, we must, explore the costs in competitive systems. First we can use the conventional systems to set a standard. For large (base load) power stations as in Ontario burning coal at $8/ton, with the relatively low annual charges on capital appropriate to public utilities such as Ontario Hydro, power costs are estimated at about 5·4 mills per kilowatt-hour, of which the coal cost is about 3 mills. In about 6 years Ontario Hydro expects to have to generate about two million kilowatts in thermal as distinct from hydro power plants. Using coal for this, the annual payments for imported coal would be about $40 million a year. A fuel cost of 3 mills/kWh is thus seen to involve a significant annual budget.

In atomic-energy proposals we are mostly concerned with systems in which the "burn-up" of the initial uranium supply is in the range from a small fraction of one per cent to perhaps a maximum of 3 per cent. The *only* exception is in very long term (about 40 years) systems using fast-neutron, "plutonium-breeder" reactors. Table I shows relevant fuel costs for uranium at $20/lb. and 25 per cent thermal-to-electrical conversion efficiency.

TABLE I

Burn-up %	Contribution from fuel supply to cost of power mills/kWh
0·3	2·6
0·5	1·5
1·0	0·74
2·0	0·37
3·0	0·26

In the one exception I mentioned, the "plutonium-breeder", the burn-up may be 30 to 60% so the uranium supply cost would be negligible, but there are other costs and also a requirement for a large amount of plutonium or separated uranium-235 to start the system. Nobody is proposing the fast neutron breeder as a serious contender for economic power production in the next twenty years. There is a project sponsored largely by the Detroit-Edison Company in the United States following this route. If it succeeds it will provide for a few decades a market for plutonium at a higher price than others could afford to pay, so it is regarded as additional rather than competitive with the plutonium-producing reactors such as the heavy-water and the graphite reactors.

There is on the horizon another type of system which utilizes only a small fraction, perhaps 0·3 per cent, of the energy from uranium, but initiates a breeding cycle in thorium where the fissile material is uranium-233. This system also promises a large market for uranium in the first twenty years. Two of the most promising contenders on this route use heavy water; they are the homogeneous reactor of Oak Ridge and a reactor using rods of thorium oxide that we are studying.

Sponsors of the sodium-graphite reactor also talk of the thorium—U-233 cycle but the neutron losses in that type of reactor seem to preclude a net gain from breeding and a steady consumption of U-235 separated from uranium is envisaged.

Returning to Table I, it is apparent that if we are to compete with coal we must be interested in burn-up of more than 0·3 per cent, which is close to the limit that can be reached without either processing the irradiated fuel or enriching the uranium by isotope separation. Either of these introduces extra costs so a still higher burn-up must be aimed at.

Heavy water is a great help towards achieving this higher burn-up because it absorbs neutrons far less than any of the possible alternative materials. We use the neutrons that are saved to make new fissile atoms. Suppose we destroy ten atoms of U-235 but use the spare neutrons from fission to make nine atoms of Pu-239. We have all the fission energy from the ten U-235 atoms but we have only lost on the balance one fissile atom. We have, in effect, increased the attainable burn-up ten times. This can only be done by saving neutrons from being captured by other materials in the reactor. Heavy water captures so few neutrons that the loss is negligible.

Another way of looking at this is to note that for every neutron lost, it will be necessary to supply to the reactor from the fuel supply one new fissile atom. This enables us to set a value on neutrons and an irradiation cost on materials that absorb neutrons. I presented such a table of costs in my paper to the United Nations Conference on the Peaceful Uses of Atomic Energy held last year in Geneva; it is reproduced as Table II with the addition of graphite.

I would like to emphasize that these are the lowest costs and assume that we can get the new fuel into the reactor at a cost of $20/lb. of natural uranium. The unit of irradiation, the neutron/kilobarn, needs explaining; an example is given in the footnote to Table II—4 months (116 days) at 10^{14} neutrons per square centimetre per second, or say 2 months in NRU or a year in NRX, and most power reactors are expected to fall between these limits.

TABLE II

Material	Atomic Weight	Density (grams per cubic cm.)	Ability to capture neutrons (barns)	Irradiation Cost per neutron/kilobarn (*b*)	
				$ per kg.	$ per litre
Graphite (AGOT)	12·0	1·7	0·0048	0·58	0·99
Lead	207·2	11·37	0·17	1·3	15
Zirconium	91·2	6·50	0·18	3	19
Magnesium	24·3	1·74	0·06	3·6	6·2
Aluminum	27·0	2·7	0·22	12	32
Sodium	23·0	0·97	0·50	32	31
½ (Heavy water)	10	1·10	0·00046	0	0
½ (Natural water)	9	1·00	0·33	53	53
Iron	55·8	7·86	2·4	62	490
Stainless steel (*a*)	55·3	7·92	2·88	76	600
Nickel	48·7	8·9	4·5	111	990

(*a*) Composition 68% Iron; 18% Chromium; 10% Nickel; 2% Manganese; 0·8% Niobium; 1% Silicon.
(*b*) For example, 4 months (116 days) at 10^{14} neutrons per square centimetre per second.

It may be noted that heavy water at $28/lb. or $62/kg. is not extravagant as a coolant compared with ordinary water or sodium that can increase the fuel cost by this amount in less than a year of operation.

Table III is intended to present the basic costs of fuelling derived from the cost of fuel alone at the following prices

Natural Uranium	$40/kg.
Thorium	$40/kg.
Fissile Material High Price	$25/g.
Low Price	$15/g.
Credit on residual fissile material in irradiated fuel above the natural U-235 content in uranium.	
High Credit	$15/g.
Low Credit	$ 5/g.

The fuelling of the reactors follows the best proposals of the proponents as presented to the United Nations Conference at Geneva (1955), with the exception that the irradiation of natural uranium in the heavy-water reactor is half that proposed. If the author's proposal were accepted, the fuelling costs for this type, which already appear the most favourable of all, would be still smaller.

The designs for all reactors are no doubt capable of improvement, but allowing a fairly wide margin for this, it still appears that the heavy-water reactors have a clear advantage.

The actual fuelling costs are liable to be higher than indicated in the diagram and Table III because the cost of sheathing and making up assemblies of the fuel elements is unlikely to be negligible. There is room for much lowering of costs in this respect but current fuel manufacturing costs add between 0·3 and 2·5 mills/kWh to the cost of power. Since we require the total for all fuelling costs to lie well below that for coal, it is recognized that only the cheaper fabrication techniques can be employed.

TABLE III

Comparison of Fuelling Costs

—	Sodium-Cooled Graphite: Enriched Uranium (NAA)	Sodium-Cooled Graphite: U-235 + Thorium (NAA)	Gas (CO_2) Cooled Graphite Natural Uranium (G. 2 France)	Natural Water U-235 + Natural Uranium (PWR)*	Heavy Water: U-235 + Thorium	Heavy Water: Natural Uranium (ANL 100 MW)
Geneva Paper Reference	P/493	P/493	P/337	P/815	—	P/495
Thermal Power Megawatts	250	250	120	231	800	1000
Efficiency %	32·5	32·5	25	26	25	25
Electrical Output Megawatts	81·25	81·25	30	60	200	250
Total Fuel: Nat. U. or Th. Tonnes	24·3	9·74	100	11	53	39·4
Total Fuel: Extra U-235 kg	265	370	0	52	800	0
Fuel Inventory $/kW$_{EI}$: Low	$60·9	$ 71·3	$130	$ 20·3	$ 70·6	$6·3
Fuel Inventory $/kW$_{EI}$: High	$93·5	$115·6		$ 29·0	$110·6	
Fuelling Costs—						
Low Prices: Inventory Charges: Th. or Nat. U	·068	·027	·744	·042	·061	·036
Low Prices: Inventory Charges: U-235	·279	·380		·074	·343	
Low Prices: Fuel Supply: Th. or Nat. U	1·71	·437	2·225	·384	·134	1·33
Low Prices: Fuel Supply: U-235	6·99	6·062		1·82	·758	
Low Prices: Total	9·05	6·91	2·97	2·32	1·296	1·366
Low Prices: Credit—Plutonium	·187		·53	·149		·425
Low Prices: Credit—U-235 + U-233	1·645	1·71		·202	·237	
Low Prices: Net, mill/kWh	7·22	5·20	2·44	1·97	1·059	0·941
High Prices: Inventory Charges: Th. or Nat. U	·068	·027	·744	·042	·061	·036
High Prices: Inventory Charges: U-235	·466	·633		·124	·572	
High Prices: Fuel Supply: Th. or Nat. U	1·71	·437	2·225	·384	·134	1·33
High Prices: Fuel Supply: U-235	11·65	10·11		3·03	1·263	
High Prices: Total, mill/kWh	13·89	11·21	2·97	3·58	2·030	1·366
High Prices: Credit: Plutonium	·560		1·59	·447		1·275
High Prices: Credit: U-235 + U-233	4·935	5·13		·606	·710	
High Prices: Net, mill/kWh	8·40	6·08	1·38	2·53	1·32	0·091

Note: T = tonne = 1000 kg. kW$_{EI}$ = kilowatts of installed electrical generating capacity.

Moreover, the lesson to be derived from Table III is that fuel costs can only be low enough if the fuel irradiation, and thus the energy yield per gram of fissile material, is high. The use of heavy water makes this easier to achieve.

The choice of operating temperature and consequently the efficiency of conversion from steam to electrical energy, depends on an economic balance. If a high temperature is chosen, then the costs rise because of corrosion effects. In the presence of high radiation levels from radioactivity, corrosion costs are high, so the optimum temperature is lower than in power stations burning conventional fuels. It is not at all certain that the best practice even after many years will employ higher steam temperatures with water-cooled reactors. With gas cooling higher temperatures would be used. It is clear from the comparison between the sodium-cooled and the other reactors that high operating temperature does not necessarily confer an overall economy.

This comparison has omitted the liquid fuel reactors; these avoid fuel fabrication costs, but each reactor becomes a radioactive chemical plant. Costs of construction and operating radioactive chemical plants on this scale are difficult to estimate, but do not promise to be low within the next 15 to 20 years. It seems unlikely that fluid fuel reactors would be competitive within that time.

APPENDIX II

CANADIAN INDUSTRY AND ATOMIC ENERGY

by

J. L. GRAY

One of the major hurdles to early economic nuclear power is the applied engineering required in the design and fabrication of reactors and reactor equipment. Economic nuclear plants can be specified now, but until many of the technical fabrication problems are solved they cannot be built within the limit of funds that keeps them economic. The research scientist is, of course, still struggling with the problem of how to specify the *most* economic reactor. The engineering problems are mainly of a development nature and concern not only the more exotic tasks of producing nuclear fuels and fuel systems, but such mundane problems as welding, plating, and structural fabrication of large parts.

Although much engineering development work can be done by the staff at Chalk River, including the fabrication of test equipment, industry must build reactors and major reactor components. They face and will continue to face manufacturing problems beyond their experience not only in materials to be used but in size of pieces and complexity of fabricating procedures. The only logical approach to the combined problem of putting Canada in its proper position in the new field of nuclear engineering and of getting reactors and their equipment designed and manufactured, is to encourage industrial participation, and this the Company is doing, but with considerable difficulty.

It is clear that the Company cannot and should not engage in the manufacture of reactors or major reactor components since it would involve very heavy expenditure on plant which could not be used economically, and it would contribute nothing to the development of Canadian manufacturing industry. It is also clear that, in broad terms, Canadian industry is already equipped with tools and plant and with designers basically capable of undertaking this work. Taking industry as a whole, no vast expenditure would be required to acquire and house such production equipment as is not currently available.

The Company, and the Canadian reactor designer, is finding the greatest difficulty in bridging the gap between proven research results and the production of operating equipment at a reasonable cost. Many of the problems met in the design of reactors are beyond the existing knowledge of the engineers. They are faced with using new materials and little may be known about their strength, corrosion resistance, and how they react with other materials. Apart from their properties under normal conditions there is a similar series of properties under intense radiation that must be considered and which may be quite different. Materials that behave satisfactorily in a normal atmosphere may break down completely when located where there is considerable radiation. Many electrical insulating materials stop insulating under irradiation and are useless unless adequately shielded. The properties of materials under irradiation can really only be adequately ascertained at reactor test sites such as Chalk River, and active programs have been and are under way studying many materials.

Some power reactors require the design and fabrication of structural items such as pressure shells that are beyond anything that has previously been built. In addition to the pressure shell itself the requirement for many openings in the ends for rod-type reactors pose new and very complicated conditions.

The matter of moving radioactive liquids and gases under varying pressures from reactors to heat exchangers, boilers, or turbines has posed problems of pumps, valves, and expansion joints that have limitations many times more stringent than have ever been faced.

The designer normally refers to engineering handbooks or experience or basic design when facing new problems. However, when he finds that there is nothing in a handbook and the problem is beyond his experience and cannot be solved from basic principles, he talks over possible designs with a manufacturer. This is where Canadian industry falls short. The problems are beyond the normal industrial design office and can only be answered by actually building and testing equipment in an orderly fashion and by employing an experienced development group.

Without the assistance of qualified and experienced engineering development groups in industry, the designer is setting specifications that are either very difficult to meet in the shop or are ultra-conservative. In either event costs increase. This, of course, is not the only cause of expensive designs, lack of knowledge of the real limitations of reactor operations coupled with the general inexperience in this new field is producing designs that tax the manufacturers resources and techniques to the limit. The limits are mainly in size, coupled with accuracy and perfection of workmanship and the use of unfamiliar materials. Accuracy and perfection in large pieces is very expensive, particularly when, as in the case of the NRU reactor, it is achieved by trial and error. Normal costs of some fabricated steel parts for NRU were multiplied by ten. Development is sadly needed in Canada to establish fabrication techniques, many of which are already established in other countries. Such development work will show whether we are demanding more accuracy than is needed, and if not, find other methods of producing a satisfactory product.

Lack of fabrication experience cannot be clearly separated from lack of general engineering development resources and experience. One manufacturer, for instance, was asked to make some very accurate and somewhat complex parts for the fuel-changing mechanism for NRU. He had a suitable plant, capable of the accuracy required, but he clearly did not know how to use it to ensure success. Another manufacturer to whom this work was transferred had had the experience at someone else's expense and achieved the desired result without undue difficulty. This happy result is a more or less isolated case and development by expensive trial and error has been the rule.

One recognizes that development work is always carried out by industry at the customer's expense, but the lamentable fact that comes out of the NRU experience is that the potential education, which has been a very expensive by-product of the project, may have been lost to industry. By trial and error methods on the shop floor—and at no higher level—various individuals have learned very valuable lessons on the finer points of their trade and learned some new techniques which should be regarded by management as a general asset to their business, to be firstly recorded, maybe developed further, to be spread throughout their organization and even discreetly advertised as an achievement. The new techniques could then be used again when a similar problem arose or so that a new field of business could be entered, or an old reputation improved, or costs reduced. The technical problems have been surmounted with no noticeable recognition by management of the educational value of the exercise. They know it was expensive and took a long time, but, in general, give the impression of not wanting to do anything like it again. Only if the same personnel are available will they be able to do it again without all the same difficulties recurring and certainly the experience gained on this job is unlikely to be used to full value on any other. One knows of a welding foreman who learned the technique of almost perfect welding of aluminum without distortion, but the Company did not learn it, record it or propagate it. This foreman has now gone elsewhere to weld mild steel on a footage basis.

Apart from the aircraft and electronic industries there are no experienced development departments in Canadian engineering manufacturing companies. The reasons for the exceptions are not difficult to understand. In both aircraft and electronics, nearly all the products are developments in themselves and in the main are paid for as such so that a profit comes directly from the development effort. There seem to be several reasons why the engineering industry has no development organizations. With the abundance of raw materials, Canadian industry has not faced a requirement to conserve resources by developing new materials or new uses for old materials. It has been profitable to manufacture well-established lines of equipment often based on designs of a parent company. Usually these parent companies are located in the U.S. or the U.K. where the original development work was done in well-equipped and experienced laboratories. Other companies not directly connected with a foreign company with development facilities often purchase licensee rights to manufacture proven equipment. The Canadian economy has been growing so fast and so successfully that there has been little shortage of work for industry that can compete on a price basis.

The atmosphere of an abundance of work in a fairly competitive price field does not encourage expenditures on research and development as these increase costs on anything but a long-term basis. On the other hand, if the need is not recognized in times of prosperity, there is little likelihood of the expenditures being made in a recession—when the value of their past results could be greatest.

We have some special problems with which no one else has been confronted and which it would be unrealistic to expect industry to have yet tackled. But we should be able to lean on Canadian industry for many things which are closely allied to their normal business. We should, for instance, be able to assume that first-class welding will be done by just specifying it, we should be able to get first-class chromium plating done in the same way without purchasing the plant and doing the development work. One well known Canadian company with an American parent asked to be given some work involving aluminum welding and forming. Their management had been to the parent company which had these processes well developed. When shown a job involving this work already included in his NRU contract, he asked us, after examining the details, to find another contractor to carry it out. His explanation was that he was looking for what he described as ordinary commercial-quality work, he did not want this really high-class stuff.

The development department of a company is not just a few engineers and draftsmen working on special problems the design department does not have time for. One of the first essentials is that the Board and the Management should recognize the need for it and be enthusiastic of its promise. Development work should thrive on many initial failures and disappointments or it will not thrive at all. For this reason it must have the backing and enthusiasm of Management and they must give it work-shop and test facilities without regard to immediate return. The development department, if it is healthy, can never be over-loaded with problems, whilst a production shop will always be overloaded if it has one. A healthy development department will always be producing useful results, but, in terms of profit, they may take time to add up. With an organized and properly run development section, Management knows what the organization can do technically, what it cannot do and what it may sometime be able to do. Additionally, the development section which is competent, makes its mistakes relatively cheaply as compared to the production unit and the ill-informed designer. The customer does not have reason to think so badly about a failure if it occurred in the development shop. A development section is a good breeding ground and nursery for ideas and ideas are, after all, the basis of commercial profit and play a large part in national prosperity and prestige.

The obvious question to be posed—what is the Company doing about it, other than complaining? Gradual interest is being raised in some industrial firms and contracts for development work are being let. The main difficulty is convincing Management that a development effort is essential for their normal growth and existence. Anyone can take on a cost contract for development work and handle it with a special design group as an ad hoc problem. This approach does not produce satisfactory results. The company we would like to deal with is one that has a development section with a lot of rather expensive facilities and a desire to put them to work. They see the ultimate benefit of so-doing, not only in connection with reactors, but generally in respect to new materials and processes as applied to their present business.

We have contracted with the Canadian General Electric Company to design, develop and fabricate the NPD reactor. They have acquired a well qualified staff from within the company, from Chalk River and elsewhere and should produce a very good result. Although they have not organized a separate development group per se the experience gained in designing, developing and fabricating this reactor will be systematically recorded and available for future work in the company.

Canadair Limited have recruited a small staff in an atomic energy division and after a few months of preliminary design work have submitted a satisfactory fixed-price proposal for the complete design and fabrication of a small research reactor for Chalk River (PTR).

Canadian Westinghouse Company are actively engaged in their atomic energy division on a design and development contract with us for in-pile test equipment for the NRU reactor. This poses many new and difficult problems of reactor systems in miniature requiring ingenuity in design and prototype development and testing.

The Company is considering proposals by several organizations for the manufacture and supply of complete fuel elements for the Chalk River reactors. Such a contract contemplates development work on new types of fuel and fuel elements for use in existing and proposed reactors.

AECL will continue to encourage Canadian industry to enter the atomic energy field, to set up development groups and thus to undertake, not merely routine design and production, but also some of the applied engineering research which is essential to progress in this field. There are signs that some of the larger companies are becoming aware of the need for development groups, but until this outlook becomes more general, AECL will need to continue to do much of this work itself at Chalk River.

APPENDIX III

PHYSICS DIVISION

Director—Dr. L. G. Elliott
Staff —Professionals 54
—Others 60

Branches: Nuclear Physics I
Nuclear Physics II
General Physics
Theoretical Physics
Electronics

4·1 *Introduction*

Progress in the technology of atomic energy depends now as it did in the days of the wartime project, on progress in fundamental nuclear science. Research workers all over the world have been acting with vigour since the war to strengthen the flimsy scientific foundations on which the first practical achievements of atomic energy were based, and to stimulate further advances. But the primary goal of science is not to develop weapons or power sources or new industrial products; it is to understand nature. Its purpose is not to invent but to comprehend. Its most important products are not new devices but new facts and new laws concerning the behaviour of nature.

Nevertheless, the future strength and progress of technology depends on the present strength of science. Even ignoring the intrinsic value of research as an intellectual endeavour, the best and indeed the only way to ensure advances in technology and industry is to maintain an active program of basic science.

This conviction of the value of fundamental research is the chief motive behind the work of the Physics Division. Because of the nature of the Chalk River Project the Division's main interest is the atomic nucleus—to find out how it is put together and what forces operate within it. If we understand the structure of the nucleus we understand the whole basis of atomic energy and of matter itself. Equally important in the program are studies of the many elementary particles, particularly the neutron, which are the building blocks out of which nuclei are made and which interact in various ways with them.

There are additional and less obvious benefits arising from a vigorous research program at an establishment such as Chalk River. First, due to the international reputation that physics at Chalk River has achieved, our scientists can meet on equal terms with scientists from laboratories all over the world in many fields of atomic energy, and in fact can often get information from other countries that would not otherwise have been released. Second, the research atmosphere implied by such a reputation attracts top-ranking scientists and engineers to work on our staff. Third, our laboratories are a training ground supplying experienced research workers to Canadian industry and universities.

In addition to its program of fundamental research the Physics Division also carries out a considerable program of applied research and development for the rest of the Project in fields such as instrumentation and nuclear reactor theory.

These broad programs are pursued by a staff of 54 professional research workers assisted by 60 laboratory technicians, divided into five branches: Nuclear Physics I and II, General Physics, Theoretical Physics, and Electronics. Allocation of work among the Branches is not sharply drawn; for example, many General Physics professionals conduct experiments in nuclear physics, and most experimenters contribute to the design of their electronic equipment and to theoretical studies based on their work.

The following are examples of the work carried on by the Physics Division:

4.2 *Nuclear Structure*

The most generally used method of studying atomic nuclei is to bombard them with other nuclear particles such as protons or neutrons, and observe what happens to both the target and the projectiles. The hits, misses, and near-misses all supply information about the structure of the nucleus and the forces holding it together. Chalk River like many other laboratories obtains some of its bombarding projectiles from a particle accelerator, in this case an electrostatic generator of the Van de Graaff type, built by the National Research Council. It generates potentials up to 3 million volts to accelerate charged particles (usually protons) to speeds high enough that they can penetrate target nuclei of many elements. This type of accelerator, while not capable of producing energies as high as a cyclotron, is best suited to the high-precision studies that are the speciality of our group. Two low-voltage accelerators are also available for special experiments; one staff member is stationed at McGill University where he uses the high-energy cyclotron to measure neutrons produced by bombarding heavy elements with protons.

Another method of investigating the energy levels of nuclei is to observe the beta-rays (electrons) emitted spontaneously when radioactive atoms decay. Beta-decay is studied chiefly with an instrument known as a beta spectrometer. Probably the best-known physics research at Chalk River involves the simplest of all examples of beta decay, when a neutron decays into a proton by emitting an electron. The half-life of this fundamental process (12½ minutes) was measured for the first time at Chalk River, and the experiment has since been extended to measure the angles at which the particles resulting from the decay are emitted.

A third method of probing nuclear structure, and one for which Chalk River is particularly well-known, allows a beam of neutrons to strike the nuclei being studied. A nucleus may capture one of the neutrons and immediately give off a gamma ray (a high-energy x-ray). These "neutron-capture gamma-rays" yield important information about the detailed structure of the resulting nucleus.

4·3 *Other Experimental Studies*

Cosmic rays provide a natural source of many elementary particles which are difficult to produce in the laboratory. Many of these particles strike the earth's atmosphere with energies much higher than particle accelerators can attain. For some time we have maintained a mobile laboratory at a high-altitude station in Colorado to measure the yield of neutrons produced by very high-energy cosmic-ray protons on heavy-element targets. Another section is studying the meson, one of the elementary particles found in cosmic rays.

One group is conducting an intensive investigation into the physics of the fission process, not only with well-known fissionable nuclei such as uranium but also with recently discovered artificial elements such as californium. Measurements have been made of the neutrons associated with the heavy and light fragments that are always produced when a nucleus undergoes fission.

Another section has undertaken a theoretical study of thermonuclear reactions that produce large abundances of heavy elements in stars. This work, which is still underway, has proved to be an important contribution to the field of astrophysics.

The Radioisotopes Standardization Section collaborates closely with the National Bureau of Standards in the United States and the National Physical Laboratory in England to establish and maintain standards for radioactive nuclides. This work calls for great precision in a variety of experimental techniques to obtain absolute disintegration rates, neutron capture cross-sections, half-lives, fission yields, etc.

A unique and important new technique was developed at Chalk River for unravelling the complex properties of solids and liquids, such as their molecular structure and the dynamics of their molecular motion. It uses a beam of neutrons from NRX in a manner similar to the use of x-rays in diffraction studies, and has not yet been duplicated anywhere in the world. Because of the availability of a helium liquefier it has been possible to extend neutron diffraction techniques to a study of liquid helium, a substance whose peculiar properties give it special theoretical interest.

The helium liquefier also makes available temperatures approaching absolute zero for other experiments, including studies of the process in which positrons and electrons combine to annihilate each other. The speed of this process and the gamma rays resulting from it have been investigated in great detail, and Chalk River physicists discovered a hitherto undetected effect.

4·4 *NRX Experimental Facilities*

A number of the experiments listed above as well as others not mentioned were made possible only because of the unsurpassed facilities of the NRX Reactor. It provides broad, intense beams of neutrons at ports around its outer face enabling experiments to be done that have not been duplicated at any other laboratory. This remarkable piece of equipment therefore influences strongly the experimental program of the Physics Division, and plans are well underway to use the new NRU Reactor similarly.

4·5 *Theoretical Physics*

This branch applies part of its effort to problem of reactor design and other matters of immediate interest in the development of atomic power, and part to fundamental research. Most staff members assist in interpreting the results of experiments done in the other branches of the Divisions and in designing new experiments, as well as engaging in independent theoretical investigations. In all this work extensive use is made of large, fast electronic computers to obtain results that would otherwise take months or years to calculate by hand. A small staff is stationed at the University of Toronto Computation Centre to supervise Chalk River problems being solved on the "Ferut" computer, but the Branch will soon install its own machine at Chalk River to handle the increasing load of computation carried out as a service to all Divisions of the Project.

In this connection it is interesting to note that because the results of most experiments in nuclear physics consist of vast quantities of numerical data, they are difficult to interpret without the assistance of machine-processing and electronic computing. The Physics Division is one of the pioneers in applying modern methods of automation to the laboratory, with punch-cards and other data-processing tools forming an integral part of the experimental equipment; it has established a committee to follow new developments and recommend new methods.

4·6 *Applied Research and Development*

As a service to the rest of the Company, the Physics Division maintains a Counter Development Section which not only develops but manufactures a variety of geiger tubes and other radiation-detecting devices for special purposes. Demand for some of these has proved so great that Canadian industry has taken over production of our designs on a large scale.

In the early days of the Project the Electronics Branch was faced with the necessity of designing a wide range of electronic instruments to satisfy the needs of the Project. Because most of the circuits developed then are still satisfactory, the current program emphasizes conversion to instruments that are more reliable, compact, and that consume less power. These improvements are possible because of the availability of new components such as transistors and cold-cathode tubes. They are necessary because only the greatest possible reliability can be accepted for the instruments which control complex and expensive equipment such as nuclear reactors; compactness and low heat-generation are becoming necessary because of the large amount of electronic instrumentation required by even simple laboratory experiments.

Whenever possible, instruments designed and developed at Chalk River are manufactured under contract by outside companies, and are often catalogued by the manufacturer for sale on the open market. The Electronics Branch in co-operation with the Counter Development Section has also assisted the Department of National Defence in designing radiation detection devices for the Armed Forces and Civil Defence. In these ways the special knowledge and skills of the Division are made available to other Canadian organizations.

4·7 *Conclusions*

This selection of examples, representing only a part of the total program, make it clear that the Physics Division has contributed greatly to Canada's scientific reputation in the past and is continuing to attack the fundamental problems posed by nature. As to the future, no scientist can predict the results of his work; if he knew these in advance his experiments would be unnecessary. It is probably true to say however that most scientists working in atomic energy have in their minds the hope of eventually discovering a method of releasing the vast store of energy in the nucleus still untapped by the fission process. If we can learn how to break down heavy elements into fragments smaller than those produced by fission, or tame the thermonuclear process by which heavy elements may be built up from lighter ones, then energy will be available tens or hundreds of times greater than even nuclear fission provides.

APPENDIX IV

REACTOR RESEARCH AND DEVELOPMENT DIVISION

Director—Dr. G. C. Laurence
Staff —Professionals 35
—Others 30

Branches: Reactor Physics
Nuclear Engineering

An important part of our research at Chalk River is directed towards the design of nuclear reactors. It receives the full attention of the Reactor Research and Development Division, and other Divisions participate in it.

The research and development effort required for the many problems in the design of new kinds of reactors is very great. It will account for a large part of the cost of the first nuclear-electric power stations. Later, when additional reactors of a similar kind are built, the high development costs can be avoided, and only then will economical nuclear power be realized.

Some of the research carried out by the Division is concerned with fundamental neutron physics and it is hoped it will lead in time to a more complete understanding of the complex processes which take place in the core of a nuclear reactor. However as soon as one becomes concerned with a particular kind of reactor for a particular purpose, many engineering problems arise which are peculiar to that system and which require a great deal of development work. Perhaps the best way of explaining the nature and purpose of reactor research and development is to describe how the design of a reactor grows from its first conception. The design of NRU is a good example.

A few years after NRX came into operation it was realized that a new and more powerful reactor would be required if we were to keep pace with rapid advances elsewhere, and if we were to develop atomic energy for the production of electric power in this country. The senior scientists and engineers discussed the type of reactor required. After considering various possibilities it was decided that the reactor would be moderated and cooled with heavy water. It would use natural uranium for its fuel. It would be designed for a power output of 200 megawatts and a neutron flux of 3×10^{14} neutrons per square centimetre. It would produce about 50 kilogrammes of plutonium per year.

We were confident that these objectives could be accomplished, but we did not know in detail how this would be done. The first step, therefore, was a feasibility study. The staff was reorganized to bring together in one division those who would carry out this preliminary study and determine how the basic design requirements might be met. They included many of the staff of this present Division, a small group of mechanical engineers and draftsmen under Mr. I. N. MacKay, and a small group of metallurgists under Dr. M. J. Lavigne which was assigned by the Department of Mines and Technical Surveys to assist our Company.

The feasibility study began with calculations to determine the conditions necessary for the release of nuclear energy in the reactor. The approximate size, specifications and performance of the important components were calculated. Outline drawings were made of important parts. The more novel parts were considered in more detail. The approximate cost of the plant was estimated.

At the end of the year we were able to recommend to the Government that a complete and detailed design should be undertaken.

A contract for the detail design was let to the C. D. Howe Co. Our staff, however, continued to play an important part. First, we instructed the engineers of the C. D. Howe Co. in the special technology of nuclear reactor engineering. Secondly, we contributed directly to the design where our special scientific training and experience was required. Thirdly, we carried out much of the necessary research and experiment. Our fourth major contribution will be in experimental work in bringing the plant safely into operation.

The first important problem in the design of NRU was how to cool the uranium so that it would not be damaged or melted by the great heat released by nuclear fission. This could not be done if the uranium was in thick round rods, as it is in NRX. The uranium in NRU is in flat strips about ¼″ thick. It must be cooled under conditions that are far outside the range of the usual engineering experience. There was no past experience to tell us how the cooling water would flow around these bars and what size of pumps would be required to make it flow. An experimental rig was constructed containing five of the uranium bars, and the pressure and power required to circulate the water between them was actually measured.

In these experiments it was found that the flow of water caused the bars to vibrate in a manner that would probably lead to trouble. It was found that the distribution of the flow from the end of the tube containing the rods changed erratically in a troublesome manner. These faults were overcome by slight changes in design which were found by trial.

Since the design was so different from common engineering practice we could not rely entirely on calculation to be sure that the cooling would be adequate. Preliminary small scale experiments in our own laboratories gave us confidence to proceed with the design. Later the National Research Council in Ottawa which is better equipped for this difficult type of experiment, carried out a more thorough investigation. These tests indicated that the rods would be kept sufficiently col to avoid trouble.

It was found, however, that the aluminum covers on the uranium bars do not press firmly against the uranium. We wanted to be sure that this would not lead to other troubles when they were used in the reactor. For this and other reasons a few rods of this type were manufactured and used in the NRX reactor. So far no serious troubles have been encountered. Tests of this kind are continuing and may lead to further improvements in the design of the rods.

The possibility of releasing atomic energy depends on many factors. It depends critically on the number, size, shape and distance apart of the uranium bars. If these details are not right the reactors will not operate. The required conditions and dimensions for the NRU bars was first determined by calculation based on our knowledge of the behaviour of neutrons and of the properties of atoms—information and data that come from fundamental research in nuclear physics of the kind that is done by the Physics Division. The calculations enabled us to fix the dimensions and shape of the uranium bars approximately so that we could proceed with other details of the design. However, it could not be accurate enough to settle the design exactly. That was done by experiment. When sufficient numbers of the new design of uranium bars had been manufactured they were put in the ZEEP reactor. Thus ZEEP became an experimental model of NRU. It was operated at a very low power. Tests were done to find the best spacing and arrangement of the bars. Many other features of the design of NRU have been tested in ZEEP n this way.

Another important question is the amount of concrete and other shielding that would be required around NRU to protect us from the unhealthy radiation. This also was calculated from atomic data obtained from fundamental research, but the calculations are very complex and approximate. To obtain such information that could be applied more directly and more surely in calculating the shielding requirements for NRU, careful measurements were made of the penetration of radiation through the shielding of the NRX reactor.

An important problem in the design of NRU was the mechanical provision for the replacement of the uranium fuel bars. There will be nearly a thousand bars in the reactor, divided into groups of five bars each. Each assembly of five bars is replaced through a separate hole in the top of the reactor. The holes contain a complicated mechanism to seal the hole under normal operation and to permit removal of the five bars when required. The space in the hole is very small, and it was very difficult to design a mechanism that would fit in it and yet be durable and strong so that it would not break down and wear out. Moving parts can not be lubricated with oil and grease because these materials are rapidly destroyed by the radiation in a reactor. Several designs were worked out in detail before we were satisfied. When the first of the mechanisms was completed it was tested in an experimental rig built for this and other tests in our Engineering Laboratory. We were very pleased to find that the mechanisms operated entirely satisfactorily—but it would have been very rash to complete the manufacture of the whole order of 200 without making these tests.

The power output of NRU will be regulated by moving bars containing cadmium, called control rods, in and out of the reactor. The mechanisms for moving the control rods were also difficult to design owing to space limitation and lack of lubrication. The first control rod has just been tested and found to be satisfactory.

The experimental equipment in which these tests are made is large, complicated and costly. It illustrates why development takes so much time and effort and adds so much to the cost of design of a plant of a kind which has not been built before.

A very important part of our development work is what we call loop experiments. In these experiments we investigate the behaviour of fuel bars and cooling liquids under the very severe conditions that exist in the reactor. Owing to these conditions fuel bars that have been fabricated by a new method, or fuel bars of novel design or composition, may change in shape, swell or split after a short time in the reactor, or their protective sheathing may be penetrated by corrosion. New operating conditions for the cooling liquid such as high temperatures or pressure may lead to corrosion, deposition of corrosion products where they are not wanted, or chemical breakdown of the liquid. Faults of this kind in the design can only be found by actual experiment in a reactor. The fuel bars to be tested are placed in NRX. Each is provided with its own cooling system, with pumps and heat exchangers and its own instrumentation. The complete assembly of equipment, which is called an experimental loop, might be described as a reactor within a reactor. NRX is particularly suitable for this type of experiment and the United States Atomic Energy Commission and the United Kingdom Atomic Energy Research Establishment are permitted to use some of its facilities under arrangements of collaboration that are advantageous to them and to us. Better facilities for loop experiments are being provided in NRU.

The development of special instruments is an important part of our work. For example, an instrument was required that would detect and give warning if the protective aluminum covering over the uranium bars leaked. Leakage would permit the cooling water to come into direct contact with uranium producing rapid corrosion and resulting in the spread of radioactive material throughout the whole cooling system. Two new instruments were devised and developed for this purpose and they are being tested in NRX.

Two other instruments have been developed to give early warning of leakage of ordinary water into the heavy water so that leaks can be found and stopped before the heavy water becomes badly diluted.

The development work for NRU included many other experiments, tests and studies. It included tests of the corrosion of various alloys under conditions that will occur in operation, the development of methods for making and cladding the uranium bars, the design of the protective equipment and circuits, and the testing of various mechanical components. Some of these investigations are reported in chapters dealing with the work of other Divisions. Where possible, development work has been done for us by other organizations and by private industry under contract.

We expect that in the future much development work of this kind will be done by private industry. For example, Canadian General Electric Co. is preparing to do a large part of the development work for the new reactor, NPD, which they cannot do because it requires the use of powerful research reactors like NRX and NRU will be done for them at Chalk River.

As a general policy the participation of private industry in nuclear-energy development is encouraged. Development contracts are arranged with other companies for projects which they are competent to undertake. We are endeavouring to assist them in becoming familiar with nuclear-energy technology. However, Canadian industry, with some exceptions, is not yet well prepared with equipment and staff for development work. It relies on parent companies in the United States and in the United Kingdom. Also there is a shortage of engineers in this country with training and experience in research.

There are some aspects of nuclear-energy development that will probably not be undetaken by private industry, but will continue to be an important part of the work at Chalk River. Research that requires large research reactors like NRX will be done at Chalk River. Moreover private industry may not feel prepared to undertake research of more remote application. It will be left to Chalk River to give attention to longer-term projects with a broader interest in future progress.

Our effectiveness has been lessened recently by the loss of some of our most experienced men to help private industry. The situation will be eased as younger men gain experience. But we, like private industry, and like Government departments, are having difficulty in finding young engineers with ability and training for research.

APPENDIX V

CHEMISTRY AND METALLURGY DIVISION

Director—Dr. L. G. Cook	Branches: Research Chemistry
Staff —Professionals 75	Development Chemistry
—Others 82	Chemical Engineering
	Fuel Development
	Metallurgy Research

The Chemistry and Metallurgy Division is concerned with the investigation of

i) construction materials to withstand the peculiar conditions in reactors,
ii) fuel materials to withstand the strenuous thermal and mechanical stresses to which reactor fuel is subject,
iii) chemical techniques and processes for the recovery of unburned fuel and of other useful by-products.

Since this technology is completely new in many aspects, the basic information is often non-existent. Hence a broad program of pioneering fundamental research is an integral part of the program.

6.1 *Construction Materials*

The chief materials used for the construction of reactors have been aluminum and its alloys, stainless steels, and zirconium alloys, because of their good nuclear properties, strength and corrosion resistance. However it is known that the strength and sometimes the corrosion resistance of these metals is altered by exposure in reactors, and in ways that are not understood and not yet predictable. Nor is it good enough just to "try it and see"; this approach can be both expensive and misleading.

Three basic studies of these effects are in progress. The first has confirmed that with certain aluminum-magnesium alloys relatively short exposure in a reactor will increase the strength by a factor of two. The second has shown that even with relatively inert metals such as platinum peculiar effects occur. The third study is aimed at learning more about the basic reasons for the effects. If one looks at a large crowd of people from a great distance it may appear fairly static even though on close examination the individuals in it are running around violently and continuously bumping into each other. So it is with metals and the atoms of which they are composed; and when exposure in a reactor changes the properties of the metal, it must be basically because of some interference or changes brought about in this internal atomic bumping. So studies of the details of this bumping are very important. The use of reactor-produced radioactive isotopes is of particular help, since they can be used to "tag" certain of the atoms, and to follow them specifically as they bump along. This technique is being applied to platinum.

Although not exactly materials of construction, graphite, heavy water, and light water are necessary in certain types of reactors. Graphite is subject to changes in shape, size, and strength of the sort just described; in addition continued irradiation in a reactor seems to build up a store of heat in the graphite, which under certain circumstances can be suddenly released raising the temperature of the graphite several hundred degrees. This can be embarrassing to say the least. A basic study of these effects on graphite is being made. As to water, the important effect which occurs is decomposition of the water to hydrogen and oxygen gases. A continuous program on various aspects of this decomposition has revealed that under certain practical conditions the effect can be reduced effectively to zero. However a small residual decomposition is always found due to corrosion of the metal parts of the system. This has directed efforts to the corrosion problems.

At present aluminum is favoured for the main structural material in the cores of research reactors, and zirconium alloys in power reactors — since aluminum corrodes rapidly at the high steam temperatures necessary for power generation. For both kinds of reactors stainless steel is used for piping and tanks outside of the reactor itself. But zirconium is an expensive metal and if an aluminum alloy could be found which would stand up to power reactor conditions it would be very valuable. Two such alloys with some promise have been found and a program of test and development is under way.

6.2 *Fuel Materials*

Although the basic fuel for reactors is uranium, it may be actually used in many shapes and forms. For example it may be as uranium metal rod as used in the NRX reactor, or it may be as uranium oxide pellets as planned for the NPD reactor, or it may be in the form of alloys with small additions of molybdenum, silicon, etc., to the uranium metal, or it may be in the form of aluminum, zirconium, or stainless steel base alloys with a little uranium or plutonium in it, or it may be as uranium oxide dispersed in aluminum, or uranium metal spheres imbedded in magnesium, etc., etc. No matter what the form, since the heat is produced in tremendous quantities within a small volume of fuel the temperature variations produced in the material cause large mechanical stresses to be set up; in addition the fuel suffers from the same kind of irradiation damage to its properties as the structural materials but much more severely. For example uranium fuel rods have been observed to lengthen by 4 in. in 10 feet after relatively short periods of operation. A continuous program of preparation and testing of improved types of fuels is carried on.

6.3 *Fuel Processing*

After the fuel has become useless either because of mechanical or corrosion failure, or because of the accumulation within it of too much nuclear ash, the fuel must be removed from the reactor and either stored safely, or processed for by-products. The chief by-product is usually un-burned fuel, which, if it can be recovered cheaply enough, is useable again. The radioactive ash materials are still mainly unwanted and dangerous nuisances, though undoubtedly a market for some of them will develop.

Because of the intense radioactivity in the spent fuel, the examination of the fuel elements to study the causes of failure is in itself a difficult operation. To do this a concrete trough is used, with thick windows in the sides, and with artificial remote-control hands, periscopes to see over the walls and other like equipment.

Since the radioactive ash is distributed throughout the uranium, and not just on the surface as is usually the case with coal lumps, a simple shaker or such will not separate it from the fuel. Rather the fuel has to be melted or dissolved and chemical techniques used. If dissolving is chosen, as has been general in the past, a number of chemical separation methods may be used of which the more important are known as solvent extraction, precipitation, and ion exchange. All of these have been studied and used on both laboratory and pilot-plant scales. The use of melting instead of dissolving, and subsequent separation by distillation, or by metal extraction is relatively new in concept, and most of the work so far has been on the laboratory scale. However pilot plants are planned in connection with projects in other countries and it may well be that with increase in importance.

The development of specialized equipment for use in plants handling radioactive material is of particular importance. Such plants, once they have gone into service become difficult if not impossible to repair or service. Equipment which may be perfectly satisfactory in most ordinary plants may be nothing but a continuous problem in a radioactive plant. The careful engineering thought and planning required has to be of top quality.

Finally, the radioactive ash has to be disposed of in a manner which will guarantee that it remains intact and unavailable to harm living organisms, for hundreds of years. The standard method heretofore has been storage in tanks, with continual monitoring for leakage. However other methods such as baking the materials into clay or glass, for readier storage in vaults or caves are being studied.

An important aspect of the work is the assessment of the interplay of all these factors from a cost standpoint in order to be able to concentrate effort on those items which appear to be placing the most difficulty in the way of cheaper electrical power from uranium power stations. A cost estimating group keeps these factors under continuous review.

6.4 *Other Investigations*

There are a few aspects of the work which although slightly more abstruse, are of special importance.

The heat generated in uranium reactors comes from the splitting of uranium-235 atoms by neutrons. Many important aspects of this splitting process are still imperfectly understood, and a continuing program of study is maintained. The heavier uranium-238 absorbs neutrons to form a whole series of previously unknown elements—nine to date. These are all present in spent fuel; some of them have fissionable isotopes and therefore count as fuel; all nine have different chemical and metallurgical properties. A program of preparation and study of these elements is maintained.

Uranium occurs as a blend of three different kinds (isotopes) of uranium, which differ mainly in their density. Likewise plutonium and all the other nine new elements occur as blends. Whereas in nature elements like iron, which is a blend of four different isotopes of iron, occur blended in the same proportions no matter what mine the element comes from, this is not so with the elements formed in a reactor. Every sample is differently blended. Thus although a chemist may weigh a sample of iron and be reasonably sure he knows what he is doing, this is not the case with these artificially produced elements—nor indeed even with uranium or iron or other element if it has been put through an isotope separation plant to alter the blend. A blend analyser, known as a mass spectrometer, is essential and a continual program of improvement and construction of these machines is maintained.

Another important program is the study of the estimation of very small amounts of radioactive materials. Special techniques are needed and are under continual development. This pays off in many ways. The air around us contains small amounts of radioactive material all the time, both as a result of the uranium which exists in the earth and in rocks, and also as a product of reactions in the upper atmosphere caused by cosmic-ray particles which approach the earth from outer space. Added to these there are now small amounts of radioactive ash from atomic-bomb explosions. One of these ash materials, strontium, is particularly poisonous to life, since it is chemically like calcium and concentrates in bones. A co-operative program is under way with the Department of Health and Welfare to make a survey of the minute amounts of radioactive strontium from bomb debris now present in milk at various points in Canada. These low-level techniques under another name, that of activation analysis, form the most certain and sensitive method for analysing for traces of many elements, that exists This is making the method of particular interest in many newer industrial problems.

There are many other problems being studied, most of which are in the nature of detailed application of these special techniques to problems of special interest either here, or elsewhere.

APPENDIX VI

BIOLOGY DIVISION

Director—Dr. C. A. Mawson
Staff —Professionals 20
—Others 74

Branches: Radiation Hazards Control
Health Physics
Biology

7.1 *Introduction*

The Biology Division has broad responsibilities ranging from fundamental research to supervision of safety precautions.

The Radiation Hazards Control Branch is responsible for the day-to-day safety of our workers and gives advice on the design and operation of equipment both within the Plant and for outside organizations. The Health Physics Branch carries out research on instruments for measurement of radioactivity, mainly in relation to health hazards and investigates the mechanism of decontamination procedures. This Branch also acts as a general consultant on such problems and within our own organization is responsible for services such as the Film Badge system and the investigation and safety control of waste disposal. The work of the Biology Branch is devoted to arriving at an understanding of the basic reasons for radiation damage in living tissues, and to the application of radioactive isotopes in physiological and biochemical research. Cooperative work with Government Departments is carried out beyond the borders of the Plant.

7.2 *Radiation Hazards Control*

In an Atomic Energy plant men have to live and work with sources of radiation which are so active that a constant watch must be kept on methods of work and on equipment to prevent harm to men or reduction in the efficiency of operations.

The protection of personnel is the most obvious function of Radiation Hazards Control. Surveyors and Monitors are always available when operations are being carried out which could give rise to over-exposure of personnel. This is very necessary in a plant where the most serious perils can be neither seen nor felt. A man could be carrying out a technical operation which he had done many times before without a hitch, but because of the unnoticed displacement of a piece of shielding or an undetected failure of a ventilation system, he could be exposed to radiation without having any idea of his danger. Monitoring services provided by Radiation Hazards Control keep a constant watch for such situations and the people working with active materials are dependant upon the vigilance of these men for their safety. If an accident should occur the evidence provided by the monitoring staff would be vitally necessary for determining the cause, and the advice of the Branch would be of great importance in the revision of procedures to ensure that such circumstances should never arise again.

In the operation of an atomic energy plant which is carrying out a routine process with which everyone is thoroughly familiar the provision of monitoring services will always be necessary because accidents can always happen even on the best-regulated production lines At Chalk River, so much of our work is experimental that new and unexpected situations are likely to occur frequently However carefully hazards are considered during the design of new experiments the true magnitude of the hazard can sometimes be measured only when the experiment is being carried out. This means that the staff of the Radiation Hazards Control Branch must be constantly on the alert and capable of dealing promptly with incidents which they have not been able to anticipate.

Protection against amounts of radiation dangerous to health is not the only duty of Radiation Hazards Control staff. When radioactive materials are being handled, there is always the possibility that minor spills and small amounts of personal contamination will occur which are not really dangerous to the workers but may seriously interfere with the operation of the plant. This is because there are many delicate measuring instruments which depend for their accuracy on a low level of general "background" radiation, and if minor contamination were allowed the "background" would gradually rise and the instruments would eventually become unusable. A great many experiments depend upon the use, detection and measurement of minute amounts of radioactive material and a very little contaminated dust falling into apparatus or reagents used in such work could completely ruin the experiment This is one reason for the constant checking of laboratory surfaces, corridors, floors and plumbing systems for amounts of contamination which at first sight seem unimportant It must also be realized, of course, that people live and work in the laboratories and shops and any rise in the general background might well result in a gradual increase in the amount of radiation to which workers are subjected, both externally and by absorption into their bodies. Only excellent housekeeping habits can obviate this danger. It is the duty of the Radiation Hazards Control Branch to ensure that the housekeeping is sufficiently good.

The Radiation Hazards Control Branch is responsible for operation of a Decontamination Centre. This is an operation of very great economic importance to the Plant. In the ordinary course of work valuable apparatus becomes contaminated with radioactivity and if it is to be used again it must be cleaned up. To decontaminate a vacuum pump or a complicated piece of chemical or electrical apparatus is a highly skilled job which requires the services of specialists and special equipment. The owner of the apparatus could sometimes decontaminate it with much effort and expenditure of time, but without the special equipment and knowledge assembled in the Decontamination Centre he might very well contaminate himself and his laboratory in the process. During the past year $400,000 worth of equipment was decontaminated and put back into service by this section.

The breathing of contaminated air is a likely route of entry of radioactive material into the body, and it is necessary that the respirators supplied to people working in the presence of air-borne radioactivity should be in first class order. Respirators are serviced and tested by Radiation Hazards Control, who are also responsible for decontamination of the protective clothing and rubbers which are worn by workers in the active areas.

7.3 *Health Physics*

Much of the special equipment used by Radiation Hazards Control has been designed and developed by the Health Physics Branch. Instrumentation is a rapidly developing art and the needs of different Atomic Energy Projects are not entirely similar, so that commercial sources of instruments cannot be relied upon to anticipate and supply all our requirements. Different projects tend to develop instruments for their own specialized purposes and in doing so frequently produce devices which are of interest to others. Several devices developed by workers in the Health Physics Branch have helped to solve problems common to ourselves and other Projects.

It is the duty of the Health Physics Branch to take a long-term view of hazards likely to arise in the Company's work. In the design of plant and the planning of operations the advice of the Branch is sought to ensure that all possible precautions are taken, and the measuring devices for detection and control of hazards are chosen and located with the assistance of Health Physics personnel.

The advisory services are available not only to this Project but also to other organizations with unusual radiation problems. We have co-operated closely with the Department of National Health and Welfare and with the National Research Council. Guidance on technical problems has been given to the Armed Forces and to Civil Defence, and training courses have been provided for these Services. Investigations have been carried out to estimate hazards in uranium mines and instruments have been designed by the Branch to be used in this work.

All workers in the Plant wear film badges to record any exposure to radiation. The reading of these films and the standardization of film-reading methods and instruments are carried out by the Health Physics Branch.

Investigation of the Waste Disposal System is another part of the work of the Health Physics Branch. Part of the radioactive waste products which arise during the operation of the plant are in such dilute form that they cannot be economically stored or concentrated. Some of these wastes are so dilute that they can be safely bled into the river, while others are put into the ground in the Waste Disposal Areas. Radioactive isotopes are adsorbed by the soil and any movement which does occur is slowed down, giving an opportunity for radioactive decay. However, these two methods of disposal have to be carefully watched and the Health Physics Branch employs an ecologist who investigates the uptake of traces of radioactive material from the river into fish, animals and plants. He also tests the trees and plants in and around the disposal areas and his results are used as an index of any movement of radioactivity in the part of the soil reached by the roots. A soil chemist investigates the efficiency of the local soil for adsorption of radioactive elements, and he checks the movement of wastes below the surface soil horizons by deep drilling to bedrock. The holes are constantly checked with counting equipment and the soil removed during drilling is analysed in the radiochemical laboratory of the Health Physics Branch. This laboratory also estimates radioactivity in river muds and in water taken from the river, from creeks near the disposal area, and from various drains and tanks in the Plant. Constant vigilance of this kind enables us to be sure that our operations are not causing significant radioactive contamination outside the disposal areas.

Looking to the future, when wastes from power piles have to be dealt with, our soil chemist is working on a method for synthesizing fission products into micas. If this research is successful it should give us a material which will resist leaching by water and will only be weathered over geological periods of time.

7.4 *Biology Research*

The work of the Biology Branch is mainly concerned with research, though many of its activities have practical implications either now or in the future. The Branch carries out work on the use of radioactive isotopes in biological investigations, and studies the nature and consequences of radiation damage to cells and tissues.

The work with radioactive isotopes has led to close co-operation between the Branch and Government scientific departments concerned with forestry and entomology. We have assisted the staff at the Petawawa Forest Experiment Station in tracing the movement of sap in pines, birches, and maples by injecting radioactive material into trunks and roots, and similar work on this subject and on calcium metabolism is planned for the coming summer. Marking of insects with radioactive isotopes to trace their movements has been done at Petawawa, and similar work will be done this year at the Forest Insect Laboratories of the Department of Agriculture at Sault Ste. Marie and Fredericton.

In our own laboratories we have been studying the significance of metals in animal nutrition. Traces of certain metals are essential to life and they are often present in such small amounts that analytical work by conventional methods is difficult. It is often of interest to find out how rapidly trace metals move into and out of animal tissues and this can only be done by use of radioactive isotopes. We have found that zinc is much more concentrated in the prostate gland and parts of the intestine than in most other parts of the body and that it moves rapidly into and out of these organs. One of the first effects of zinc deficiency is male sterility, and we have been able to show that this is due at least in part to failure of the pituitary gland to produce certain hormones.

The Biology Branch has been working on two main aspects of radiation damage. These are, firstly, damage to the body of an individual exposed to radiation and, secondly, damage to the germ cells which causes no inconvenience to exposed individuals but which can be handed on as hereditary changes and may affect their descendants.

The ultimate aim of investigations on bodily damage must be to find methods of prevention and cure, and in order to attack this problem we want to know a lot more about the very great differences in sensitivity to radiation of various forms of life. The adult Dahlbominus wasp can usually survive 200,000 roentgens of X-rays, whereas 500 roentgens is likely to be fatal to a man. This difference might be due to the presence of a protective chemical substance in the insect, or to the fact that cell division does not occur so often in insects as in man. We are working with three different species of insects to discover the reason for their high resistance to radiation.

The mechanism of the killing of cells by radiation is probably similar in all forms of life, and it is sometimes possible to simplify problems by studying the simplest forms of life. We have investigated a certain bacterium which is killed by unusually small doses of X-rays and it has been found that the reason for this is that the bacterium is infected with a virus which multiplies in an uncontrolled manner after the irradiation and consumes the host cell. If the bacteria are given a very heavy dose of radiation a few of them survive and no longer contain any virus, so they are unaffected by a subsequent small dose of radiation which would previously have been fatal. In this case, therefore, we have a type of radiation damage for which we know both the reason and the cure.

Another approach to the problem of the effects of radiation is to study these effects on some of the complex chemical substances which are known to play an important part in the life processes of the cell. Working with chemical substances rather than cells enables us to use larger amounts of material and greatly simplifies analytical problems. We are studying the effects of radiation on nucleic acids, which are substances intimately connected with reproduction and inheritance. It has been possible actually to isolate and identify one of the substances altered by radiation and even to convert it back again to its original state. There is a big gap between these chemical changes and the biological changes, but the fact that we also know of some reversible biological effects makes this work particularly interesting. There is no easy solution to the problem of radiation damage in the human but the matter is of such importance that all clues must be carefully followed.

The hereditary changes produced by radiation present an even more difficult but just as pressing a problem in a world in which human populations are exposed to a rising background of radiation. Very little is known of the effect of irradiating successive generations of mammals, and we have started an experiment to see whether a small population of rats would become less fit if the males were irradiated in each generation. Loss of fertility is one of the results of radiation and we are now determining the effect of this loss before planning the main experiment.

Genetic experiments with sufficiently large populations of mammals are expensive and because of the length of their life span the results come out slowly. Bakers' yeast is a quick-growing organism which undergoes certain lethal mutations after irradiation, but the killing effect may not take place for several generations. We are trying to find out whether the cells bearing the hidden lethal mutation are in any way less efficient than normal cells.

The exact nature of the hereditary changes or mutations produced by irradiation is often difficult to define. The end result is obvious, but the mechanism is obscure. By the use of compounds labelled with radioactive elements it is now possible to work out some of the details. The use of radioactive carbon has enabled us to compare a radiation-induced mutant organism with the normal variety and to pin-point with some precision the type of damage induced in the mutant.

The problem of the genetic effects of radiation on human populations is so pressing that a start must be made on a study of this subject in spite of the very great difficulties. We have been advising the Department of National Health and Welfare in an attempt to design a procedure to detect genetic changes in human populations. Routine public health statistics are inadequate for this purpose because they take no account of family relationships, but the family information exists in registrations of births and marriages. More detailed medical information on birth and death certificates will be required and new statistical procedures will have to be devised to gather the information together in a usable form. This will be an elaborate and very long-term study but we know so little about such fundamental things as the normal mutation rate and the incidence of diseases having some genetic element in humans that information of this kind could not fail to be valuable even if we were not faced with the problem of determining the influence of radiation upon the quality of our population. Some work of an allied nature is being done by the Institute of Human Genetics in Denmark but the study proposed for Canada is unique and should help us to make our contribution to the knowledge we can pass on to future generations of how to deal with the inherent hazards of radiation.

APPENDIX VII

OPERATIONS DIVISION

Manager—Mr. F. W. Gilbert
Staff —Professionals 73
—Others 205

Branches: NRX Reactor
NRU Reactor
Reactor Safeguard
Chemical Extraction
Chemical Control
Waste Farm Disposal
Production Planning and Control

The Operations Divisions are made up of three main groups. The first and largest is the Reactor Operations Division whose duty is to operate the NRX reactor and eventually the NRU reactor. The second group is the Chemical Operations Division which operates the extraction processes, the control laboratories which form a service group to all the operating branches, and the waste farm section which looks after the disposal of radio-active wastes in the disposal area. The third group which is called Production Planning and Control, is a service organization to handle all the stenographic and clerical work, contacts with Commercial Products Division, and paper work in connection with all the experiments going into the reactors. It has a number of other duties which come up from time to time and are not necessarily assigned to any other branch. Each of these groups will be discussed in turn.

8.1 *NRX Reactor*

At present, the NRX Reactor Branch employs 26 professional men and 46 prevailing-rate operators. These are in addition to the maintenance personnel supplied by the Service Divisions. Their duty is to operate the NRX at maximum efficiency (24 hours a day, 7 days a week) and to give the greatest service possible to the experimentalists.

There has been a considerable change in experimental effort, since the reactor was first conceived. When it started operating in 1947, it provided for the production of plutonium for experimental work, neutron beams for pure research, and the irradiation of samples in the so-called self-service positions. As time went on it was found that the self-serve positions did not give a sufficiently high neutron flux to supply the radiation required both for research and the production of cobalt-60 used in beam-therapy units for hospitals. Facilities were then provided to irradiate these materials inside the reactor vessel, in fact, in positions normally occupied by uranium fuel rods.

The next stage was to install small experimental units in similar positions to study such things as temperature of samples under irradiation. Presently the major effort is directed towards the operation of loops. These loops are best described as pilot plants to study the effects of fuel behaviour and corrosion under the conditions to be expected in power reactors.

The term "loop" suggests a simple unit, but in fact these units can be very complex. It is not unusual to have a loop which is more complex than the entire heavy-water-helium system of the reactor itself. At present there are either under irradiation or projected, 6 loops for the NRX reactor. These loop experiments are being performed as joint efforts with the USAEC and/or the United Kingdom Atomic Energy Authority. In all the loops which are presently installed, the equipment has been supplied by the U.S. or Britain. The value of the equipment runs from about $250,000 to $450,000 per unit. The Chalk River Project shares the local operational and installation costs. All the information obtained from the operation of these loops is available to AECL.

Because these loops absorb a large number of neutrons, it has been necessary to add enrichment to the reactor. The enrichment at present is U^{235} which is obtained from the USAEC. In the past, locally produced plutonium was used for the purpose. Due to some technical difficulties this use has been curtailed temporarily. The installation of loop equipment was not foreseen in the original design and provisions were not made for the required extensive external equipment. As a result it has been necessary to utilize any floor space or shielded-room space that could be made available. With the NRU reactor shielded rooms have been provided in the original design.

The complexity of the experiments that are going into the reactor have necessitated an increase in operating staff. In 1952 the staff consisted of 16 professional staff and 26 prevailing rate. As mentioned above, the present staff is 26 professional and 46 prevailing rate.

Also, it has been necessary to take certain calculated risks with reactor components to perform some experiments. However, these experiments are very important to the production of power both in our country and in Britain and the United States. The risk could be reduced by installing a reactor vessel specially redesigned to handle loop experiments but the change would require a minimum of 3 months shutdown. On the other hand, to repair and make the change, if we do damage the reacting vessel, will require just about the same length of time. It is therefore felt that it is better to proceed under these risk conditions than to alter the equipment now.

8.2 *Van de Graaf Generator*

As a convenience, the Van de Graaff equipment is operated by NRX Reactor Branch. The equipment, which produces very high voltages, is operated for the Physics Research Division and is generally under its direction. The function of the Reactor Operations Division is to provide continuous and safe operation of the unit.

8.3 *NRU Reactor*

It is expected that the NRU reactor will be staffed with 32 professional men and 105 operators. At present the staff is being hired and trained to operate the reactor. The professional men hired are employed writing operating manuals and design manuals. They are also studying the equipment as it is being installed so as to become thoroughly familiar with the operation. A number of them have been transferred from the NRX reactor where they worked on the operation. The training program requires some prior operating experience in NRX. Most senior men have had considerable NRX experience.

Before the NRU reactor is in service, 592 design manuals, 354 operating manuals, 52 testing manuals and 50 start-up procedures will be written. Quite obviously, no one will know all the details in these manuals. They will however, provide a reference which will be available at all times.

It is expected that most of the equipment in the NRU reactor will be turned over to operations by the end of the year. At this time the operations people will begin a series of performance tests. These tests will differ from the normal proof tests provided by the contractor. Essentially the equipment will be tested in individual parts and as complete assemblies to see whether it performs according to the intent of the design engineers. The tests will continue until the time the reactor is at a full power of 200MW. It is estimated that the complete job will require about 3 months.

After the reactor is brought to full power, it will provide four major services. The highest priority will be the production of plutonium. The second priority which should in no way interfere with other operation, is the production of cobalt-60 and the irradiation of other materials. Approximately 750,000 curies of cobalt-60 will be produced each year. The third priority will be the operation of three sets of loop equipment.

The NRU will have one major advantage over NRX for the operation of the loop equipment i.e. its higher flux. Inside an NRX loop the flux is not as high as that expected in power reactors so that it is necessary for the design engineer to extrapolate from the lower flux to the anticipated higher flux. However, in the NRU reactor it will be possible to run with a flux almost identical with that expected in power reactors.

The fourth facility which the NRU reactor will provide and that should not interfere with the other priority jobs is higher-flux neutron beams. These beams will permit the physicists to extend their knowledge in the nuclear field.

8.4 *Reactor Safeguard and Training*

Two additional functions are performed in the Reactor Operations Division. One is by the Reactor Safeguard Branch. At present only one man is employed on this work but eventually, when men can be hired and trained, there will be a staff of five. The duty of the branch is to check on the safe operation of the two reactors. The duties are similar to those of inspectors. The interest is the safe operation of the plant, not the efficiency nor the total production.

Due to the rapid expansion of Reactor staff and the increasing demand for men trained in reactor operation, it has been necessary to employ a full-time training supervisor. Although he cannot do all the training himself, he assists by arranging lectures, demonstrations, discussions and reading courses.

8.5 *Chemical Extraction Branch*

The Chemical Extraction Branch has been operating since 1949. Originally it was equipped with a batch-type solvent-extraction process for the extraction of plutonium. This particular process had a number of advantages but later developments have made it obsolete. Two other methods have been studied at this plant, a continuous solvent-extraction process and an ion-exchange process. Both are very useful methods. Combined they can provide a service to the overall operation of the plant. The plant is presently staffed by 7 professionals, 5 technicians, and 33 operators.

8.6 *Other Operations*

The other sections in Operations Divisions are essentially service groups both for operations branches and some of the other plant facilities. The ultimate disposal of the dilute aqueous radioactive wastes is one of the problems that has not been completely solved. One major experiment which is being conducted by the Biology Division is the study of ground disposal of active waste. An operation section provides a link between the Biology Division and those who wish to dispose of these dilute wastes, primarily because by far the largest volumes arise from Operations work. There are a number of trenches in the disposal area each receiving certain solutions depending on their source. The Waste Farm Disposal Group sees that these are distributed according to the wishes of the Biology Division.

The Control Laboratories are run by the Operations Division to provide routine chemical analyses for the operations branches and such outside groups as might request their services. This group employs 5 chemists and 30 technicians.

The Production Planning and Control Section has a number of functions. These are best described as follows:

- (i) Stenographic Pool for all the operational branches and to assist the Chemistry and Metallurgy Division with some of their typing.
- (ii) Liaison with the Commercial Products Division in Ottawa.
- (iii) Procurement of and accounting for fissionable and fertile materials. It also looks after the storage of these materials.
- (iv) Assistance in the planning of the experimental loads that go into the NRX reactor. It will provide a similar service to the NRU reactor when it is operating.
- (v) Any duties which do not naturally fall into the sphere of the other branches. This last item is a little hard to describe as it varies from day to day but actually takes a fair amount of time of the group.

The group is staffed by 3 professional people, 9 clerks, 10 stenographers and 2 technicians—a total of 24 persons.

Generally speaking, the Operations Division is a service group to the general overall research and development program at this Plant.

APPENDIX VIII

ENGINEERING DEVELOPMENT AND SPECIAL PROJECTS DIVISION

Manager —Mr. F. M. Sayers
Staff —Professionals 28
—Others 7

Branches: Analytical Engineering
Engineering Development
NRU Technical Liaison
NPD Technical Liaison
Nuclear Power

9.1 *Reactor Design*

The main functions of the Engineering Development and Special Projects Division are the coordination of design and construction work for the NRU reactor, the management of A.E.C.L.'s responsibilities in connection with the NPD reactor (and similar major projects involving industrial participation), and the provision of an engineering development service for the entire plant. The personnel engaged in this work may call for information and assistance from the other Divisions on the Project, and frequently undertake a substantial amount of planning and pre-design work themselves. To provide answers quickly to the many miscellaneous problems arising, the Engineering Development Branch operates laboratory and testing facilities in which large numbers of specific engineering projects are tackled. The work of this Branch includes problems related to NRU and NPD, as well as improvements in the NRX reactor or other engineering sections of the Project. The nature and scope of reactor design and development has been discussed in Appendix III in connection with the work of the Reactor Research and Development Division and is therefore not repeated here.

9.2 *Nuclear Power Branch*

The Branch was established in January 1954 under the direction of Mr. H. A. Smith of the Hydro-Electric Power Commission of Ontario; since its organization and functions are unique, it merits special discussion here.

The function of the Branch is to study the feasibility of constructing nuclear-electric power plants and to prepare preliminary designs for such plants. In this connection, the term "preliminary design" has a somewhat different significance than in the case of more usual engineering projects. In the latter—for example, the design and construction of conventional power plants—the work preceding actual operation may be considered as comprising five stages: preliminary design, detailed design, procurement, construction and performance testing. For such projects there is usually a large amount of background information and experience available from previous work. As a result, little or no experimental work is normally required. In the case of the nuclear plant, however, the necessary data and experience are seriously lacking at the present time. These can only be provided by a sixth stage—the experimental or development stage—interposed between the preliminary and detailed design stages. Thus, for this case, the preliminary design assumes a greater significance—and less certainty—than in the case of more conventional projects.

The basic purposes of preparing preliminary designs with the supporting studies are to:

1. Co-relate existing information, and prepare analyses to demonstrate insofar as practicable, the effect on physical design and costs of the main factors therein.
2. Assign suitable values and conditions to the various factors to form an outline specification for the plant.

3. Formulate a physical design, based on the outline specification, in sufficient detail to demonstrate its potential feasibility.
4. Serve as a quantitative basis for an integrated program of experimental work to provide the necessary information for the detailed design stage.
5. Provide approximate estimates of cost to orient the economic considerations of the design.

The Branch is staffed by a small group of engineers provided principally by various Canadian companies interested in the development of nuclear power. Due to re-assignment of staff by these companies, the staff of the Branch is somewhat transient. At the time of formation it comprised 6 engineers from 3 outside companies. Additions during 1954 from 3 other outside companies, as well as from A.E.C.L., raised the total to a peak of 11 in January, 1955. Since then, withdrawals and re-assignments have accounted for reduction of the staff to the present total of 9, one additional company being represented now. In all, a total of 15 engineers (12 from outside companies) have recorded service with the Branch for various periods, providing somewhat less than 20 man-years of effort.

The seven outside companies contributing to this effort have been: Canadian-Brazilian Services, Ontario Hydro, Montreal Engineering Co., Shawinigan Water and Power Co., Babcock-Wilcox and Goldie-McCulloch, British Columbia Electric Co. and the Manitoba Hydro-Electric Board.

Previous general experience of the staff assigned to the Branch has averaged approximately 13 years per person, covering mainly electrical and mechanical work in various phases of industrial and power-system engineering, as well as chemical development engineering. Only two engineers provided part-time by A.E.C.L. have recorded experience with nuclear plants prior to joining the Branch.

The work of the Nuclear Power Branch during the past two years may be considered in three stages. The first of these—the training stage—occupied approximately the first seven months of 1954. The second, extending to April, 1955, covered the preparation of a preliminary design for a relatively small-scale demonstration nuclear plant. The third stage on which work is still proceeding, is directed towards a preliminary design for a full-scale nuclear plant suitable for use by a power-supply utility.

The training stage commenced with informal instruction, by A.E.C.L. staff, in elementary nuclear physics, reactor physics and engineering problems related to the design of nuclear plants. During the instruction, a large proportion of the time was spent in reading applicable literature, and in becoming familiar with the design problems peculiar to nuclear reactors and their systems of heat removal. While numerous types were studied on a qualitative basis only, most of the effort during the instruction stage was directed specifically toward an understanding of the heavy-water-moderated natural-uranium reactors—the type on which A.E.C.L. has specialized.

Following the instruction period, the training stage was continued along several lines, each intended to give the staff more of a "feel" of the work by applying some of the theoretical considerations to pertinent engineering problems. For example, rough cost analyses for rudimentary reactors were attempted; qualitative comparisons of the engineering aspects of various reactor types were made; the methods and costs of producing heavy water were reviewed. In addition, considerable effort was spent in reviewing, assessing and co-ordinating data from existing literature, especially on the properties of materials having possible application in reactor construction. In all, the effort expended during the training stage amounted to about five man-years.

The second stage of the work was started in August, 1954, when the Branch was assigned the task of preparing a preliminary design for a small nuclear power plant. The purpose of the plant was to demonstrate the generation of nuclear-electric power from a plant of relatively small capacity but having characteristics such as to provide information and experience in design and operation for use in developing a future full-scale plant. By designing a small capacity plant it was possible to keep the capital outlay to a minimum and yet build a reactor big enough to give the desired experience. A capital cost was chosen which led to a maximum power rating of about 20,000 kilowatts electrical and the scope of the work was further limited by restricting the design to the heavy-water-moderated type of reactor, fuelled with natural uranium.

Before a physical design could be undertaken, it was necessary to develop an outline specification with supporting data, where practicable, and with qualitative reasons where the necessary data were lacking. This was accomplished through a series of technical and economic studies of numerous basic design factors in order to determine their effect on cost and feasibility of physical design. With these studies as a basis, the necessary outline specification was established and approved. The group then proceeded to formulate a physical design in sufficient detail to allow approximate capital costs to be estimated, and to permit a rough assessment of some operating characteristics of the proposed plant. This was accomplished essentially by pooling design suggestions from the various engineers of the Branch, assessing these on a semi-quantitative basis and selecting those ideas which were favoured by the majority of the group. These were then incorporated in drawings and specifications showing plant layout and considerable detail of the main components. As a last step, capital costs were estimated, with the physical design as a basis.

This second stage of work culminated in the issue of two reports, one covering the outline specification, the other presenting the physical design and cost estimate for a 20,000 kilowatt plant. Subsequently, estimates were also prepared for 7,500 and 10,000 kilowatt plants. The results of this work served as a basis for a decision to undertake development, detailed design and construction of the plant at a rating of 20,000 kilowatts. This project, now known as NPD—for "Nuclear Power Demonstration"—is a joint undertaking by A.E.C.L., Ontario Hydro and the Canadian General Electric Company.

As mentioned previously, the third stage of the group's work, now in progress, consists of preparing a preliminary design for a full-scale nuclear power plant. The general pattern for this work is similar to that followed for NPD. However, the scope of the work has been broadened by removing restrictions on capital cost, plant rating and type of fuel. The primary object is to develop a preliminary design which is considered most likely to lead to nuclear power at a cost competitive with that from conventional plants. As a result a greater effort is being devoted to more detailed general studies on which to base an outline specification.

At present it is too early to define any precise target date for completion of the work. The exploratory nature of the work and the requirement for originating new design ideas are not conducive to the type of work, planning and scheduling expected in more conventional engineering projects. However, it would appear that the work will have advanced sufficiently by the end of this year to issue a series of reports. It is intended that the first of these will report results of the general studies and establish the technical and economic basis for a physical design; the second will present at least one relatively complete physical design and cost estimates, and perhaps one alternate design; the third will define the development work required to carry on with further detailed design.

It is hoped that this work by the Nuclear Power Branch may serve as a basis for another step in the development of economic nuclear-electric power in Canada.

APPENDIX IX

ENGINEERING SERVICES DIVISION

Manager—Mr. R. F. Wright
Staff —Professionals 42
—Others 733

Branches:
- Design
- Maintenance and Power (M & P)
- Workshops, Estimating and Planning (W E & P)
- Building Maintenance and Construction (B M & C)
- Transport

10.1 *Introduction*

As the name Engineering Services implies, the Division's primary function is that of making available to all branches in the plant, engineering facilities which are essential to their operation. The work involved might not be considered by some to have the interest attached to research or reactor operations, and is not of the type which promotes prominence outside the Project.

The anonymous aspect of the Division's effort is, however, certainly compensated for by its diversity. The scope of work can cover the design and construction of an addition to the chemical plant, the removal and replacement of a damaged calandria tube in the NRX reactor, the repair of electronic instruments or even the plowing of snow on the plant roads. A portion of the Division's work is carried out as routine plant upkeep. The remainder arises from requests from other Divisions.

The Division is large counting the number of people employed, which amounts to approximately 775, since it carries the majority of the plant hourly-paid workers. Its yearly personnel requirements are based on estimates of money needed for normal plant services, plus the total of the amounts other Divisions budget for work which they will require.

The five branches function as separate units but their work of necessity overlaps, different phases of the same projects being carried by individual branches. For example, a tank may be fabricated by the W E & P Branch, taken to its location by a truck supplied by the Transport Branch, and installed by the M & P Branch. The blueprints for its manufacture were produced by the Design Branch and it was inspected by them prior to its removal from the workshops.

10.2 *Design Branch*

The Design Branch's responsibilities fall into two general categories. It provides general engineering service to all parts of the Project requiring design of special equipment, new processes, buildings, or alterations to existing equipment to improve operation. It also acts in an engineering liaison capacity between other branches and outside engineering organizations who may carry out major design and construction projects for us.

The branch personnel are grouped in three main sections, Project Engineers, Senior Design Engineers, and Drawing Office.

The Project Engineers are responsible for either the design associated with specified plant areas or for special projects requiring engineering attention. There is, for example, a Project Engineering group over reactor design work since a large number of design changes are constantly being made to improve both the operation of the NRX reactor and its research facilities. The Chemical Design group of Project Engineers carried out the design work on an improved method of plutonium extraction, facing many unique engineering problems in which radical changes in design philosophy were incorporated. Another group is working with Canadian Westinghouse and Canadair to provide major research installations for the Reactor Research and Development Division. One of the most recent projects has been to assemble the information needed by the Shawinigan Engineering Company in designing the modified version of the NRX reactor which is to be built in India under the Colombo Plan.

The Senior Design Engineers are specialists in various fields of engineering such as electrical power, instrumentation, heating and ventilating or architecture. They provide assistance in their fields for all jobs being carried out by the Project Engineers.

The Drawing Office is organized under the technical direction of an engineer, and provides drafting service as required to the branch engineering staff.

10.3 *Maintenance and Power Branch*

This branch carries out the repair and maintenance of all mechanical, electrical and instrumentation equipment, and the installation of such equipment when operating funds are involved. It also operates the Power House from which the plant is provided with essential services such as steam, water, air and electricity.

Its 250 personnel are grouped into four sections: Mechanical, Electrical, Instrument and Power House. Each section is headed by a professional engineer with the exception of the Power House which is under the supervision of a Stationary Engineer. The Mechanical Section is further broken down into different trade groups. Also area maintenance crews have been set up in both the NRX reactor building and the chemical extraction plant. These area crews have been found necessary since the nature of the operation demands a group of tradesmen who are thoroughly familiar with this specialized work, know the equipment, and know all regulations relative to any radiation hazards which might be involved.

The Power House operates on a 24-hour basis. The electrical power is fed to the sub-station from two independent 110 kilovolt sources—Bryson and Des Joachims. The two sources are connected in such a manner that if either fails the failed load is switched automatically to the remaining source in approximately one second. This ensures continuity of reactor operation through a Hydro power failure from either source.

Steam is generated from six boilers having a total capacity of 200,000 lbs. per hour.

The reactor cooling water is pumped from the Power House, the pumping capacity being approximately 60,000,000 gallons per day. This is more than adequate to supply a city larger than Ottawa.

10.4 *Workshops, Estimating and Planning Branch*

This branch consists of three main sections—Machine Shops, Estimating and Planning and Rod Fabrication Shop.

There are three machine shops in all. The largest is located in the Inactive Area. Its personnel consists of machinists, tool and die makers, welders, sheet-metal workers and leadburners. Equipment and parts normally designed at the plant are fabricated in this shop. It specializes on new fabrication and does not work with contaminated material.

The shop in the Active Area fabricates certain types of special reactor rods and works on equipment and material from the Active Area that must remain there.

There is also a small shop in the Electronics Branch sepcifically to provide shop service for the manufacture of electronic equipment. There are two leadburning shops, one in the Active and one in the Inactive Area.

The Estimating and Planning Section provides cost estimates on projects which other branches are considering or on equipment which they might wish to have fabricated. They also plan and schedule the work on certain major jobs.

The Rod Fabrication Shop is located in the Active Area. It is operated for the fabrication and out-of-pile testing of NRU reactor fuel elements. Uranium ingots are hot rolled to rough dimensions for individual flat elements by outside suppliers. The flat sections are then transported to the Rod Fabrication Shop where they are heat treated, straightened, machined, cut to length, degreased and assembled into sheaths. After the ends are welded the flats are tested, and assembled into the outer sheath.

10.5 *Building Maintenance and Construction Branch*

The work in this branch consists of actual construction of new buildings and services, or additions and alterations to existing buildings. The maintenance of building structures, plant roads, grounds and supply of janitor service is also its responsibility. The work is accomplished by a staff of approximately 250 employees.

The bulk of the construction consists of smaller projects in which outside contractors would not be interested: also those which, due to security or radioactivity considerations are more efficiently and economically carried out by plant forces. The value of this type of work runs to approximately $1,000,000 per year.

Besides normal grass cutting, snow shovelling and janitor service, there is also the maintenance of fire trails throughout the bush country surrounding the plant. Areas must also be maintained in this territory for the disposal of garbage or other waste material removed from the Active Area in the plant.

The branch operates a sizeable amount of heavy equipment such as bulldozers, snowplows, graders, etc., required in construction and road maintenance. The plant is situated approximately six miles from the main highway and the road leading to the highway must be kept in repair and free of snow in the winter, to permit efficient operation of our bus fleet.

10.6 *Transportation Branch*

Its main function is the operation of a fleet of forty-six buses which carry the bulk of the plant employees to and from work. The buses operate from both Pembroke, a distance of 28 miles from the Plant and Deep River, which is 12 miles away.

It also operates a fleet of thirty trucks and seven passenger cars which are necessary to supply plant trucking service and to meet special transportation requirements of the project.

All vehicles are serviced at the plant in a well-equipped garage staffed by twelve mechanics. Besides repairing the vehicles mentioned, these mechanics also service the fire trucks, ambulance and any other gasoline-powered equipment in the plant such as emergency generators and fire pumps.

It is worthy of mention that since the commencement of operations at the plant, although we have had vehicle accidents, no passenger has ever received an injury except of a very minor nature requiring only first-aid treatment.

10.7 *Conclusion*

As can be seen the Engineering Services Division is very similar to many plant engineering groups in other industries. Its problems are increased by the presence of radioactivity which complicates the methods used and sometimes introduces unavoidable delays. We are learning daily the new techniques in plant engineering which are going to be essential to the smooth working of the atomic energy industry in its future development.

APPENDIX X

MEDICAL DIVISION

Director	- Dr. C. G. Stewart	Branches:	Village Hospital
Staff	- Professionals 6		Plant Hospital
	- Others 48		Medical Research

11.1 *Introduction*

The Medical Division is responsible for providing good medical care for the employees of the Company and the population of the Village of Deep River. The Division deals not only with the ordinary medical problems arising in the population at the Village and at the Plant, but in addition, with the problem of radiation exposure of personnel engaged in the day-to-day operations at the project. Because of this latter responsibility, primary functions of the Division also include the assessment of scientific literature on the biological effects of radiation in terms of potential damage to humans who may be exposed, and in addition research directed at improving procedures for the measurement of the body burden of radioactive materials in individuals exposed. The Director of the Division, as a member of the Committee on Permissible Dose for Internal Radiation of the International Commission on Radiological Protection, has a unique opportunity to discuss with representatives of the United Kingdom and the United States methods directed at more accurate measurement and at reduction of body burdens of radioactive materials in exposed personnel. This circumstance effectively links practices used in this Division for the estimation and control of the internal radiation hazard to what is believed to be the best of contemporary thought on these matters in the Western World.

11.2 *The Village Hospital*

This branch is responsible for all medical care in the Village, the more complicated medical and surgical emergencies that occur at the Plant, and with time has come to serve the medical needs of the majority of the people living along Highway 17 from Petawawa to Stonecliffe. Physically, the hospital contains 30 adult beds and 10 bassinets for the newborn. The professional staff consists of 4 doctors, 3 technicians, and 19 graduate nurses. There are 6 administrative and clerical workers, a total of 7 hourly-rate workers (laundry help, maids, janitors, etc.), and 1 part-time dietitian. One physician, Dr. W. R. Skelly, as Chief Physician of the Hospital, and as Medical Officer of Health for the Community, including the Plant property, is head of this branch. The standards of patient care in this hospital are very high, probably higher than any hospital of comparable size in Canada. This is evidenced by the fact that no other hospital of this size, and in fact, no other private hospital in Canada, has received full accreditation by the Joint Commitee on Hospital Accreditation. For example, there is no fully accredited hospital between Ottawa and Sudbury, except the Deep River Hospital. Contributing to this situation is not only the standard of training attained by the medical staff, but also the fact that only graduate nurses are employed, and that the facilities for laboratory and other special procedures available in this hospital are considerably greater than those usually available in hospitals of this size in Canada.

The magnitude of the operation at the Village Hospital can perhaps be most readily presented in tabular form:

—	1953	1954	1955
Number of admissions (adults and children)	953	898	910
Average in-patient occupancy	56·8%	54·4%	48·4%
Number of births	187	206	198
Number of surgical procedures performed in operating room	485	520	505
Classification of in-patients—			
(a) AECL and dependents	72%	56%	60%
(b) Construction workers	9%	8%	6%
(c) Others	19%	36%	34%
Total out-patient visits (including house calls)	10,786	10,983	11,863

It is apparent from the number of out-patient visits, that the work load of the Village Hospital medical services is gradually increasing with time.

11.3 *The Plant Hospital*

The Plant Hospital has, as its main function, the health supervision of the personnel employed by this project. Pre-employment examinations, which include blood and urine examinations and chest x-rays, are carried out on all personnel and are repeated at regular intervals. These procedures are carried out by a staff consisting of one doctor, two nurses and three technicians, assisted by one contamination monitor and one clerical worker.

In addition to the care of our own employees, a relatively large number of construction workers are treated for on-th-job accidents or illness. The Plant Hospital is equipped to handle the initial treatment of any accident or illness occurring during the course of a working day. Subsequent ambulatory treatment is available to those wishing to use the services of this clinic. Dr. E. M. Renton, the Plant doctor and head of this branch of the Division, is available also to all employees at the Project for special consultations.

In addition to the regular facilities provided by an industrial hospital, this branch has certain responsibilities and opportunities peculiar to the operation of an atomic energy project. In spite of all precautions, instances occur which lead to the contamination of the body surfaces of workers with radioactive materials. In most cases, these contaminations are of a minor nature and can be dealt with in the wash-up facilities provided in each laboratory building. However, if this procedure proves to be inadequate to a monitor, the medical service is responsible for the further decontamination procedures. For this purpose a separate and self-contained personnel decontamination unit was incorporated into the Plant Hospital building.

Routine examination of the blood done at intervals on all workers on this project has never revealed any significant changes attributable to radiation. This, no doubt, is due to the fact that the level of external radiation permitted has been below the threshold at which one might expect changes to occur in the blood picture.

The magnitude of the operation at the Plant Hospital is illustrated by the following figures:

—	1953	1954	1955
Total hospital visits (including return visits)	6,878	6,865	7,712
Number of new occupational accidents		1,035	1,152
Number of new non-occupational accidents/illnesses		2,814	3,187
Number of radioactive decontaminations performed		116	67

And again it may be noted that the total number of hospital visits has increased appreciably in the past year.

11.4 *The Medical Research Branch*

This branch was originally conceived as the investigating arm of the Medical Division. At the time of its creation, methods for the determination of the internal body load of radioactive materials carried by individuals exposed to radioisotopes were just beginning to be used. It is therefore natural that this branch of the Division evolved into an organization whose main function in the project is the measurement and control of the internal contamination hazard of exposed personnel. However, fundamental biochemical research into intracellular enzyme mechanisms is planned to begin within the year. Nevertheless, the research done to date has been chiefly directed at devising and improving methods for the detection and measurement of an ever-increasing number of radio-elements in human material, particularly urine, and in setting maximum levels based on rates of excretion, that may be tolerated with safety. These procedures are carried out by four research technicians, with the assistance of one clerical worker, all under the supervision of one doctor who also acts as Director of the Division as a whole.

The operations of this branch for the past three years again can probably be presented best in the following table:

Bioassay Laboratory

SUMMARY OF TESTS FOR RADIOACTIVITY DONE ON AECL AND ATTACHED PERSONNEL

(PROJECT PERSONNEL AND COMMERCIAL PRODUCTS DIVISION PERSONNEL)

—	Fiscal year 1953-54			Fiscal year 1954-55			Fiscal year 1955-56		
	Total	Pos.	** % Pos.	Total	Pos.	% Pos.	Total	Pos.	% Pos.
	No.	No.	%	No.	No.	%	No.	No.	%
Fission products..........	2,852	603	21·2	2,274	327	14·4	2,464	285	11·6
Gross Alpha (sol. Pu, Am, Cm, Ac^{227}, Rd. Th.)....	323	31	9·6	709	21	3·0	734	5	0·7
Tritium..................	Not Done..............			66	12	18·2	306	116	37·9*
Uranium (natural and enriched)................	Not routine............			3	0	0·0	77	32	41·6
Polonium................	Not stated here........			17	8	47·0	0	0	—
$Radium^{226}$................	Not stated here........			6	0	0·0	35	3	8·6
Miscellaneous Beta determinations; Ra D+E, Co^{60}, Gross Beta, Cu, Ru, Fe, Cd............	Not routine............			75	0	0·0	57	0	0·0
I^{131}......................	Not done..............			6	1	16·7	4	1	25·0
All tests.............	3,175	634	20·0	3,087	369	11·9	3,677	442	12·0

* The apparent increase in the number of analyses positive for tritium is due in the main to technical improvements permitting many more analyses to be carried out in the same number of technician man-hours.

** The term "positive" indicates only that a measurable amount of the particular radioisotope is being excreted by the individual, and therefore that the individual has been exposed. Radiation protection procedures in force at the project have thus far prevented any individual from acquiring a dangerous body burden of radioactive material.

It is again apparent that the work load of the branch is increasing with time; nearly 20% more analyses were done in the year 1955 and 1956 than in the year 1953-1954. It also may be noted that a large number of the positive results in 1953-1954 were due to the pile accident. Though the distribution of positive analyses with respect to elements is different in the year 1954-1955, and the year 1955-1956, the fraction positive remains essentially the same. Since the number of tests performed in the year 1955-1956 is about 20% greater than in the year 1954–1955, it is apparent that there are some 20% more positive tests in the year 1955-1956 than in the year 1954-1955. This is just one more indication of an expanding operation in the use of radioactive materials, and points clearly to the necessity for continued sampling of the human population who work with radioactive materials,—for their own protection.

APPENDIX XI

ADMINISTRATION DIVISION

Manager—Mr. T. W. Morison		Branches:	Personnel and Office Services
Staff —Professional	7		Purchasing
—Clerical and Other	140		Security—Personnel and Physical
—Prevailing Rate	180		Industrial Assistance
			Library
			Village of Deep River

12.1 *Personnel and Office Services*

This branch is responsible for the project personnel functions as well as for the operation of certain office services.

The personnel functions consist of employment, industrial safety, wage and salary administration, training and development, and general employee relations and welfare. Twenty-five employees are engaged in this work.

The primary function of the employment office is recruitment and placement of new employees, but it also handles much of the administrative detail concerning promotions, transfers, reclassifications, employee ratings and terminations.

Employees are recruited through the National Employment Service, newspaper advertising, visits to educational institutions, and direct mail inquiries. Due to the general Canadian shortage of scientifically trained university graduates, a continuous and extensive campaign is necessary to maintain the staff at the desired strength. Each year the Canadian universities are visited, talks given to students, and interested students interviewed. Contact is maintained particularly with students undertaking post-graduate training, and with the university professors. Each summer approximately 40-50 university students and professors are taken on the staff. This program benefits the project directly by the work contributed and, at the same time, gives the participants an opportunity to see the work carried out at Chalk River.

In the recruitment of technical, clerical, and other skilled employees, efforts are made to interest high-school student and to give them on-the-job training. High schools and collegiate institutes in the area are visited each spring, and students interviewed.

On April 30, 1956, the number of project employees was 356 scientific; 777 technical, clerical and other staff; and 1,073 hourly-paid employees. The labour turnover compares favourably with similar industries.

A Safety Office, under the direction of a Safety Engineer, is responsible for an accident prevention program. The program is based on the principle that all work is to be done safely and that supervision has a responsibility to this end. The Safety Engineer acts in an advisory capacity to plant supervision to assist them in detecting and eliminating safety hazards and, in addition, carries out inspections and investigations of radiation, fire, transport, and industrial accidents, and handles cases which are to be reported to the Workmen's Compensation Board.

To co-ordinate the safety prevention program, there is a Central Safety Committee made up of senior project personnel who meet monthly to define safety policy and review progress, and the Safety Engineer acts as secretary to this committee. Safety consciousness is promoted among the employees by safety meetings and through general publicity. All lost-time accidents and those considered likely to have produced a lost-time accident are investigated and the results publicized in order to eliminate accident hazards and to prevent similar incidents.

Membership is maintained in the National Safety Council and the Industrial Accident Prevention Association of Ontario in order that we may have available the results of accident prevention work in other industries.

Generally speaking, we have been able to maintain a very excellent safety record. There have been two fatalities since the plant began operation in 1945. Other accidents have been of a minor nature, and during 1955 a record of 261 days, during which there were no lost-time accidents, was attained. Direct comparisons are made with similar industries in the United States and Canada and, with the exception of those years in which there were fatalities, the record has been considerably better than the average for similar industries. There has not been a lost-time accident due to radiation.

An office is maintained to study wage and salary administration problems. Salary surveys are conducted and, in addition, a number of co-operative arrangements with other organizations conducting salary surveys have been set up in order that the company can keep abreast of salary and wage developments in similar industries in Canada. Information secured in these surveys is used as the basis of recommendations for salary adjustments, and in union-management negotiations. Close liaison is maintained with other Government departments, particularly the National Research Council, the Defence Research Board, and the Civil Service Commission.

In the field of employee relations, union-management contracts are in existence covering (*a*) all hourly-paid employees, except security guards, and (*b*) salaried research technicians and draftsmen. In these negotiations, the Company comes within the terms of the Industrial Relations and Disputes Investigations Act. The hourly-paid employees are organized into nine separate A.F. of L. trade unions who negotiate with the Company through a co-operative council known as the Atomic Energy Allied Council. One master contract exists for these employees. A separate contract exists for the salaried research technicians and draftsmen, who are organized under the American Federation of Technical Engineers. The Personnel Office is responsible for preparing background information for negotiations, as well as for the day-to-day operation of the contracts.

The Personnel Office also operates the various welfare plans available to employees. Salaried staff generally receive all of the plans available to the members of the Civil Service, including those provided for under the Superannuation Act. Hourly-paid employees are covered under separate Pension, Insurance, and Accident and Sickness Indemnity Plans. All employees are covered by the Blue Cross Plan for Hospital Care. In all of these plans the employees contribute a part of the cost.

An apprenticeship training program is operated, and there are approximately 25 apprentices now undergoing job training under the direction of qualified journeymen and foremen. A course in machine shop training has been made available to research technicians, and a program of university and post-graduate level lectures in various subjects is promoted through an extension school arrangement in Deep River.

A supervisory development program is also carried out.

Due to the location of Deep River, it has been deemed necessary since its inception for the Company to participate in the development and operation of a community recreation program in order to make available to residents recreation and cultural pursuits and facilities which would be available to them in a larger centre. The program is developed in conjunction with the residents, through the Deep River Community Association. The Company makes available certain recreation facilities, and supplies the services of a Recreation Supervisor and an assistant, and maintenance staff. This personnel, operating under the general guidance of the Deep River Community Association, assists community clubs in setting up recreation programs. Every effort is made to assist residents in making their own arrangements and developing programs which best meet their needs.

The Office Services function of the branch includes the operation of registries for correspondence and documents, a small printing section, photographic laboratory, telephone and switchboard, and stenographic services. The registry provides for the handling of all mail, and operates a main registry in addition to six strategically-located subregistries. These offices are responsible for the filing and custody of all correspondence and records, as well as blueprints, scientific reports, and design and operating manuals. The correspondence registry receives and dispatches all plant mail, including diplomatic mail and cables, and operates a messenger service. The documents office sends out scientific and technical publications under exchange agreements and also puts these on sale; there are currently more than 300 items in print.

A reproduction office is operated in order to reproduce reports and internal forms. The photographic laboratory takes and reproduces photographs of experiments, experimental apparatus, plant operations, and construction for use as permanent records and in reports. This section also assists in the preparation of material for public information.

12.2 *Purchasing*

The Purchasing Office is responsible for the placing of purchase orders for all project requirements. The purchase requisitions for materials or supplies are raised by authorized plant personnel and, on their receipt, the Purchasing Office takes action to secure the goods. Firm prices are secured in advance on all orders where the value will be in excess of $100 and, wherever there is more than one known supplier, competitive prices are secured in advance. Where competitive prices are received, the order is placed with the supplier offering the lowest price, providing the specifications are met and the delivery time is satisfactory. Tenders are called on all construction work being done by other than the plant forces, and the contract is placed with the contractor offering the lowest price, providing he is able to assure completion within the desired period. Preference is given to goods manufactured in Canada over those of foreign manufacture.

The office is also responsible for customs clearance and for the recovery of tax rebates where applicable.

During the fiscal year 1955-56, 18,800 purchase orders were placed, of which 15% were for amounts in excess of $200. Twelve thousand, five hundred requests for quotation of prices were sent to suppliers, and approximately 2,600 items were cleared through customs.

The staff consists of 19, senior staff being the purchasing agent and three buyers. The staff, in addition to carrying out normal purchasing duties, assist in securing information on materials, preparing specifications, and advising on price changes and new products.

12.3 *Security*

The Atomic Energy Control Act and the Regulations pursuant thereto provide for the establishment of regulations and procedures to safeguard and "keep secret information respecting the production, use and application of, and research and investigation with respect to, atomic energy as, in the opinion of the Board, the public interest may require." The responsibility for establishing the regulations and procedures in respect to Chalk River has been assigned to Atomic Energy of Canada Limited. The Manager of the Administration Division acts as Security Officer for the Atomic Energy Control Board in the implementation of security policies set by the Board. The security standards followed at Chalk River are in keeping with general Government security policy and have been developed in consultation with the appropriate atomic energy authorities of the United States and the United Kingdom.

The security procedures and regulations cover three main areas; namely, the determination of what material should be classified as requiring special protection, the determination of who shall have access to such classified information, and the safeguarding of the information in physical form. The Administration Division is responsible for the latter two aspects of the security program. The operation of these aspects of security is as follows:

Personal Security. In any security program, the most important single aspect is to attempt to ensure that all persons who have access to classified data are reliable. Therefore, all persons being given access must be checked to attempt to ensure that they meet the standard for reliability. This checking is done by having an investigation of the individual's background carried out by the Royal Canadian Mounted Police, and the information so secured reviewed to see that it meets the security standards established by the Atomic Energy Control Board. Every effort is made to complete the investigation prior to the employment of a person so that security risks are prevented from entering the program rather than having to eliminate them at a later time.

There are 3 persons involved in this program.

Physical Security. The plant property consists of 10,000 acres which has been declared a Protected Place under the Atomic Energy Control Regulations. Access to the property and, in particular, to the plant area is limited to persons granted permission to enter. A force of security guards is maintained to control entrance to the project, to prevent theft of Company property, and to assist in carrying out the regulations for the storage of classified information. They also provide escort where classified material is transported outside of the plant area.

Entrance to the project is controlled by a pass and identification system, and this system is used in addition to limit movement within the plant where this is considered advisable either from a security or health standpoint.

The staff, which is on 24-hour duty, consists of 60 guards, 4 corporals, and 6 sergeants.

This staff, in addition to direct security guarding, does watchman service and fire prevention inspection. Due to the nature of the project work, there are many unusual fire hazards and, from experience over the past years, the inspection of buildings after hours has been, in preventing fires, a very good investment. These inspection tours, which are on a punch-clock basis, also afford the security force an opportunity to see that classified documents and materials are in proper safekeeping.

The handling of classified documents requires special attention in order to see that they are properly safeguarded. This involves the proper marking of documents, the assurance that they are protected while in the custody of individuals, and that they do not get into the hands of unauthorized patries. Documents are issued to persons on a receipt system, regular inventories are taken, and efforts made to see that such documents are properly safeguarded at all times.

Classified documents are issued to persons not on the project only on a need-to-know basis and providing there is assurance that proper safeguards for their protection are being taken. Physical inventories are taken regularly of such documents.

The safeguarding of classified documents is the responsibility of all persons holding such documents. In addition, a central Scientific Document Distribution Office is operated, consisting of five people, which distributes classified documents and keeps inventories of them.

Associated with the guarding force is the fire-fighting force, which is also on 24-hour duty. Due to the location of the plant, fire protection is not available from any surrounding municipality and, therefore, must be supplied by our own forces. In addition to the standby duty of the Fire Department, they carry out regular inspections of all buildings to detect and eliminate fire hazards. As the number of firemen on duty at any one time is small, auxiliary fire fighters from employees on the project are trained and ready to assist in major fires. In the operation of the project since 1945, there has been only one major fire, that occurring in February of this year.

The staff of this Department consists of one Fire Chief, 5 Fire Captains, and 23 firemen.

There is fire-fighting equipment in each building and, in addition, there are two fire trucks manned by the Fire Department.

12.4 *Industrial Assistance*

Since 1945 Canadian industry has participated in various ways in the work and development of the Chalk River Project. In recent months, due to the increased interest in the development of atomic power and the improvement in the international exchange of information, more Canadian industries are showing an interest in learning how they may participate in the future development of atomic energy. To meet this new demand as well as to co-ordinate all industrial participation in the work of the project, the Office of Industrial Assistance was established.

This office, which is under the direction of one of the senior professional staff, has the following functions:

(a) To make available to industry information in the field of atomic energy and to handle any inquiries which arise from industry.

(b) To encourage industry to become interested in the development of atomic energy.

(c) To arrange for representatives of industry to visit the project.

(d) Under the terms of the Bi-lateral Agreement with the U.S.A., to make arrangements for Canadian industries to have discussions and enter into arrangements for the exchange of information with American firms who have greater experience in this field.

12.5 *Library*

As at any research establishment, books and reports are one of the vital tools of the research staff, and for this reason a Library is maintained at the project. It is operated under the general guidance of a committee consisting of representatives of all the Divisions of the project in order to ensure that the Library is best serving the needs of all users.

Having had a continuous history since the first days of the project, the Library has built up the most complete collection of atomic energy documents in Canada. This is supplemented by scientific literature in all those fields that are relevant to the work undertaken at Chalk River. Its prime function is to serve the project staff here but, because of the extent of its atomic energy collection, it also serves in this field as a reference library for other research organizations and Canadian industry.

Perhaps the most valuable material in the Library is not books but technical reports. These are reproduced by a great variety of research laboratories in Canada and elsewhere; they contain very specialized treatises, of which many are of only short-term interest; many are classified.

The Library has a collection of 18,000 books growing at a rate of about 2,300 a year, and 30,000 reports growing at a rate of about 5,000 a year.

The staff consists of 8 people, of whom two are trained librarians.

12.6 *Village of Deep River*

The village of Deep River, which has a population of approximately 3,100, was developed by the Company to house personnel employed in or associated with the Chalk River plant. It was operated as a Company town until April 16 of this year when it was incorporated as the Improvement District of Deep River under Provincial legislation.

The town, as developed by the Company, consists of 750 family dwellings with 50 more under construction; single accommodation for 400 persons; two public schools and one high school; stores; hospital; recreational facilities; heating plant, water pumping, sewage disposal and electricity supply; churches and clubs. All of the land and buildings are owned by the Crown and, with the exception of some of the commercial premises, are managed by Atomic Energy of Canada Limited. The Company, therefore, acts as landlord, and until April 16, 1956, carried out all municipal duties including the operation of a Police and Fire Department.

The change in the status of Deep River from a Company town to that of a municipal corporation was brought about at the direct request of the Company. The reasons for this request were that under a company town operation:

(a) The employer is the landlord, and this tends to produce certain undesirable relations with employees.

(b) The residents are denied the usual right of democratic control over their own affairs.

(c) It was not possible to grant true home ownership, and many employees are anxious to own their own homes.

(d) The normal development of the community was inhibited as it was not possible to encourage private capital to build houses and other facilities as arrangements could not be made to permit ownership of land. There is insufficient housing development in the area to keep pace with the needs of the project, and the Company has been required to continually build additional housing.

Last year, after a critical review of the future of the project, it was decided that immediate steps should be taken to establish a municipal set-up. Discussions were held with the Provincial authorities, and it was indicated by them that, providing appropriate arrangements could be made, the village could be incorporated as a Local Improvement District. Subsequently, the matter was presented to The Honourable Treasury Board, and approval was given to proceed along the following lines:

(a) The Company was authorized to take steps immediately to terminate ownership and management of Deep River in a manner which would not impede the Atomic Energy Project at Chalk River.

(b) The Company was authorized to enter into arrangements with the Province of Ontario for the formation of a municipality to encompass the village of Deep River as well as the Federally-owned property on which the Atomic energy Project at Chalk River is located and to assist in this plan—

(1) to transfer without charge to the municipality such of the existing municipal facilities and services as are necessary to permit the municipality to meet Deep River needs for adequate schooling, utility and other services.

(2) to enter into arrangements with the new municipality for payment by the Company in lieu of taxes on those Company facilities within the municipality which would be taxable were such land and facilities privately owned.

(c) The Company was authorized to begin a program of selling its houses in Deep River to Deep River residents or other persons directly associated with the Atomic Energy Project.

Subsequently, negotiations were entered into with the Department of Municipal Affairs, Province of Ontario, in which details in keeping with the above instructions were developed. On November 3, 1955, The Ontario Municipal Board held a hearing in Deep River at which an application was made to have the area incorporated as an Improvement District. The Board rendered a decision on April 8, establishing as of April 16 the Improvement District of Deep River with town status to encompass the existing Company town area, the plant property, and some private property.

At the same time, details of the house sale plan were developed and made known to the residents of Deep River. Consideration was also given to the sale of commercial premises and arrangements made for an independent appraisal. The sale program will commence as soon as the lots are surveyed and registered in the Registry Office.

The Company are of the opinion that the arrangement is sound and one which will permit the operation of Deep River in a satisfactory manner. It is naturally of great importance to the project that Deep River remain an attractive community in order that scientific and other skilled staff may be attracted and retained. The Department of Municipal Affairs, Province of Ontario, has been very cooperative and helpful, and with their assistance an orderly development of the community should take place. There has been considerable interest already demonstrated in house purchase and also in house construction.

The municipal organization has just begun to function, and as quickly as possible the changeover to full municipal operation will take place.

In the meantime, the Company continues to operate the family housing and single accommodation, and associated services in Deep River. The extent to which the Company will remain in this operation will depend directly on the house sales program and the development of Deep River in future years.

APPENDIX XII

COMMERCIAL PRODUCTS DIVISION

Manager—Mr. R. F. Errington		Branches:	Works
Staff	—Professionals 36		Production
	—Others 140		Development
			Special Assignment
			Sales
			Administration

The activities of the Commercial Products Division of Atomic Energy of Canada Limited are fairly well indicated by the name.

Due to the nature of the work involved the Division operates somewhat as a financial entity within the Company. It resembles operation of a subsidiary. This approach simplifies the doing of commercial business with customers and also keeps a "Divisional cost incentive" continuously in front of Management. It is our opinion that this "Cost Incentive" does and will make for a better choice of work to be done and a better quality of accomplishment. The Division maintains its own record of assets and carries on accounting and other operations on a straight commercial basis.

Very little competition exists between the Commercial Products Division and private industry in Canada, but active competition is apparent on the export market. A large export market is both desirable and necessary in the interest of keeping down costs and consequently prices to Canadian users.

The Commercial Products Division was originally a part of Eldorado Mining & Refining Limited at which time it was primarily concerned with the processing and sale of radium and radium products. With the advent of radioisotopes produced in the high flux reactor at Chalk River the Division was, in August 1952, transferred to Atomic Energy of Canada Limited.

Its objective and responsibility since that time has been to provide a good service (in radioisotopes) to Canadian users and generally to expand the business in order to place distribution on an economic footing. The type of commodity being new and the market small it was obviously desirable to stimulate interests in Canada and in other countries by the carrying on of some applied research into the applications of radioisotopes. The processing and distribution of radium (as an allied commodity) has been completely taken over from Eldorado by the Commercial Products Division because of the obvious similarity in facilities and personnel required to carry on the work and because of Eldorado's diminishing interest in the field.

At the time of transfer of the Division (August 1952) it was recognized that circumstances did not permit of an operation which could be immediately profitable and it was expected that this condition would continue for at least several years. In fact there was no assurance of the operation ever making profits.

The commercial outlook of the Division combined with a modest long-term development program and assisted by a co-operative and progressive approach by the Company at Chalk River, has made possible a continuously expanding program and a gradually improving economic position. The volume of business has continuously increased from an average of about $50,000 per month in 1952 to an average of $125,000 per month in 1955. In the 3½ year period losses occurred in the first part and modest profits since, so that the overall position has been "break even".

In order to carry on the work required, the Division is divided into the several necessary groups as Administration, Development, Chemical Production, Engineering Production, and Sales. The responsibilities of these departments are fairly obvious.

Business is obtained in Canada and the United States by mail and by personal contact. In other countries the same methods are used but these are supplemented where practical by the use of local sales agents operating on a commission basis. Orders are referred to the appropriate producing department for completion. If an order requires a pile irradiation the irradiation is specified to Chalk River groups. Final shipment and invoicing is done by Commercial Products Division.

Our business consists of isotopes (including radium) and equipment accessory to their use. Isotopes are generally thought of as being artificially produced and radioactive. They are not necessarily either. All isotopes of any element have the same atomic number but different atomic weights. The difference between isotopes of the same element is in the neutron make-up of the nucleus. The term "isotope" was derived from the Greek word for "same place" since isotopes of an element occupy the same place in the periodic table of elements.

The isotopes which the Commercial Products Division offers for sale are mostly radioactive. They are generally produced either by fission in the normal burn up of uranium in a reactor (and subsequently separated by chemical means) or by the capture of neutrons when a target material is inserted in a reactor for irradiation. They are useful because of their instability which permits them to disintegrate at a known rate and give off radiation. This radiation, which may be alpha, beta, or gamma can be measured accurately and hence small quantities make possible very accurate "tracer" tests. Gamma radiation is penetrating and this property permits numerous applications such as radiography of metal and tracing of stoppages in pipelines. Radiation is attenuated by absorbing materials and hence its application to therapy where the process of attenuation absorbs energy in the tissue thus breaking down the cell structure. Fortunately cancerous tissue is more radiosensitive than ordinary tissue. If the process of therapy treatments with radiation is properly controlled the replacement of destroyed cells with healthy tissue will proceed normally. Radiation is a well known method of treating cancer but is not a cure-all.

Some isotopes decay slowly and thus have a long "half-life". These can and are produced in advance and kept on hand for prompt shipment. Others have short half lives and must be produced as required. The range is from seconds to thousands of years. All of the isotopes which we offer for sale are classified in our catalogue according to type of radiation, and length of life. This assists customers in the selection of an isotope for a particular application. For example, a customer wishes to trace the movement of some reagent in a chemical or other process, he selects an isotope which, in a suitable chemical form will behave in the same manner as the reagent. The isotope must also have a half life suitable to any resulting disposal problem and it must provide a type of radiation which will permit of its adequate detection without introducing expensive radiation protection problems. For many processes such a selection can be made with resulting savings in operating costs obtained.

Some isotopes with examples of uses in research and industry are listed below:—

ALPHA EMITTERS

Radium, Polonium, Radium D—Actinium, Radiothorium

1. Neutron Sources	Activation analysis Petroleum well logging Soil moisture meters
2. Ionization	Static elimination Conductivity of gases

BETA EMITTERS

Strontium 90, Phosphorus 32, Thallium 204, Calcium 45, Promethium 147, Sulphur 35, Carbon 14, Tritium

1. Tracers	Fertilizer uptake experiments Related to type of soil, time of application, etc. Wear tests—lubrication tests
2. Ionization	Static elimination Voltage regulator tubes
3. Sources of Energy	Thickness gauges Polymerization Sterilization Therapy
4. Miscellaneous	Luminous compound Radioactive batteries

GAMMA EMITTERS

Cobalt 60, Sodium 24, Antimony 124, Thulium 170, Caesium 134, 137, Tantalum 182, Gold 198, Iodine 131, Iridium 192

1. Penetration	Radiography Thickness control Narrow beam inspection Pipe line pigs Liquid level gauges and controllers
2. Source of Energy	Sterilization and pasteurization Catalyst Photo neutron sources Therapy Irradiation of plastics
3. Tracers	Tagged mail carriers Tagged fish Pine weevils, mosquitos Oil soluble iodine for tracer work, acid treatment of wells Vitamin B. 12 tagging
4. Genetic Changes	Irradiation of plants

For therapy those isotopes providing beta and/or gamma radiation are the most widely used. They include phosphorus 32, strontium 90, sulphur 35, caesium 134, caesium 137, cobalt 60 and gold 198. By far the most important of these is cobalt 60. It has a practical half life (5·3 years) and fairly high energy 1·2 Mev. and can be produced economically by irradiation of ordinary cobalt 59.

We might come back to the matter of development leading to expanded uses of isotopes. A number of small development programs have been undertaken from time to time. The most important of our development programs up to now was the design of a Cobalt Therapy Equipment intended to use large strength sources of Cobalt 60. The early work on this was done while the Division was still in Eldorado Mining & Refining Limited. Further improvements have been added and the usefulness and markets have grown to the extent that last year about 70% of our business was in the field of such machines and sources. These equipments are competitive with high voltage X-Ray machines and hence it fell on this Division to pioneer the field. About three years after delivery of our first equipment, competitive companies in the United States made their first delivery. At present several companies in the United States offer equipments and a number of companies in Europe have completed development of others. This competition in the field is healthy and will no doubt serve to stimulate a more general acceptance of such machines. NRX being inoperative for about a year at a very critical time in this program gave us a very severe set-back from which we are now recovering. In this field, Canada still leads all other countries in numbers of equipments sold and in quantity of Cobalt 60 sold. The pressure of import duty (on machines) and private competition in the United States has already limited us to only a share of that market which is of course the largest single market for such machines.

Atomic Energy of Canada Limited's machines are now installed in the locations listed below and many more are on order, only awaiting production of sufficient cobalt 60.

ELDORADO MODEL

Hospital	*Completion Date*
Victoria Hospital, London, Ontario.	October 18, 1951
British Columbia Cancer Institute, 2656 Heather Street, Vancouver, B.C.	September 10, 1952
Montefiore Hospital, Gun Hill Road Nr. Jerome Ave., New York, New York.	November 30, 1952
Manitoba Cancer Institute, 442 Williams Avenue, Winnipeg, Manitoba.	March 10, 1953
University of Minnesota Hospital, Minneapolis, Minnesota.	March 30, 1953
Cook County Hospital, Chicago, Illinois.	June 12, 1953
Toronto, General Hospital, Ontario Cancer Foundation, Toronto Clinic, Toronto, Ontario.	September 30, 1953
Ospedale Civile "S. Lorenzo", Centro Tumouri del Trentino, Borgo Valsurgana, Italy.	October 11, 1953
Hamilton General Hospital, Barton Street, Hamilton, Ontario.	March 19, 1954

ELDORADO MODEL—*Conc.*

Hospital	*Completion Date*
Ontario Cancer Foundation, Thunder Bay Clinic, General Hospital of Port Arthur, Port Arthur, Ontario.	April 23, 1954
Edmonton Cancer Clinic, 11250-84th Avenue, Edmonton, Alberta.	May 1, 1954
Centro Italiano di Radiocobaltoterapia, Clinica "R. Bastianelli", Viale Reg. Margherita 277, Rome, Italy.	November 13, 1954
St. Luke's Hospital, Morningside Heights, Amsterdam Avenue & 113th Street, New York, New York.	November 15, 1954
Centre Chirurgical Henri Hartmann, 26 Blvd Victor Hugo, Paris, France.	February 1955
Centro Lombardo di Telecobalterapia, Nuova Casa di Cura, Lecco, Italy.	April 1955
Dr. Oslando J. Machado, Av. Graca Aranha, 333 Sls. 209-210, Rio de Janeiro, Brazil.	May 1955
Penrose Cancer Hospital, 2200 North Cascade Avenue, Colorado Springs, Colorado.	March 1955
Chattanooga Tumor Clinic, Erlanger Hospital, Chattanooga, Tenn.	November 1955
Clinica Orestano, Palermo, Sicily.	January 1956
Societa Medico Salernitana di Radiocobaltoterapia, Salerno, Italy.	March 1956
Canton of Geneva, Centre de Telecobaltherapie, Geneva, Switzerland.	March 1956

THERATRON MODEL

Hospital	*Completion Date*
Francis Delafield Hospital, 99 Fort Washington Avenue, New York 32, New York.	May 28, 1953
Mount Vernon Hospital & Radium Institute, Northwood, Middlesex, England.	October 1, 1953
Memorial Centre for Cancer & Allied Diseases, 444 East 68th Street, New York 21, New York.	October 8, 1953
Lankenau Hospital Research Inst., 7701 Burholme Avenue, Philadelphia 11, Pa.	December 7, 1953
Lovelace Clinic, 4800 Gibson Boulevard, Albuquerque, New Mexico.	December 22, 1953
Metropolitan Hospital, 1687 Wyandotte Street, Windsor, Ontario.	July 26, 1954
Henry Ford Hospital, 2977 Grand Boulevard, Detroit, Michigan.	November 1954

THERATRON MODEL—*Conc.*

Hospital	*Completion Date*
Hartford Hospital, Hartford, Connecticut.	November 1954
Alleghany General Hospital, Pittsburgh, Pa.	December 1954
University of Michigan Hospital, Ann Arbor, Michigan.	January 1955
U.C.L.A. Medical School, Los Angeles, California.	February 1955
Groupement d'Importation de Produits, destinés à la Droguerie, Pharmaceutique et la Pharmacia, c/o Institute Gustave Roussy, Villejuif, Seine, Paris, France.	April 1955
University of Michigan Hospital, Ann Arbor, Michigan.	June 1955
Baylor University Hospital, 3500 Gaston Avenue, Dallas, Texas.	August 1955
Notre Dame Hospital, 1560 Sherbrooke Street, Montreal, Quebec.	September 1955
Ontario Cancer Foundation, Ottawa Civic Hospital, Carling Avenue, Ottawa, Ontario.	November 1955
Mercy Hospital, Miami Florida.	December 1955
Clinica Regina, Rome, Italy.	February 1956
Foundation Curie, 26 Rue d'Ulm, Paris, Ve, France.	February 1956
Ontario Cancer Foundation, Kingston Clinic, King Street, West, Kingston, Ontario.	March 1956
Butterworth Hospital, Grand Rapids 3, Michigan.	March 1956

Important development programs now underway or nearing completion include production of Actinium 227, a new model of therapy machine and design of a cobalt 60 radiography machine for industrial use.

Actinium 227 is a good alpha emitter of fairly long half life (22 years). It occurs in nature, but is not economically available from existing processes. It can also be produced by irradiating radium (itself a radioactive material) and subsequent chemical extraction. There is evidence that actinium 227 will be well received for the logging of petroleum bore holes. This, of course, means that it must be suitably combined with beryllium powder so that the alpha radiation produces secondary neutrons useful in the logging process. We expect to have this program underway this year.

A third design of Cobalt therapy equipment is now well advanced. It should fill many of the purposes of present machines at a somewhat lower cost. Further designs of machines to use cobalt or other isotopes may be expected at the appropriate time.

A Cobalt 60 radiography machine is now in an advanced stage of development. It should take the place of expensive high energy X-ray machines now used in foundries and steel working plants. About 500 curies of Cobalt will be used in each such machine.

Over the past one or two years much interest has been shown in the use of large gamma radiation sources for sterilization of foods, drugs or other materials, to inhibit sprouting of potatoes in storage, to kill weevils and similar pests in stored grain, and to produce desirable chemical reactions in the processing of certain petroleum and plastic products. This new field is receiving attention within our means both in terms of keeping abreast of possibilities, and in the supplying of experimental sources of low specific activity to universities and private companies doing work in the field. Considerable business has developed in this type of cobalt which can be produced in large quantity without interfering with cobalt production for therapy machines.

The result is that this Division ships more curies or radioisotopes per year than either the United States or the United Kingdom and possibly as much as the two combined.

The value of the isotopes program to the Canadian economy is difficult to assess with accuracy. From the point of view of the distributor (ourselves) it represents about $1,500,000 of business at present with employment for some 200 people. This may well grow in a few years to several times the present level. The principal value is in the savings to Canadian organizations using the isotopes. Data given in the United States indicates that industry saves annually about ·1% of the Gross National Product as a result of the use of isotopes. A similar figure is probably applicable in Canada and hence we assume that isotopes have an annual value to Canadian industry of about $26,000,000. The value of isotopes used in therapy may not be easily calculated in dollars.

Many programs are underway in Government laboratories and in private industry. As these develop the need for isotopes will grow.

Our policy is to interest as many organizations as possible in doing their own development and subsequent manufacturing of accessory equipment if this is indicated. We, being small can only hope to point the way for others to throw in their efforts and carry on.

APPENDIX XIII

PUBLIC RELATIONS OFFICE

Officer in Charge—Mr. C. C. E. Kennedy

The Public Relations Office distributes general information on the activities of Atomic Energy of Canada Limited, produces booklets describing the reactors and the work of the various laboratories, answers queries from the public, addresses or arranges speakers for service clubs and similar non-technical groups, arranges tours of the Chalk River project for a variety of visitors and shows many of these visitors around the plant, and assist radio, movie and television groups to produce films and broadcasts. The office puts special emphasis on assisting newspapers and other publications in not only gathering information but also putting this information into a form understandable to the layman. Exhibits are prepared for Canadian and foreign conferences and exhibitions.

Visitors

During the past 12 months, 1,700 people visited the project. This total does not include such people as sales representatives and maintenance men.

Representatives of every major industry in Canada have visited the project and most of the universities have sent individuals or small groups to visit the laboratories.

Some idea of the variety of groups visiting the project and their sizes is given by the following partial list:

Canadian Institute of Mining and Metallurgy (67)
Canadian Weekly Newspapers Association (25)
Canadian Managing Editors' Conference (8)
Rotary and Kiwanis Clubs, Pembroke (54)
National Employment Service (79)
Canadian Pulp and Paper Association (23)
Renfrew County Medical Society (12)
Ontario Cancer Treatment and Research Foundation (30)
Canadian Legion (6)
Toronto High School Students (19)
International Joint Commission (28)

Technical and diplomatic visitors have come to Chalk River from many countries. During the past year, for example, the following foreign countries sent representatives: United Kingdom, United States, Belgium, Japan, India, Switzerland, Israel, France, South Africa, Pakistan, Germany, New Zealand, Netherlands, Burma, Australia, Brazil, Egypt, Spain, Sweden and Nationalist China.

A group of 250 members of the Toronto Board of Trade has been invited to visit the project next September.

Newspapermen and television crews are encouraged to visit the project, with the policy being to urge writers to produce articles based on personal visits rather than solely on material prepared by the Public Relations Office.

Members of the Canadian Managing Editors' Conference, which represents all the daily newspapers in Canada, were invited last year and this year to visit the project and 14 managing editors have done so. These newspaper executives have been invited to send their reporters to the project at any time. Forty-eight press representatives visited the plant during the past year.

Ten crews have shot movies of the project: four from CBC, three from the National Film Board, and three from private companies. Eight still photographers have taken their own pictures in the plant: two from the National Film Board, two from the Canadian Army, and four from newspapers.

These totals do not include the movie and still photographers who took pictures during the visit of the Duke of Edinburgh to Chalk River.

Exhibits

The most extensive exhibit presented to date was that shown at the International Conference on the Peaceful Uses of Atomic Energy, Geneva, August 8 to 20, 1955. It covered, 1,150 square feet and included models of the Chalk River reactors, actual Cobalt-60 Beam Therapy Units (the Eldorado and the Theratron types), and display panels describing the Canadian program.

A public exhibit covering 800 square feet of space was shown in Toronto March 3, 4 and 5, 1956.

An NRX model together with photographs of Chalk River were shown in Paris during March of this year and were then sent with a UNESCO exhibit to various countries in the Far East.

An exhibit was shown at the international exhibition held in Washington September 26, to 30, 1955, by Atomic Industrial Forum. This included models of the NRX and NPD reactors, and panels describing the Canadian program.

An NRX model together which actual sections of reactor fuel rods and various display panels were shown May 9, 10 and 11, 1956 at the Ottawa Civic Hospital clinic of the Ontario Cancer Treatment and Research Foundation. The exhibit was left in place until May 24 to allow various groups to see it after the official opening activities of the Foundation.

The larger exhibits include not only realistic models—and sometimes actual cancer therapy units—but also photographs that show extensive detail of the reactors and actual blueprints of the reactors and fuel rods. Sections of uranium fuel rods are displayed with the diagrams and pieces of shielding (such as the "heavy" concrete containing magnetite and ilmenite) and flasks of heavy water give visitors an opportunity to see the main ingredients of an atomic energy program.

Cloud chambers illustrate the various types of radiation given off from such material as radium and strontium-90.

Publications

The Public Relations Office has produced, or has sent to press, the following publications:

1. *Atomic Energy in Canada, 1955*—This 72-page booklet was produced for the International Conference on the Peaceful Uses of Atomic Energy and has proved so popular that it has gone out of print. It was distributed to some 3,000 delegates and representatives of 74 countries at the Geneva conference, to newspapers and other publications throughout Canada, and to a wide variety of other people requesting information on the Canadian program.

2. *Atomic Energy in Canada, 1956*—This 92-page booklet is now in press. A new feature of the publication is a section on "The 'ABC's' of Atomic Energy" which describes in simple language the fission process, reactor fuel, heavy water, and the principle of operation of reactors with emphasis on atomic power.

3. *Understanding Atomic Power*—This 24-page booklet, now in press, describes in layman's language why uranium gets hot in a reactor and how this heat is used to produce steam for driving electricity generating equipment. It includes a description of NPD, Canada's first atomic power station.

4. *Opportunities in Atomic Energy*—A 70-page employment booklet designed particularly to give university students a picture of the various activities of the Chalk River project, this publication emphasizes work of individual divisions and branches.

5. *A Bibliography of Atomic Power and Related Atomic Energy Topics for the Non-Specialist*—An 87-page booklet containing brief description of books on a variety of atomic energy subjects. Last published in May, 1954, it is now being revised.

Press releases are issued when major developments take place. However, as mentioned, the general policy is to keep releases to a minimum and to encourage newspaper and magazine representatives to visit the project to get a first hand account of the program.

The more important addresses by A. E. C. L. staff are printed and distributed to a mailing list.

Photographs and Illustrations

A total of 833 photographs are available from the Public Relations Office catalogues. These were all taken with a view to satisfying the requirements of the non-technical and the trade publications. Prints of about half this number are kept on file so that they can be supplied immediately upon request. As the others are asked for less frequently or are for more specialized types of articles, prints are made only upon request.

One hundred schematic diagrams—such as simplified drawings showing the principle of operation of the various reactors—have been designed by the Public Relations Office and have been produced with the assistance of the drafting office. They are available to any publication wishing to illustrate articles.

Thousands of illustrations are sent out each year to publications in Canada and in many foreign countries.

Addresses and Broadcasts

The Public Relations Office gives addresses to service clubs and other non-technical groups and arranges other speakers for such groups and for radio broadcasts.

During the past year A. E. C. L. Staff presented 70 addresses in addition to the various papers presented to technical conferences. In addition to "performing" at Chalk River, A. E. C. L. staff appeared in a variety of radio and television programs originating outside the plant.

APPENDIX XIV

CANADA'S FIRST ATOMIC POWER PLANT

by

I. F. McRae, Vice-President, Canadian General Electric Co. Ltd.

In 1954 a nuclear power group was organized at Chalk River for the purpose of preparing a preliminary design of a small nuclear power plant. This group was recruited from electric utilities and engineering firms across Canada and was backed up with the services of nuclear scientists on the staff of atomic energy of Canada Limited. The group completed their study in April 1955 and presented their report known officially as N.P.G.-5. This report of course did not incorporate a detailed design of a nuclear power plant but it did provide sufficient information for a general assessment of the physical and operational characteristics of such a plant. As Mr. W. J. Bennett stated in his speech to the Toronto Board of Trade in the spring of 1955 it was the intention of A.E.C.L. To turn over the development and design of the first nuclear power plant to industry. A.E.C.L. scientists and engineers had developed most of the nuclear background for such a plant through their work with the various research reactors at Chalk River and it was felt that they should continue this fundamental and applied research and leave the development of commercial nuclear power to industry. In keeping with this policy various manufacturers were invited to quote on the development, design and construction of this first nuclear plant on a competitive basis. Canadian General Electric Company were one of a half dozen firms bidding for this contract and were successful in convincing A.E.C.L. That their long-term interest in the development of such plants, their engineering background and skills, and extensive manufacturing facilities warranted their being entrusted with the design and erection of this first nuclear power plant. Starting last spring, C.G.E. set up a civilian atomic power department to which they assigned some of their outstanding engineers and administrators. In addition A.E.C.L. made available to them a number of key engineering personnel with substantial nuclear background. This select team has been augmented with technicians and draftsmen and is now engaged in the detailed design of the 20,000 kilowatt nuclear electric power plant. Aside from its contribution of a carefully selected engineering staff, C.G.E. will contribute up to $2,000,000 towards the development and design of this first nuclear plant. A development laboratory for specialized reactor work is now under construction in Peterborough works occupying part of the building housing the civilian atomic power department. This laboratory will check the various mechanical and hydraulic aspects of fuel rod design—radiation testing will be carried out in the research reactors at Chalk River.

The success of Canada's first nuclear power reactor rests squarely on the shoulders of three organizations. First, A.E.C.L. are providing the background of nuclear research information on which the whole project is founded and as well are providing the funds for building the reactor section of the plant. Ontario Hydro are performing the consulting engineering services on the conventional end of the plant, are providing the site at Des Joachims and the funds for building and equipping the conventional end of the plant and will operate the whole plant as part of their generating system. In addition to their considerable financial contribution to the project, Canadian General Electric are designing the nuclear end of the plant and are responsible for the provision, construction, installation and testing of all the equipment in the plant and placing it in a "ready to run" condition. In other words, C.G.E. are serving as prime contractor in addition to their design and manufacturing duties.

The NPD power plant will consist of a heavy water reactor delivering heat to a steam generator to operate a conventional turbo-generator set. The reactor will use natural uranium fuel and will have many features in common with the NRX and NRU reactors. However, it differs from them fundamentally in other respects. The relatively high operating pressures adopted for efficient power generation require that the reactor be housed in a heavy pressure shell. The absence of experimental facilities permits the reactor to be located underground and completely changes its appearance. Because the costs will be used in estimating the costs of power from future large reactors, every effort consistent with the production of a single unit is being made to keep down the capital cost.

A steel pressure vessel 11½ feet diameter and about 30 feet high will house the reacting core, the coolant headers and associated parts. In an emergency shut-down, the heavy water moderator falls into a space in the lower end of the vessel. The core will be arranged much like that of the NRX reactor except that there will be only a little over 100 fuel rod assemblies. There is no aluminum calandria. Each fuel assembly will consist of 19 zirconium tubes filled with sintered uranium oxide pellets. Sintered oxide has the great advantage over metal that it does not react with hot water or steam, and minor flaws in the sheath will not result in disintegration of the fuel element.

Consideration will be given to the eventual use of thorium oxide fuel elements enriched with U235 or plutonium to determine the possibility of breeding U233 in this type of reactor. Greatly extended radiation times could result. The NPD reactor will provide excellent facilities for proving statistically new materials and designs of fuel rods.

The control of all solid fuel reactors built to date has been at least partly by means of rods of some neutron-absorbing material which are moved in and out of the reactor mechanically. These are difficult to design, expensive, and their failure was instrumental in causing the 1952 breakdown of the NRX reactor. The primary control and emergency shut-down of the NPD reactor will be by means of the heavy water level and no control or shut-off rods will be used. The reactor core vessel may be likened to a tumbler filled with water inverted in a saucer; emergency shut-down is accomplished by breaking the vacuum and allowing the water to fall out rapidly which immediately shuts down the reactor. Normally, the level will be controlled by adjusting the rate at which heavy water is pumped into the core; it is arranged to drain out at a constant low rate. A slow-acting control to compensate for reactivity changes such as occur when the fuel deteriorates takes the form of moderator temperature control, the heat developed in the moderator being normally used for feed water heating. The automatic control elements associated with this system will have some features in common with that of NRU, but will be considerably simpler because of the absence of the requirement to operate many control rods in sequence. In operation, the control system will be actuated by the steam pressure to the turbine, maintaining this at a constant value.

The heat generated in the reactor is carried to a steam generator in the form of a heat exchanger by means of a heavy water circulating system, much as in the NRU reactor. The main difference is that this system operates at about 500°F. and 950 pounds per square inch pressure. Steam is generated from ordinary water at 425 p.s.i. and goes direct to a 20,000 kw turbine. No superheater is used in this plant because it was felt that it would not further any of the stated objectives and would add to the complication and first cost. The use of an oil-fired superheater for this plant would provide the opportunity of burning oil with a thermal efficiency of about 45% without affecting the efficiency of the nuclear part of the plant. Superheaters of some form will very likely be components of larger plants.

The first slide shows a cross-section of the power station. You can see that the reactor hall is empty; it is required for maintenance purposes only. A wall with removable panels separates it from the turbine room so that the two 25 ton cranes can be used together during construction and major maintenance operations, but all radioactive components will remain on one side of it. The vaults containing the reactor, the main and moderator coolant pumps, the steam generator, and the rod changing room will be inaccessible while the reactor is operating, but the turbine and condenser rooms will have normal access at all times. These vaults also form secondary containment shells in case of radioactive leakage, and make maximum use of the bed rock for shielding purposes.

After careful consideration of a number of alternative sites, one has been selected at the Des Joachims Generating Station a dozen miles up the Ottawa River from here (i.e. from Deep River). It is convenient to the village of Rolphton and hydro maintenance facilities on the one hand, and to the Chalk River staff, active waste disposal, and other special facilities on the other. The site provides a solid rock foundation, good cooling water, simple connection to the hydro system, with reliable station power supplies and adequate isolation. The second slide shows an artist's conception of the power plant in its surroundings.

A staff of about 70 persons is now well advanced in the design of the reactor in Peterborough. Tenders have been requested for the major components. The layout of the building has been agreed upon with the architectural group of the hydro, steel for the building has been ordered and we hope to be able to start work at the plant site in August. A high pressure experimental set-up will be operating in Peterborough in July to check the hydraulic and corrosion characteristics of the fuel elements. Prototype fuel elements will be irradiated in the NRX reactor commencing in September. Completion of the plant is scheduled for mid 1959.

Now that we have looked at the plans for Canada's first reactor power plant let me review the reasons why so much money and technical effort are being expended on this project. The objectives briefly are as follows:

1. To demonstrate the practicability and reliability of nuclear power from essentially natural uranium.
2. To provide cost data which may be used for estimating the costs of 100 to 200 M.W. power plants.
3. To provide statistical data on the performance of various types of fuel assemblies.
4. To provide a training ground for atomic power station operators and associated types of personnel.
5. To demonstrate the practicability of a nuclear reactor generating power for use in a large electrical system.

It is needless for me to point out that the economic welfare of any country —its standard of life—depends on its supply of energy. Canada's present position with its standard of living second only to that of the United States, has been founded on its abundant supply of low-cost hydro power. We are nearing the end of our hydro resources in some parts of the country, and, with the greatly increasing demand for electrical energy throughout Canada, it is essential that we do not lag in the development of man's greatest energy resource—nuclear power.

Before the end of next year Canada will lead the world in the production of uranium. The reactor I have just described will use natural Canadian uranium. It is obvious therefore that the success of this nuclear power demonstration project will have an important and direct bearing, not only on our electric utilities and in industries dependent on them for power— it will also be of major importance to our mining industry.

Nuclear power cannot compete today with either hydro or fossil-fuelled plants. The tremendous resources of engineering knowledge focussed on nuclear power development, however, will doubtless solve the many present difficulties and the day will not be far off when units of 100,000 kw. and larger will compete with conventional thermal plants in Canada. Speaking for C.G.E., let me assure you that we are very happy to be engaged in this historic development. There are serious problems to contend with as your visit here today will have made clear. We are confident, however, that in collaboration with A.E.C.L. and Ontario Hydro these problems will be solved.

HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 10

ATOMIC ENERGY OF CANADA LIMITED
ELDORADO MINING AND REFINING LIMITED

THURSDAY, JUNE 7, 1956

WITNESSES:

Mr. W. G. Bennett, O.B.E., LL.D., President, Atomic Energy of Canada Limited and President and Managing Director of Eldorado Mining and Refining Limited. Mr. Donald Watson, Secretary of the former Corporaticn.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956

75407—1

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McIlraith, Esq.
and Messrs.

Bourget
Brooks
Byrne
Coldwell
Dickey
Forgie
Green
Hardie
Harrison
Hosking
Leduc (*Verdun*)
Low
MacLean
Murphy (*Lambton West*)
Richardson
Stewart (*Winnipeg North*)
Stick
Stuart (*Charlotte*)
Weaver—(20).

(Quorum 9)

Antonio Plouffe,
Acting Clerk of the Committee.

MINUTES OF PROCEEDINGS

THURSDAY, June 7, 1956.

The Special Committee on Research met this day at 10.50 a.m. Mr. G. J. McIlraith, Chairman, presided.

Members present: Messrs. Dickey, Forgie, Green, Hardie, Hosking, Leduc, (*Verdun*), Low, McIlraith, Richardson, Stick and Weaver.

In attendance: Mr. W. G. Bennett, O.B.E., LL.d., President and Managing Director, Eldorado Mining and Refining Limited, and President, Atomic Energy of Canada Limited; Mr. Donald Watson, Secretary, Atomic Energy of Canada Limited; and Mr. R. C. Powell, Secretary, Eldorado Mining and Refining Limited.

Mr. Bennett was called. He was examined at some considerable length on the statement he made at the previous meeting. He was assisted by Mr. Watson in replying to certain specific questions.

At 11.45 a.m., Mr. Weaver, Vice-chairman, assumed the Chair.

Mr. Bennett, in anticipation of the Committee's visit to the Chalk River plant, tabled a second brief dealing with raw materials. He also filed with the clerk the following appendices:

(1) Uranium Mining in Canada
(2) Canadian Practice in Uranium Recovery Plants
(3) Research Activities
(4) Refinery Operation
(5) Organization Chart, Eldorado Mining and Refining Limited
(6) Organization Chart of Atomic Energy of Canada Limited
(*NOTE: This chart was tabled at the previous meeting but was not printed.*)
(7) Comparison of Typical Power Reactors

(*NOTE: This chart was tabled at the previous meeting but was not printed.*)

On motion of Mr. Hardie, the above brief was taken as read and ordered printed in the evidence with the above-mentioned appendices. (*See this day's evidence.*)

At 12.15 p.m. Mr. McIlraith, having returned, took the Chair.

At 12.30 p.m. the Committee, having concluded Mr. Bennett's examination, on motion of Mr. Weaver, resolved itself into an executive session.

The Committee discussed the proposed visit to the Chalk River plant on June 11 and 12 next and Mr. Bennett outlined a tentative program therefor.

At 12.55 p.m. on motion of Mr. Hosking, the Committee adjourned to the call of the Chair.

Antonio Plouffe,
Acting Clerk of the Committee.

75407—1½

EVIDENCE

June 7, 1956,
10.30 A.M.

The CHAIRMAN: Gentlemen, I see a quorum. At the last meeting at the outset of the presentation, Mr. Bennett stated that he was proposing to discuss the program of atomic energy under two headings: research and development directed towards the peaceful application of atomic energy; and the raw materials. We had his presentation on the first heading, the research and development, and today we can either proceed to question him on that part of his presentation, or we can proceed to have him make his presentation on the subject of raw materials. It is just as you wish.

Mr. GREEN: Mr. Chairman, in view of the fact that we are going to Chalk River on Monday, I think perhaps it might be well to deal with the submission which was made last week. As I understand it the next submission deals with the production of uranium.

W. J. Bennett, O.B.E., LL.D., President, and Managing Director, Atomic Energy of Canada Limited, President, Eldorado Mining and Refining Limited, called:

The WITNESS: That is right.

The CHAIRMAN: We will proceed as you wish.

Mr. DICKEY: Why not start with the questions on the submission of last week and see how long the members want to deal with it; then see if we have time for the other later.

The CHAIRMAN: Is that your wish?

Some Hon. MEMBERS: Agreed.

The CHAIRMAN: Mr. Bennett is available for questioning.

Mr. HOSKING: I wonder if he would explain to us what a reactor is and how it works?

The WITNESS: Before answering that, I should point out first, as I did in my brief, like most of you here I am a layman in this business. I am not trying to evade answering the question, but I think we can give you a more expert explanation at Chalk River.

One of the things we are proposing to do, in fact it is the first item on the program, is to have a description and an inspection of the Zeep reactor, the NRX reactor and the NRU reactor.

This word "reactor" has been adopted generally now in this business. I am not too sure that it is a very apt word in describing what takes place. However, it is the word that is commonly used, a reactor briefly, and in layman's language, is the structure in which the nuclear fission takes place. It consists in the main of a reactor vessel which is the container for the uranium fuel and the moderator. The fuel can either be natural uranium or enriched uranium, and the moderator can be a number of things: graphite; heavy water; light water under pressure and so on. It also consists of an outer structure which is made up, in the main, of shielding, concrete. This is to shield the operators from radiation that is produced when the fission takes place. I do not know whether that answers the question adequately at this point or not.

By Mr. Hosking:

Q. Would it be comparable to a boiler using coal? Is it a furnace type of thing?—A. Yes, it is. That is right. In the way in which we propose to use it for the generation of power it certainly corresponds to the boiler of a coal-fired generating station, or an oil-fired generating station. In other words it is the heat box of the power plant.

By Mr. Forgie:

Q. This question will show how little I know about this subject, but what causes fission to take place?—A. This is a question I am going to pass on to Mr. Watson.

Mr. GREEN: Is not Chalk River in your riding?

Mr. FORGIE: Yes, it is in my riding but—

Mr. DICKEY: There are several kinds of fissions in his riding.

The WITNESS: Again, I could give you a layman's answer to this question, but since we have a physicist here, I think I will pass the question on to him.

Mr. DONALD WATSON (*Secretary, Atomic Energy of Canada Limited*): Natural uranium consists of two distinct blends of uranium, one of which is known as uranium 238, and the other known as uranium 235. The fraction of the content which is uranium 235 is one part in 140, in other words 0·7 per cent. This uranium 235 when hit by a slow neutron disintegrates or fissions. It also shoots off neutrons, small particles which are contained in the nucleus. It is the only naturally occuring fissionable substance. If these neutrons are slowed down to a certain velocity, and if they hit other uranium 235 nuclei which are also in the fuel, this causes them to split too, or the uranium 238 can add a neutron, and eventually become a new substance known as plutonium.

Mr. STICK: Where do you get the heat from?

Mr. WATSON: When uranium splits in two the particles are, so to speak, blown apart. These particles are contained in the material and are brought to rest by the other atoms. As you know, if you hit something hard you generate heat.

Mr. STICK: You get friction and you get heat?

Mr. WATSON: Yes.

Mr. STICK: And the controlling of this heat is essential for a power plant?

Mr. WATSON: Controlling the heat is very essential, not only for that reason, but in order to keep the temperature of the reactor within bounds.

Mr. HOSKING: How hot does it get?

Mr. WATSON: You can get it as hot as you like. If you get a reactor such as an atomic bomb it gets up into thousands of degrees.

One of the things to do in a reactor is to keep it cool, otherwise ordinary materials melt.

The WITNESS: I might interject here—the distinction and I think it is an important one, between a reactor of the NRX type, and the NRU type, which you will see, and a power reactor. In experimental reactors such as the NRX and NRU you are exhausting your heat in your coolant; you are not using it. In other words, the purpose of the reactor is not to produce heat. So, in the case of the NRX the heat is being carried away in a coolant, which is light water. In the case of a power reactor, of course you are going to use this heat. It is transferred to the coolant, to raise steam to drive a turbo-generator. So you have that distinction between experimental research reactors and the power reactors.

By Mr. Hosking:

Q. In respect to a power reactor, is there anything that limits the size of it? What are your limitations?—A. What do you mean by size?

Q. The number of horsepower.—A. Megawatts.

Q. Yes.—A. No. There is no physical condition which would limit it. There might be economic conditions which would limit it.

Q. How do you feed this fuel in so that it does not all go "bang", like a bomb, and burn up in one second, instead of over, say, 24 hours?—A. Of course this is one of the problems in designing a power reactor as distinct from designing a bomb. Since I have no information on how bombs are designed and manufactured I am really not able to answer that question.

Q. Does it just burn off the outside?—A. No, no. The so-called burning of the U235—and this is a popular way, I should say of describing what happens—takes place through the entire composition of the fuel element.

Q. All right.—A. It is not like a piece of coal, in other words, where you—

Q. You burn on the outside?—A. —the outer part of the coal is burnt and the inner part usually is unburned on the first pass, because combustion is slowed up by ashes and gases and so on.

Q. How do you control the size—and that was my first question? Can you build it any size you like? Do you just put in a bigger lump of uranium—A. You could do it that way, but this gets you also into the question of whether you are fueling your reactor with natural uranium, in which case you have this 0·7% U235 content, or whether you are fueling it with enriched uranium—that is, fuel elements which have a higher percentage of U235. The percentage can be any percentage you want to establish. You can reduce the size of reactor vessel by going to enriched fuels.

Q. I still do not understand how you feed this stuff in. Do you blow it in like dust?—A. No, no. This is difficult to explain. Or, at least, it would be easier to explain if you saw the method, which you will see when you go to Chalk River, of putting the fuel elements into the NRX reactor and withdrawing them. There is a loading mechanism which is quite complicated. The fuel goes into the NRX reactor in the form of uranium metal rods which are sheathed in aluminum. There are a number of these fuel elements. They are removed from time to time, depending upon the conditions of the particular fuel elements.

Mr. STICK: May I ask a question? Are you finished?

Mr. HOSKING: Yes.

By Mr. Stick:

Q. I understand, Mr. Chairman, that in the reactors in other countries they are using graphite. Now, we are using heavy water. Can you explain why we are using heavy water and why other countries are using graphite?—A. We have a paper in the appendix on this question. The first paper. I do not believe that it is printed yet, but it is in the proceedings of the last meeting.

The CHAIRMAN: They are not printed yet, but they are in the process of being printed.

The WITNESS: The first paper, or the first appendix to my statement is a paper on why we are using heavy water, and why we think heavy water, as a moderator, is acceptable.

Mr. STICK: I have read a lot about heavy water, but perhaps this question will show my ignorance. What is heavy water exactly? What particles in water do you extract? Probably the physicist can tell us.

Mr. WATSON: Heavy water is similar to ordinary water in appearance. Ordinary water, as you know, consists of two parts of hydrogen and one part of oxygen, known as H_2O. Heavy water consists of two parts of an element known as deuterium, which is the heavy isotope of hydrogen and which has the symbol "D", and oxygen, and is referred to as D_2O. To all intents and purposes, chemically it is the same as light water, ordinary water. The heavy isotope of hydrogen has a mass 2 in its nucleus instead of a mass 1. Heavy water exists in a very small percentage in ordinary water.

Mr. STICK: How do you get the heavy water? Do you extract it from water by a process?

Mr. WATSON: There are several methods of extracting the heavy hydrogen content out of ordinary hydrogen. One can get it from ordinary water by an electrolytic process. On breaking down ordinary water you get a greater percentage of the heavy hydrogen content left in the water as compared with the ordinary hydrogen.

Mr. STICK: Will we see heavy water when we go to Chalk River?

Mr. WATSON: You can do, yes, but it just looks like this water here.

Mr. STICK: Like ordinary water?

Mr. WATSON: Yes. On the other hand, it is very much more expensive. We take very special precautions not to contaminate it because it is expensive.

By Mr. Green:

Q. Mr. Bennett, heavy water has been used in the Canadian development from the start, has it not?—A. That is right.

Q. Is it a fact that we have the outstanding heavy water reactors in the world?—A. I would say that that is true. At the time that the program started in 1942, when the three countries, the United States, the United Kingdom and Canada, agreed to start the military program, there were at least two routes that you could travel in producing plutonium for use in atomic bombs. One method which looked reasonable and feasible was to design a reactor using graphite as a moderator, as you mentioned. This is the method which the United States decided to follow and which they employed in their large establishment at Hanford, out in your country, Mr. Green.

Q. In Washington?—A. Yes. Our group, which was made up of people from the National Research Council, a British team and some scientists from the free French who had managed to get out after the German conquest, decided to go along this heavy water route. This work started originally in what was known as the Montreal Laboratory. That was the name given to it. From it came the design of the NRX reactor which we started to build in 1944, and which went into operation in 1947. This was the first large heavy water reactor in operation, and it turned out to be a very successful reactor, particularly because of its high flux. And, as I pointed out the other day in my presentation, it is still, in some ways, the best reactor for doing what we call "loop experiments". We will describe one of these loop experiments to you when you go to Chalk River.

Q. The NRU reactor, which is the one to be completed this fall, is also a heavy water reactor, is it not?—A. It is a heavy water reactor. The only broad difference between the two reactors is that in the NRX we are using heavy water as the moderator and light water as a coolant, and in the NRU reactor we are using heavy water as both the moderator and the coolant. But the basic design is the same.

Q. What about other reactors that are developed; will they also be heavy water reactors?—A. That is our present thinking, yes.

Q. So that our whole atomic energy program in Canada is based on the use of heavy water reactors?—A. At the present time, yes.

Q. At one time this heavy water used at Chalk River was produced at Trail in the plant of the Consolidated Mining and Smelting Company Limited, was it not?—A. First of all I had better say this: the Trail plant was built under a contract between the Consolidated Mining and Smelting Company Limited and what was then the Manhattan district, and which subsequently became the United States Atomic Energy Commission. In other words, the contractural relations were between Consolidated Mining and Smelting Company Limited and the Manhattan district, and subsequently the United States Atomic Energy Commission. We bought our heavy water for the NRX reactor from the United States Atomic Energy Commission. I understand that for reasons of convenience on the part of the United States Atomic Energy Commission, from time to time, some of our requirements have been supplied as a result of the Consolidated Mining and Smelting contract. But at no time did we have any contractural relations with the Consolidated Mining and Smelting Company Limited.

Q. The plant at Trail was in fact an American plant, I presume?—A. Yes, it was built under an American contract, yes.

Q. There is a good deal of disappointment over the fact that within the last two months that plant at Trail has been shut down. Now, is there any other source in Canada from which this heavy water can be obtained?—A. There is no other source in Canada at the present time. Perhaps I might try to explain the heavy water situation a little more fully, as it relates to the Trail plant. One of the main problems in the design of power reactors, as I pointed out the other day, is to get the capital cost down. One of the disadvantages of the heavy water route as compared with the graphite route or some of these other routes is that heavy water is expensive and you require a substantial quantity of it to get your reactor going and to keep your reactor going. For practical purposes or for accounting purposes the cost of the heavy water is a part of your capital cost. If you are successful, as you hope to be, in avoiding leakage, you do not expect to have to make any continuing replacement or any major replacement of heavy water in your power reactor. Therefore, for accounting purposes it is a part of your capital cost and it is a big item in your capital cost. A difficulty with the Trail arrangement was that the production was on a very small scale and this I think is a main contributing factor to high costs. I am not aware of all of the reasons why the United States Atomic Energy Commission decided to cancel the project but certainly one of the main reasons was this question of cost. The United States has built and now is operating a very large heavy water production plant at Savannah River. It is on the border of South Carolina and Georgia. They have established a commercial price for this heavy water of $28 a pound. Certainly, at the moment, none of the other production plants—Consolidated or the Norwegian plant—can come anywhere close to that price. This has been one of the factors in the cancellation of the Consolidated project.

By Mr. Green:

Q. Is this plant at Savannah the only plant which now is producing heavy water on this continent?—A. That is right, as far as I am aware.

Q. And the only one in Europe is in Norway?—A. Yes. I do not know whether the Norwegian plant is still operating or not. The Norwegians were selling heavy water at as high a price as $125 a pound and the United States Atomic Energy Commission which is making heavy water available because they have a large surplus, is selling at $28 a pound.

Q. In view of the fact that Canada and Canada alone as I understand it—is dependent on heavy water for her whole atomic energy program and that she has actually produced heavy water at Trail for many years is it not possible that that plant could be taken over by your company and put into production again, in which case we would be independent for our supply of heavy water?—A. I cannot believe that you could. I am not able to say whether the Trail process, if you blew up the plant beyond its present capacity—

Q. If you increased it?—A. If you increased the capacity—whether the Trail process would give you costs as low as $28. But certainly at its present volume it may not give you this kind of cost. We explored this with Consolidated Mining and Smelting and they examined their costs and so on and it was quite evident that they were not able to come anywhere close to this $28 figure.

Q. Have you discussed with the American Atomic Energy Commission or whatever established body would be the appropriate body in that country, the possibility of some sort of cooperation so that this plant at Trail can be put back into production again? It seems rather risky to have our whole program dependent on the product of one single factory, in another country.—A. I should point this out, that the production of the Trail plant is very small. I do not know the production figures at the Savannah river plant but I think the Trail plant produces six tons a year. The requirements for the NRU reactor are, I think, 40 tons.

Q. That would be quite a big market in itself?—A. Yes, but we need it with one crack. It cannot be spread out over ten years. You have to put the heavy water in. If 40 tons is the figure—this has to go into the reactor before the reactor begins to operate.

Q. What would be the requirements of heavy water for the other reactors you have now?—A. I do not know whether you have had a chance to read the booklet. I might correct what I just said: the requirement for the NRU is 43 tons. The requirement for the NPD reactor is something in the order of that in NRT.

Q. What would be the figure?—A. I have not got the figure but will get it for you. It is not as large as the NRU.

Q. By the way, how much of that 43 tons required for the NRU have you got from Savannah?—A. We have made arrangements to get all of the 43 tons and these arrangements were made at the time we entered into the contract with the United States, covering the plutonium made in the NRU reactor.

Q. Plutonium is produced for the bomb?—A. Yes, for military purposes. We have a contract with the United States Atomic Energy Commission and this contract was made in, I think, 1951 or 1952, which provides that the United States Atomic Energy Commission will purchase the plutonium content of the fuel elements that are irradiated in the NRU reactor. The arrangement actually provides they will buy the fuel elements. We are not going to extract the plutonium. When that arrangement or contract was made, it was also agreed that the heavy water for the NRU would be supplied or would be purchased from the United States Atomic Energy Commission and in our bilateral with the United States which was signed last June—and which was tabled in the House—there is a provision relating to our relations on such things as heavy water, natural uranium and so on.

Q. Have you endeavoured to make any arrangements with the United States Atomic Energy Commission under which at least some of this heavy water would be produced in Canada?—A. The price is the problem. The

United States Atomic Energy Commission is not interested in buying heavy water from Trail at the price at which Trail apparently has to sell it.

Q. No, but if they were to take some of the product, the price probably could be reduced, could it not?—A. No, not a six ton a year operation.

Q. I mean, if the operation were extended and increased?—A. No. Of course this would get you into problems. First, if you were going to go into large scale production at Trail, whether you would use the present process and I think there is some question on this point. I do not think it is the cheapest way of producing heavy water. Secondly, assuming that it were, you would be into the problem of the capital required to scale up your production to a point where you did get a price not higher than $28 a pound.

Q. Is there any reason, apart from the cost, why Canada could not produce her own heavy water?—A. There are no technical reasons why we should not do it, no.

By Mr. Hosking:

Q. What would be our demands over a year for heavy water?—A. What I was about to suggest on this point is that in one of the papers which we circulated on Tuesday, AECL No. 210, compiled by Dr. Davis and Dr. Lewis, on page 15 Dr. Lewis has shown a table, No. 5, in which he has indicated the possible range of heavy water requirements over the period beginning 1961 and ending 1981.

Mr. GREEN: Is that one of the books we have received?

The CHAIRMAN: Yes, it was distributed on Tuesday.

The WITNESS: This table 5 should not be taken out of the context of the paper and particularly it should be read in relation to the table which precedes it, table 4, where there is a prediction, which I included in my presentation, as to the probable role of nuclear power in meeting Canadian power requirements over the period 1956 to 1981. You will recall that I mentioned on Monday that in 1966 there might be nuclear generating capacity ranging from 200,000 kilowatts to 1 million kilowatts and by 1981 there might be nuclear generating capacity ranging from 4 million to 7 million kilowatts, depending of course on whether or not we are able to hit this cost target of 6 mills. The range is shown to provide for the possibility that we might do better than 6 mills as time goes on. Table 5 should be read in conjunction with table 4. What Dr. Lewis has done in Table 5 is to proceed on two assumptions—(1), that the range shown for the installed nuclear capacity in table 4 will actually turn out to be the case and, (2), that the heavy water route proves to be an economically acceptable route. Proceeding on the basis of those two assumptions, he has shown in table 5 the uranium inventroy requirements, the annual makeup of natural uranium and the inventory requirements of heavy water. There is a range, or a high and a low, shown in each case which corresponds to the high and low figures shown in the first column of that table. In other words, if we take 1981, and if the installed nuclear generating capacity is 4 million kilowatts, the heavy water inventory requirement would be 4,000 tons. On the other hand, if the installed nuclear generating capacity is 7 million kilowatts it would be 7,000 tons.

By Mr. Green:

Q. There is a further note at the bottom of the page:

> Even if new methods are discovered for the manufacture of heavy water which will reduce its unit price appreciably, outlays in this direction might reach an annual level of $40 million to $50 million, 25 years from now.

It is pretty obvious that a good deal of heavy water will be required. I understand that at present Americans are using or going into the use of heavy water, are they not?—A. No. Apart from the Savannah River establishment, there are no immediate requirements, substantial requirements, for heavy water in the American program.

Q. They are branching out from the use of graphite into the use of heavy water, are they not?—A. I do not think that at the moment they have any project in their demonstration power reactor program which calls for the use of heavy water as a moderator. There are five different types of reactor which they have in their immediate program and they have got at least 4 or 5 other types under consideration; but they have no project in the program at the moment which involves the use of heavy water as a moderator.

Q. Some of the other countries also are considering the use of heavy water, are they not?—A. The British program, which is the other big program, is on graphite. Their first reactors at Windscale are graphite-moderated and air cooled. Their first demonstration power station, the Calder Hall station, which will come into operation late this year, uses graphite and is gas cooled. The series of stations which they are proposing to build for the actual generation of electricity are all based on the graphite route. They do have another type of reactor which is still, you might say, in the research and development stages, sodium-graphite. Again, the moderator is graphite; sodium is the coolant. There is no provision in the United Kingdom for the use of heavy water.

Q. What about this reactor we are setting up in India? Is it not to be a heavy water one?—A. Yes, it is to be heavy water; it is the same as NRX.

Q. If NRU and our other reactors are as successful as we hope they will be, will it not require quite a move into the use of heavy water as a reactor in different parts of the world?—A. The answer to that is that we think the heavy water route is a good route. Whether it will provide the only acceptable route I would doubt.

Q. If it does prove to be a good route, would we not have quite an export market for heavy water?—A. If we can produce it at a price of $28 a pound or lower, yes; but in all of the economics of this heavy water power reactor one of your basic assumptions is that heavy water cannot cost more than $30 a pound because if it costs more than $30 a pound, this immediately adds capital charges which throw the economics off keel.

Q. Is there any reason other than the amount, the small amount produced in Trail, why the cost of the heavy water produced in Trail should be any higher than the cost in Savannah?—A. You mean is volume the only reason?

Q. Yes?—A. I would think that the process affects it. If you were going into large scale heavy water production, a scale that will give you costs of $28 a pound or better, you probably would use a different process.

Q. But we could develop that process just as it has been developed in Savannah?—A. We could get access to that process, under our bilateral.

Q. I am asking you because I think you have taken up the position that we should be processing our uranium in Canada to a greater extent than we are at the present time. In fact, we are told in the house that eventually we will be producing it completely in Canada, yet here we find that a heavy water plant which has been operating so successfully in Canada, has been closed down?—A. I do not think you can say "operating successfully" in terms of cost—and cost is the big factor in this thing. This $30 ceiling is one of the basic requirements for the successful power reactor, to make it successful economically, if it uses heavy water as a moderator.

Q. For the time being, Canada has given up any attempt to manufacture heavy water?—A. We have given up any attempt to manufacture it but of course we have not taken our hand out of the game entirely. We have a group at Chalk River in our chemical division which is keeping itself fully informed on the new developments in heavy water production and of course we are quite interested in having any Canadian industry acquaint themselves with these new technologies. We are doing everything we can to see that that happens.

Q. The Consolidated people must have acquired a good deal of know-how during the 10 years or so they have been producing heavy water?—A. Yes, on that particular process, but I doubt if this is the process you would use if you were going into large scale production with a cost target of $30 a pound.

Q. Apparently, inside 10 years we may be requiring 1,000 tons of heavy water a year.—A. If the basic assumptions contained in table 4 are correct, that will be so.

Q. Probably in the way these developments are growing now we will require more, do you not think?—A. That is a hard question to answer.

Q. Things are moving so rapidly that the expectations are like to be exceeded.—A. It is moving rapidly but you reach a point in this power reactor development program where the utilities have to decide whether nuclear power offers an acceptable route for expansion. Take the case of Ontario Hydro. There you have a situation with Ontario Hydro having a continuing demand for power increasing somewhere at a rate around 6 per cent per annum. That means you have to double your system about every 10 years. With the completion of the seaway and when that power from the seaway goes into the system, there are no other hydro resources in the province. The hydro resources that could be made available for transmitting power into the southern Ontario system are all far away. We then have the problem of transmission costs. The situation in southwestern Ontario is such that Ontario is faced with a thermal heat program; actually they are working on this thermal program now. They have the Richard L. Hearn station in Toronto, the capacity of which they have decided to double. I understand that at a certain point Ontario Hydro is to decide whether it is prepared to go the nuclear way or to stick to the conventional methods of producing thermal power. I think that is a decision which the utility—in this particular case the Ontario Hydro—has to make for itself. We cannot make that decision for it.

Mr. GREEN: No, but in your brief you stressed the possibility of Canada exporting reactors, and held out the hope it would be a very worthwhile field for Canadian trade. Now, as I understand it, every one of these reactors which you export to other countries will be a heavy water reactor and for the life of me I cannot see why we should not also be producing the heavy water rather than see these other countries go to Savannah and get their heavy water there.

The CHAIRMAN: Is it not self evident that heavy water reactors cannot be exported if the cost is prohibitive; and the cost would be prohibitive if the cost of heavy water was prohibitive. Is not that the real answer?

Mr. GREEN: I think the cost of heavy water would go down if a real attempt were made to undertake a program of that kind. I think the cost would go way down if the Americans would help such a program.

The WITNESS: They certainly were not interested in keeping the Trail plant going.

Mr. GREEN: That was when Canada had no interest in it at all.

By Mr. Weaver:

Q. Is it not the case that there are a number of things which we would like to do, but that we are not physically able to do them all; the day will come when we will be able to produce heavy water, too.—A. It may be that Consolidated or some other industry will get into this field; I assume that this is the way in which it should be done. I think the problem here is that it is a little too early in the game to be able to determine, first, the extent to which nuclear power is going to be used and second, whether or not the heavy water type of reactor is going to be competitive with other types.

By Mr. Green:

Q. We will be in an awful mess in Canada if the heavy water system proves to be non-competitive.—A. That is a risk you have to take in this business. It is a good point. If you have nine or ten ways open—and I would think there are at least nine or ten ways now—you have to make a choice. As a matter of fact they are dreaming up new ways almost every week. The question is this: do you diversify your effort and proceed on all these routes or do you stick to the technology which you know and put all your effort into that particular technology? You have good examples of both approaches in Canada; we are going the heavy water route.

Q. We have put all our eggs, here in Canada, into the "heavy water" basket.—A. That is true. And in the United Kingdom they have put all their eggs into the gas-cooled graphite basket. In the United States, on the other hand, they have a highly diversified program; you can advance arguments on both sides as to which is the better course to follow. At the Geneva conference the argument was put forward by the United Kingdom that by concentrating effort on one route you are more likely to come up with something reliable and cheap than by going in a number of different directions at the same time. Of course this boils down in the end to how much money you have to spend on this program and, more especially, to how many people you have available for the work. We are competent to carry out one program, and I happen to know that the United States, despite its enormous resources, is having great difficulty in manning the various programs they have under way.

Q. For better or worse we have gone into the heavy water field entirely and our whole atomic energy program is dependent on the success of heavy water reactors.—A. That is right.

Q. And yet we are now in the position where our one plant which was producing heavy water is shut down.

By Mr. Weaver:

Should we not also say in this discussion that the heavy water program which Canada has adopted has been just about the best there is in the world today?—A. We think it is, but there could be arguments about that.

Q. I do not doubt that, but we are not disappointed.—A. No, no. We think this is a good way to go.

Mr. GREEN: I am not raising that question at all.

By Mr. Weaver:

Q. You have scientists who are trying to find out whether there is a way of getting heavy water at a price cheaper than this figure of $28?—A. We have people in our research division who are getting information on the latest processes for producing heavy water.

Q. It would be your hope that some day you could produce heavy water at, say, $10?—A. I would hope that at some stage, certainly, a Canadian company would enter this business of producing heavy water on a large scale.

By Mr. Green:

Q. What chance does Consolidated have of producing heavy water in competition with the United States Atomic Energy Commission? I understand that it is not produced at Savannah by a private company.—A. The plant is operated by a private company—

Q. Yes, but the money is put up by the commission.—A. The plant belongs to the commission, but it is operated by Dupont.

Q. Is there any reason why Canada cannot do the same thing?—A. We have no requirement at the moment; certainly our requirement for heavy water at this moment is not such that we could expect to get a real cost of $28 a pound. When you go into these figures which Lewis has projected for the period beyond 1966, then I think you are getting to the point where the scale of the production required would probably give you a cost of $28, or perhaps even better.

By Mr. Stick:

Q. May I ask a question? There seems to be some doubt about whether graphite or heavy water will be the medium used for commercial purposes for the development of power. We have gone into the heavy water method. Can we change our method in our reactors at Chalk river from heavy water to graphite?—A. You cannot change the present reactors—no. However there is one point with regard to that which I think should be kept in mind when discussing this question of risks taken by going along one route. There are a number of factors which are common to all types of reactors, and the effort which is devoted to developing a heavy water power reactor—assuming that this did not turn out to be the best type—is not by any means lost effort. This is because when you get into what I like to call in my layman's language—the mechanical aspects of a reactor as distinct from the core—the core being in the reactor vessel where you have your fuel and your moderator—there are a number of common factors. So I would think that a large part of our development effort would be of great value even if, as I think unlikely, the heavy water route does not prove to be the most successful.

By Mr. Forgie:

Q. Who would operate this power reactor in conjunction with the Hydro?—A. C.G.E.

Q. I think that will involve heavy water also.

Mr. STICK: It is not a Hydro electric plant.

The WITNESS: We considered for some time what we should call this plant and we finally decided to call it N.P.D. which stands for Nuclear Power Demonstration. It is not an experimental plant in the sense that we are going to use it to do experiments, as we were using the NRX reactor and as we are using the NRU. This is a demonstration reactor—in other words its purpose is to demonstrate, first, that you can produce electrical energy from an atomic plant by means of a reliable operation and second, to provide very useful information—very valuable information—about fuel element design and fuel element performance. As you will hear when you go to Chalk River the fuel element is one of the key problems in power production.

By Mr. MacLean:

Q. Mr. Chairman I am sorry I was late in arriving and unable to be here in time to hear the first part of the discussion, so if I am repeating something which has been dealt with already I hope you will "shoot me down".

I gather that heavy water is being manufactured in Norway as well as in the United States?—A. It was being manufactured in Norway. I do not know whether the Norwegians are still operating their plant or not. They were selling heavy water at $125 a pound and the announcement last August of the American price of $28 a pound had some effect obviously on the Norwegian operation.

Q. In any case my question is not dependent on whether that is still operating or not. Have we information here in Canada as to what method was used by the Norwegians?—A. I would think we have, yes.

Q. Is it a third method or is it similar to the method used in Trail or Savannah?—A. I cannot give you the answer to that question now; we will give you the answer to that at Chalk River. It just occurs to me that it might, perhaps, be another distinct method.

Q. It might have possibilities?

Mr. WATSON: I believe it is the Trail process.

The WITNESS: We will check that for you and get the exact answer on that point. Most of these heavy water processes have been declassified. Information is available.

By Mr. Richardson:

Q. If that heavy water process involves a cost of $125 a pound, what would be the usefulness of it?—A. Certainly at that price it knocks the economics of the heavy water method into a cocked hat.

By Mr. Forgie:

Q. What is the cost of the graphite process, Mr. Chairman?—A. This is graphite of a certain specification; I would not know at the moment. We will get you that figure.

By Mr. Green:

Q. Is it cheaper than heavy water or more expensive.—A. Oh, it is much cheaper.

Q. Much cheaper?—A. Much cheaper, yes.

Q. Why did we adopt the heavy water process in the first place?—A. Because as I say, in 1942 there appeared to be a couple of ways by which a controlled nuclear reaction could be produced and plutonium obtained. One of these was the heavy water route and the other was the graphite route. The Americans decided to adopt the graphite route and the Hanford plant was the result. We decided to enter the heavy water route. I think this is significant: that in the second large plutonium plant the Americans built they followed he heavy water route.

Q. I think you said they did not use heavy water at all?—A. I said "apart from Savannah River". It is not in any of their power programs.

Q. But it is in their bomb programs?—A. The reactors they are operating at Savannah River for the production of plutonium are heavy water reactors.

Q. That is for the bomb?—A. It is for the military program.

Q. Do they use heavy water there?—A. Oh yes. They built the plant to supply the heavy water requirements of the Savannah River reactors; and as I pointed out earlier, heavy water is not like a fuel—you do not need to keep replacing it. Some leakage occurs. That is one of the problems we are trying to fight. Small quantities have to be replaced but by and large once you have put heavy water into the reactor there is no further requirement. The American plant was built to supply the heavy water requirement of the reactors at Savannah River; it has done that, so they have this large surplus capacity.

Q. If the Americans are using heavy water in their bomb programs there is not the slightest doubt that heavy water reactors are operating all right.—A. That does not necessarily follow, because of economic factors. The heavy water reactor is designed to produce plutonium and that is what the reactors at Savannah River are designed to do—

Q. That is what our reactors are designed for, too, is it not?—A. That is quite a different animal from a reactor designed to produce power.

Q. But we started out using heavy water to produce plutonium for the bomb?—A. That is right; that is how we got into this technology.

By Mr. MacLean:

Q. Is there any general demand for heavy water for any other purpose than cooling these reactors?—A. I am not aware of any.

By Mr. Stick:

Q. There are advantages, as I understand it through reading parts of your brief, in the use of the heavy water method with regard to the making of isotopes and other materials—advantages over the graphite method?—A. I do not think the type of moderator has much bearing on the isotope picture.

By Mr. Hosking:

Q. Would you say that the development of the heavy water process of producing plutonium out-stripped the method used by the Americans with the result that they gave up their method and used ours?—A. I did not quite follow you. What is the question?

Q. Is it not the case that the Americans have decided that the method developed in Canada for the production of plutonium by the use of heavy water has so far out-stripped their method of producing plutonium by the graphite method that they have taken the decision to follow suit?—A. I do not know the reasons for their decision but I think you are pretty close to the truth.

Q. And now we are in a position, in Canada, where we are trying to produce electrical energy without producing plutonium?—A. No, not without producing plutonium.

Q. Is plutonium used for developing electrical energy?—A. In any reactor in which you irradiate natural uranium or enriched uranium, whether it be a research reactor, an experimental reactor or a power reactor you are going to produce plutonium. However, the design of a reactor which is intended to be primarily a plutonium producer is quite different from the design of a reactor intended primarily as a producer of heat for a power plant.

Q. In order to get this quite clear in my mind, may I ask whether this new reactor which you are building—you say it will be a demonstration reactor—in which our government is putting up a figure of $9 million, the provincial government is putting up a figure of $3·5 million and the C.G.E. $2 million is going to produce plutonium? It will, however it works, burn plutonium in order to produce heat which will generate electricity? Is that right?—A. The value of plutonium—I am getting a little out of my depth now, but I will try to answer the question—in a power reactor cycle is this: plutonium is a new element which is produced in the uranium fuel when fission occurs; and plutonium is also fissionable. In other words it can be used as a fuel; it can be put back into the fuel cycle and used as a fuel. This is not quite as simple as it sounds. In a reactor of heterogeneous type, that is, a reactor which is using solid fuels, after the fuel element is irradiated, it is taken out of the reactor and you have in the fuel element some unburned U235 which, of course, was the fissionable material in the first instance; you have this new element, plutonium, and you also have some other new elements which we call fission products. These are the "bad actors" in the reactors because they poison—and this is the expression which is used—the reaction.

Now, when you get this irradiated fuel out of the reactor, if you want to use your plutonium, you must dissolve the fuel by a chemical process and separate out your unburned or undepleted uranium, the plutonium and the fission products. Of course, this is a costly process.

75407—2

There is one other disadvantage to the use of plutonium as a fuel in a recycling arrangement, and that is that it is very highly toxic. This is not a problem which cannot be surmounted, but it is one of the problems.

By Mr. Hosking:

Q. In this combined plant of the Ontario provincial government and the CGE it is not all done in one step; it is not as simple as I appeared to make it. You have got to first produce your plutonium in one type of reactor, and you take that out and treat it separately where you produce your heat. Or, do you produce your heat and steam and everything from the one reactor?—A. No. We will take the NPD reactor, which is the demonstration reactor. This reactor will be fuelled, in the main, with natural uranium. Now when fission occurs in this reactor, heat is produced, and the heat will be transferred to the coolant.

Q. Yes?—A. And the temperature of the coolant will be raised to the point where it will be possible to produce steam to drive the turbo-generator. So, this all takes place in the one NPD plant.

Q. There is not a separate one?—A. No.

Q. Where you produce the plutonium elements in this reactor and use the plutonium to produce steam, it is all done in this one?—A. We might conceivably use some plutonium to enrich the element in this NPD reactor.

By Mr. Green:

Q. At the present time the plutonium you produce is sold to the United States?—A. The plutonium produced from the NRU. The NRX plutonium is used in our own experimental research program.

Q. It is sold to the United States for use in producing bombs?—A. For military purposes, that is right.

By the Deputy Chairman:

Q. Mr. Bennett is that reprocessing of fuel done at Chalk River?—A. The NRX fuel elements are being processed at Chalk River. We do not propose to process the NRU elements at Chalk River.

By Mr. Forgie:

Q. What is the cost of this? In the purchase of the heavy water and the sale of the plutonium is there a balance?—A. This is a difficult question to answer. I read an analysis recently by one of the advisors to the International Bank in which he was attempting to analyse the economics of nuclear power. The analysis was based on papers that were given at Geneva. In this analysis he put a price—he assumed the price of $25 a gram for plutonium. Now, I think this is pretty much of an arbitrary figure. He did not say so, but I expect that the $25 was adopted because this is the price which the Atomic Energy Commission has announced for U235. What value you would put on plutonium depends, of course, on what you are going to use it for. If you are producing a military grade plutanium, which calls for certain specifications, I have no way of knowing what dollar value you would put on it.

In respect to power reactor economics perhaps I might answer your question in this fashion: since plutanium is fissionable and can be used as a fuel, whether you use it or not as a fuel will depend on whether it is cheaper to extract the plutonium, chemically, and refabricate it back into the form in which it can be put into the reactor, or whether it is cheaper to buy new fuel.

Now, this is something that has not as yet been determined. We do know from the information we have got on the processing costs—that is, the cost of processing fuel elements to etxract fission products and depleted uranium,—

the present cost experience is not too good. This does not mean that you cannot improve the operation cost-wise. I think Dr. Lewis in talking about recycling plutonium in a power reactor system has put down a figure, as I recall it, of $3 a gram for extraction.

Mr. HOSKING: Since it is now 10 minutes after 12 I wonder if we could get on with the other paper that was suggested?

Mr. GREEN: I have one or two other questions.

Mr. HOSKING: I would not like to miss this other paper. Our time is so limited.

Mr. GREEN: The other brief does not have to be read before we go to Chalk River, because it has nothing to do with Chalk River, it concerns the mining of uranium.

The WITNESS: The only thing I have done in that other brief, is to explain this burn-up phenomen.

Mr. HOSKING: I think that would be very interesting to have before we do go to Chalk River. We can ask these questions after. Once we get the brief in we will know whether we want to ask questions on it, or more questions on this.

The VICE-CHAIRMAN: I am in the hands of the committee at the moment, but Mr. Green and Mr. Richardson have indicated that they would like to ask more questions. Perhaps we could go on for a few minutes.

For brief respecting raw materials, see end of evidence.

By Mr. Green:

Q. I would like to ask Mr. Bennett about the mobility of atomic power used for peace time purposes. In his brief at page 17 he said this:

> As one might expect, there is a wide variation from region to region, both with respect to the rate of the demand for new power and the availability of hydro resources and cheap conventional fuels to meet this demand. This means simply that nuclear power will be used much sooner in some regions than in others. It will be used first in those regions which have exhausted their hydro resources and which do not have available cheap supplies of conventional thermal fuels. Southern Ontario is such a region.

Now we know that the Ontario Hydro Commission is associated with Mr. Bennett's company in the development of the first power reactor. What worries me is, how is this new development going to help such parts of Canada as Saskatchewan and the maritimes? I always hoped they would get atomic power ahead of these other provinces that have huge resources of power. Here in southern Ontario now, with far more industries in proportion than any other part of Canada, it would appear that southern Ontario is going to get first choice in regard to atomic energy power. Where is that going to leave the rest of the country? It just seemed to me that there should be some attempt made to diversify industry in Canada through the use of atomic energy. The policy would appear to be that southern Ontario comes first even with atomic energy. They are getting gas now; they are getting the power from the St. Lawrence river. Has the company any policy under which a real attempt will be made to put these atomic energy units in those parts of the country that need power the most? For example, the National Research Council have a branch in Nova Scotia, and they have a branch in Saskatchewan. Now, why could not Atomic Energy of Canada Limited be doing some of this power development work in Nova Scotia, New Brunswick, Newfoundland, or Prince Edward Island, and some in Saskatchewan rather than concentrating everything in southern Ontario, which is apparently what they are doing?—A. The answer I think to this point, Mr. Green is, first of all, that as I have pointed out in my brief, we have an advisory committee on atomic power on which all of the utilities are represented. This advisory committee comes to Chalk River as often as it wants to come. We have formal meeting once a year. We are in their hands on the question of how frequently these meetings should be held. So far they have suggested meetings once a year.

We also have an arrangement whereby any one of these utilities may send its technical staff to Chalk River at any time. The advisory committee has complete access to all of the information on the power reactor development which we have, and they have complete access to all the information which we hope to get from the NPD reactor.

In addition to the advisory committee we also have the nuclear power branch, which is staffed with people from the utilities. We have repeatedly asked all of the utilities to second staff to this branch. At the last meeting of that committee, a year ago, I made this appeal orally and subsequently made it in writing. Some of the utilities have representation in this nuclear power branch and some of them do not have representation, but they have all been invited to send members of their staff to Chalk River.

Now, here I might just say a word about the nuclear power branch. The nuclear power branch is, for practical purposes, a part of the Chalk River family. Its particular responsibility is the feasibility and resign studies for power reactors. For example the outline specification for the NPD reactor was based on the feasibility and design study which this nuclear power branch carried out.

Through these two methods, the advisory committee and the nuclear power branch, we keep the utilities across the country fully informed as to what is going on, not only in Canada but in other countries. When you come to the question of establishing branches or projects, I think you have to look again at the purpose of the NPD reactor. Its purpose is to demonstrate the feasibility of nuclear power. It is not going to produce power at competitive costs I can assure you of that at once. The capital cost of this reactor will be something of the order of $600 to $700 a kilowatt. This, of course, is due in part to its small size. It is only producing 20,000 kilowatts electric. As you come down in size, of course, you have a corresponding increase in the capital cost per kilowatt installed. The purpose of the reactor is to demonstrate feasibility. There certainly would not be any purpose at this point of building another NPD reactor somewhere else in the country.

The VICE-CHAIRMAN: Excuse me gentlemen, the time is running away from us. Perhaps we should have the other brief.

The WITNESS: I should point out that this other brief will take me 45 or 50 minutes to read.

Mr. GREEN: If it is only going to be read in, could we have it handed out to us and we can read it ourselves.

The VICE-CHAIRMAN: Does that meet with everyone's approval?

Agreed.

The WITNESS: It certainly meets with my approval.

Mr. RICHARDSON: Mr. Chairman, with your indulgence, could I ask my question? May I refer Mr. Bennett to page 13 of the brief.

The WITNESS: Could I make one final point in connection with Mr. Green's question? That is, that we are trying to carry this program out in such a way that the utilities go along with us, whether they are provincial commissions or private utilities. They are both represented on the advisory committee. As has been pointed out earlier, the ultimate decision as to whether or not a particular utility goes in for nuclear power is one for the utility. The six mills cost target, by the way, is the target still. I have put my neck out by saying I think we will hit it by 1965 or 1966, but we are certainly some distance away from this point. In evaluating the advantage of nuclear power in any particular region of Canada you would have to take a look first at the power demand in that particular region and second at the Hydro resources which are available to meet the demand and their cost and, third, the thermal resources, the conventional thermal resources which are available to meet that demand and their cost.

By Mr. Green:

Q. For instance, how would they ever get nuclear power in Saskatchewan in its present form?—A. The Saskatchewan Power Commission or corporation is being kept fully informed on this program, on the basis of our experience and the experience of other countries, and could decide that nuclear power is the way to go, cost-wise—and it will be a decision that will be made, it seems to me, solely on the basis of cost. Nuclear power has no advantage per se other than the possible advantage of producing power at cost lower than other means.

Q. Is there any reason why your next demonstration reactor should not be built in Saskatchewan?—A. There is no reason why you would not put it anywhere.

Q. Would it be feasible?—A. Yes, it is feasible to to put it in anywhere.

By Mr. Forgie:

Q. Have any other people put up a proposal?—A. We had a proposal from the Nova Scotia Light and Power Company to participate in this NPD project. However, in evaluating the two proposals the Ontario proposal and the Nova Scotia Light and Power proposal, we look into account these factors: The Nova Scotia Light and Power Company wanted a guarantee from us that the plant would operate at a minimum load factor of 80 per cent and that, if it dit not, we would compensate the Nova Scotia Light and Power Company for the difference. Nova Scotia Light and Power Company also wanted a guarantee that in the event that the plant did not operate for the full period of time which they were allowing for the amortization of their capital—their part of the cost—and my recollection is that the amortization period was 25 years—we would reimburse them for the unamortized portion of their capital cost, with interest. I forget the interest rate. We felt that since this was the first power reactor, and it is a demonstration power reactor apart from the financial considerations, it was better to operate it in a very large system which would not be dependent on the power from this staton, than to put it into a small system which would be dependent on the 20,000 kilowatts this station would produce. These were the reasons, very briefly, why we elected to go with Ontario Hydro. Ontario Hydro on the other hand, was prepared to go into the project without asking any guarantees at all from us as to load factor, reimbursement on amortized portion of capital or any other guarantees.

By Mr. MacLean:

Q. It seems to me that the assessment of electric energy generally from atomic energy sources in economics boils down to two basic things. One is the cost and in the case of atomic energy, unlike other sources of energy, provided you have your general costs low enough it is feasible then to set up a plant and generate power almost anywhere whereas in the case of coal or hydro you can produce it cheaply only where the energy is located. The cost of distribution goes up of course very rapidly, dependent on your distance from the source. Therefore, to begin with, it would seem to me that provided there is a market energy developed from atomic sources would find a market first in those areas furthest removed from hydro and coal and oil supplies.—A. That is right.

Q. Provided there is a market. You mentioned the point of mobility and I assumed you meant by that the fact that you can locate these plants anywhere.—A. The cost of transporting your fuel is negligible. I mean that as compared with the cost of transporting coal. This is the advantage. Of course with this question of location, you have another problem which every one is struggling with, the possible radioactive hazards. This is I would say, still largely "no man's land" and it raises some problems for the utilities at the moment. One of them is insurance. Underwriters so far have shied away from the insurance coverage for, let us say, a catastrophic accident, where your reactor goes out of control and distributes contamination all round the country side. Assuming that you are going to process your fuel elements, you have got the problem of the disposal of these fission products and particularly the fission products which are long lived and highly toxic. These are problems incidental to the question of location. However, I think your point is quite right that by and large one of the main advantages of nuclear power is that you are not restricted by fuel transportation costs when you decide on locations.

By Mr. Richardson:

Q. On page 13 of your first brief Mr. Bennett, you say there are 3 countries with power reactors and that Canada provides for the use of heavy water as a moderator and coolant and for natural uranium as a fuel. In the United Kingdom graphite is used as a moderator and gas as a coolant, and in the United States graphite is used as a moderator and light water under pressure as a coolant. Am I right to assume that uranium is a fuel that is common to all three?—A. Uranium is a fuel that is common. However, uranium fuel can be in the form of natural uranium, with the isotopic composition that Mr. Watson mentioned; or it can be in the form of enriched fuel, that is uranium which has a higher U-235 content than in the natural uranium, in other words higher than this 0·7%.

Q. What is the fuel used in the United States?—A. The United States, as far as I can recall, in all of the demonstration reactors they are building, are using some enrichment.

Q. And the fuel that is used in the United Kingdom?—A. It is natural uranium—this is the initial fuel. The United Kingdom does envisage enrichment with plutonium fuel which is recovered from the irradiated fuels. On this question of the difference in the type of fuels there is a factor apart from the technical differences and that is whether or not you have U-235. The United States of course has two very large diffusion plants for producing U-235 and this, I would think, has been one of the factors which has influenced their thinking in the use of enriched fuels as distinct from natural uranium fuels.

Q. In respect of the fuel, would you say that Canada has an economic advantage over the other two countries?—A. I can answer that question in two parts. Certainly we have a very fundamental economic advantage in the fact that we have large reserves of uranium. Whether enriched fuel as distinct from natural uranium gives you the better costs per kilowatt hour—which is the final determining factor—is something that still has to be demonstrated. Of course, you need natural uranium to produce enriched uranium. In other words, the feed for the diffusion plant is enriched uranium.

The CHAIRMAN: In regard to the appendices which have been referred to today, do the members wish that they be printed?

Agreed.

By Mr. Hardie:

Q. In answering in Mr. MacLean's question, Mr. Bennett, you said that the transportation cost of the fuel had very little to do with the actual cost of the fuel. Would you say that that is true because the cost of the fuel, that is, raw uranium, has very little bearing on the ultimate cost of producing power?—A. I would not say that it has very little bearing: I would say that in the projection of probable costs for nuclear power the element of cost that is put down for fuel itself is very low by comparison with the fuel cost in a conventional thermal station. This is the great advantage, I would say the primary advantage, of nuclear power—that you have much lower fuel cost.

Q. As far as research work is concerned, economic power is more dependent on reducing the cost of reactors or the building of the reactors and the producing of the coolant or moderator to a greater extent than the cost of fuel? —A. In this paper which I intended to read today, I have covered in some detail this question of the cost of natural uranium and its bearing on the future demand for uranium. I have concluded—and I hope I have put in a reasonable argument in support of the conclusion—that the lower you get the cost of natural uranium the more natural uranium is going to be used in power reactor systems. I have covered this rather fully. Perhaps we would come back to this question when you have read what I have had to say. I will not say any more than this: if the price of natural uranium were to get very high, this would throw a strong emphasis on the breeder type of reactor.

Q. There is one question about the chemical processes used in extracting the plutonium and then putting it back in as a fuel. Is it the same chemical process that is used as in extracting the unused uranium?—A. This is all done in a single processing plant. The first thing you have to do is dissolve the uranium fuel elements so that you get everything into a solution.

Q. So, if you were to use plutonium and put it back into the system, the reason would be that it would be cheaper to use plutonium, to put it back in to produce the fuel, than to put in the uranium itself?—A. That depends on what it costs you to extract the plutonium. You must put it back in the form of a fuel element.

Q. At the present time, you could not say whether plutonium is cheaper to put back in or whether it would be cheaper to use uranium?—A. That is right, although our present thinking is that you would have one recycle. In other words, you would make one extraction of your plutonium but you would not go beyond one. That is the present thinking.

By Mr. Green:

Q. In your first brief, at page 9, you say:

> In addition, we are considering design studies for other types of reactors which we consider may have a useful place in the Canadian economy—for example, a dual purpose reactor which will provide power and process steam for the pulp and paper industry and a small reactor which will provide power and heating in remote areas of northern Canada where the cost of conventional thermal fuels is excessive.

Would you tell us what you have in mind with regard to these small reactors for northern Canada and also just how far your company has gone toward providing such reactors?—A. Well, here again by way of general answer, we feel that before we embark on any particular program, bearing in mind that all of these programs are expensive, we have to be satisfied that there is a place for the particular reactor that will result from the program and we have to feel that the ultimate user should be a party to the examination of whether or not there is a need or place for a particular type of reactor. Now, in the case of the dual purpose reactor we are at this stage. We have had the pulp and paper association at Chalk River quite recently. At that conference we described our current program and there was some discussion as to what interest the pulp and paper companies might have in this type of project. The pulp and paper association, as you know, maintains a research establishment—I think they call it the Pulp and Paper Research Institute—with headquarters in Montreal. The director of the institute was at this conference. We did not arrive at a final decision that we would proceed with this project but we did arrive at general agreement that a feasibility study should be made in order to determine whether there is a need for this type of reactor.

As a first step in such a feasibility study, what you have to do is examine the particular requirements of each of the companies both with respect to power and with respect to processed steam and this we regard as the first step. In other words, it is an economic valuation. We are proposing to do that. While we have not done it yet, I would anticipate that here as in the case of the utilities you would have a very wide variation in requirements and a very wide variation in resources which are available to meet these requirements. For example, if you are talking about fuel for processed steam, some of the companies, some of the pulp and paper companies have indicated that they have a very cheap fuel; others have not. Our thought was that if the economic study indicates that there is a need for this type of reactor—perhaps not immediately but looking some years ahead to the day when some of these companies will be faced with the prospect of relocating their mills because the transportation costs has reached a point where it is not economic for them to go on producing where they are—we would set up—as we did in the case of the utilities—a team at Chalk River which would be staffed with people from the pulp and paper industry. This team would work with our people as the nuclear power branch has done.

By Mr. Green:

Q. You mean a natural uranium reactor?—A. Yes. The job would be to produce an outline specification for a dual purpose reactor for the pulp and paper industry. That is the state of that particular project. On the second project, we are having conversations and discussions with the Department of National Defence, again with a view in the first instance to determining whether or not the Department of National Defence has a requirement for small nuclear power stations, what are commonly called "package reactors". These discussions are in progress and again, if it appears as a result of our examination of the situation that this is something we should do, we will go about it in much the same way as we propose to go about the pulp and paper project.

Q. There has been no actual development work undertaken?—A. No, That is why I said we have that under consideration. That is the present situation.

Q. The development of reactors for northern Canada is purely in conjunction with the defence problems?—A. No, but we felt the Department of National Defence might have the most pressing need. Of course, something you would develop for the Department of National Defence would be suitable for use for civilians. Here you get into the problem of the size. For example, if you are thinking of a reactor to produce power and space heating for a mine in the north, such as Port Radium, there you would be into something of the order of 10,000 kilowatts. On the other hand if you are thinking of a reactor to produce power and space heating for a small community or a small defence establishment, you are into sizes of the order of perhaps as low as 100 kilowatts or in the range from, let us say, 100 to 1,000 kilowatts. Now, there is quite a difference, not only in the power rating, but in the type of design of the reactor. When you get into these very small sizes, it is pretty clear that you are going to use enriched fuels rather than natural uranium.

Q. That means they are more expensive?—A. Yes.

Mr. WEAVER: I move we adjourn.

The CHAIRMAN: There is a motion to adjourn. Perhaps that motion could be turned into a motion to discontinue the questioning and resolve the meeting into an executive meeting. Is that motion carried?

Carried.

(Executive meeting held.)

BRIEF PRESENTED BY MR. W. J. BENNETT ON THE SUBJECT OF RAW MATERIALS

I should like to discusss to-day the second part of the Canadian Atomic Energy Programme—Raw Materials. This programme, as you are aware, is the responsibility of Eldorado Mining and Refining Limited, a Crown Company. Eldorado has a double function. It is a producer of uranium, and it has also been designated as the Government's agent for the purchase of uranium which is produced by other companies.

Before I describe these functions, I should like to offer a few comments on the technical aspects of the Raw Materials Programme. The techniques employed in the several stages of uranium production are basically the same as those which are employed in the production of other metals. First, it is necessary to find economic deposits of uranium. Here, the geological reports and maps which are prepared by the Geological Survey of Canada are of inestimable value in determining what areas are favourable to the deposition of uranium. It is significant, I think that the discoveries made in the four main uranium-producing areas—Great Bear Lake, the east end of Lake Athabasca, Blind River and Bancroft, all resulted from reports prepared by the Geological Survey. When a favourable area has been selected for exploration, the methods of prospecting are not too different from those in current use, with this one notable exception. The Geiger Counter has provided the prospector with a cheap and easily operated instrument with which he is able to detect the presence of radio-activity. In the development of uranium discoveries, the usual methods are employed. The deposit is examined on surface by removing overburden and trenching. It is then tested by diamond drilling. As in the case of other metals, diamond drilling sometimes provides fairly conclusive evidence as to the grade and size of the deposit, but more often this information can only be obtained by underground exploration. This requires the sinking of a shaft and drifting, cross-cutting and raising at selected levels. Should the property prove economic, the methods of mine preparation and the methods of mining are those in standard use. Each mine has its peculiar problems of mining but so far the solution of these problems has been well within Canadian mining experience. With the thought that the Committee may be interested in more detailed information on mining methods, I would ask your permission to have included as an appendix to my presentation a paper on this subject which has been prepared by R. E. Barrett of the Eldorado organization. With the milling of uranium ores we encounter the first radical departure from common methods of treatment. The extraction of metals from ores by chemical methods is not by any means new. However, the chemical method commonly known as leaching which is used for the treatment of uranium ores, has presented some special problems. The Mines Branch of the Department of Mines and Technical Surveys and the Research and Development Division of Eldorado have made, and are making, important contributions to the solution of these problems. With the permission of the Committee, I should like to have included as an appendix to my statement papers on the treatment of uranium ores in Canada which has been prepared by Mr. Arvid Thunaes, the Director of Eldorado's Research and Development Division.

Let us now look at Eldorado in its capacity as a producer of uranium. Eldorado operates two producing mines—one at Port Radium in the Northwest Territories and one at Beaverlodge Lake in Northeastern Saskatchewan. Eldorado also operates a uranium refinery at Port Hope, Ontario.

The mine at Port Radium discovered in the early 'Thirties was Canada's first producer of uranium. As it happens, radium and not uranium was the principal product of this mine in the pre-war years, since at that time uranium had little commercial value. The Port Radium mine has been operated continuously since 1932 with the exception of two years—mid-1940 and mid-1942—when the mine was closed as a result of the dislocation of radium markets which followed the outbreak of the war. The mine was re-opened in 1942 following Canada's decision to supply uranium to the Manhattan Project, which had been charged with the responsibility for developing the atomic bomb. The story of the Port Radium operation has been told so frequently that I shall not enter upon its details at this time. There are, however, several points about the operation which may be of interest to you. The mine is not a large one in terms of the daily tonnage of ore treated, but it is a high-grade mine—that is to say, the uranium content per ton mined is substantially higher than the uranium content of deposits which have been discovered more recently, although these deposits have much larger ore bodies. The location of Port Radium—some 1,400 miles from railhead and approximately 30 miles below the Arctic Circle—poses special problems both with respect to the operation and its servicing. All heavy supplies must be moved to the mine and the product must be moved from the mine in a navigation period which usually opens early in July and closes in mid-September. The transportation of personnel, perishables, and emergency supplies is handled by air, with the exception of the break-up period in the months of May and June and the freeze-up period in the months of October, November and early December. This is the responsibility of Eldorado Aviation Limited, a wholly-owned subsidiary of Eldorado Mining and Refining Limited. The operations of Eldorado Aviation Limited are based at Edmonton. The following statistics will indicate the importance of this operation to the Port Radium and Beaverlodge mines. Over the past ten years some 24,000 tons of freight have been moved and 36,800 passengers have been carried, 31,000 flying hours have been logged, making a total freight and passenger movement of 19,000,000 ton miles.

In the early period of its operation the ore mined at Port Radium was treated in what is called in mining language a gravity mill. This is a type of concentration in which the uranium is separated from the host rock by mechanical methods—that is, the use of jigs and tables. This method, never too efficient, proved to be quite unsatisfactory in the post-war years owing to a decrease in the grade of ore available for milling. In 1952 as the result of a research programme undertaken with the assistance of the Mines Branch, an acid leaching plant was built at Port Radium. With the installation of this plant there was a marked improvement in recoveries. There was also an increase in annual production, since it then became possible to treat the impounded tailings from the old process. This will explain the fact that in recent years the annual rate of production has been higher than in any period in the mine's history.

The discovery of Eldorado's Beaverlodge mine resulted from the decision taken in the immediate post-war years to increase the supply of uranium for the atomic weapons programme. While prospecting parties were first put into the Beaverlodge area in 1946, the significant discoveries were not made until 1947. In 1948 the Company began a diamond drilling programme on those groups of claims which appeared most promising. As a result of this diamond drilling, a programme of underground development involving shaft sinking, drifting, cross-cutting and raising was begun in late 1949 and continued throughout 1950. In late 1950 sufficient information was available on one of the properties now known as the Ace Mine to indicate the existence of an economic orebody. Plans were made for the installation of a Mining and Milling Plant together with ancillary services, such as a Diesel Power Plant, and a production deadline of May 1st, 1953, was established. There were two problems associated with meeting this deadline. First, the Beaverlodge property is some distance from railhead—273 miles, to be exact—and supplies can only be transported by water for four months of the year from June 1st to October 1st. Second, the character of the ore was such that it seemed advantageous to develop a new method of extraction. To be more specific, the treatment of the ore by acid, the common method of treating uranium ores, would have required excessive quantities of acid, with the probability of increasing acid consumption as the mine was deepened. This problem was solved by the development of a process for treating the ores in an alkaline solution under pressure and at high temperature. The common practice is to test new extraction processes in pilot plants before undertaking full-scale design and construction. The production deadline of May 1st, 1953, plus the transportation problem, did not allow for pilot plant tests over the period that would normally be desirable. Despite these difficulties, the mine was brought into production in May 1953 and has continued to operate since that date. Eldorado's holdings in the Beaverlodge area lie, in the main, along a strong geological structure known as the St. Louis Fault. While at the time production was first planned in early 1951 the known ore reserves were only capable of supporting production at the rate of 500 tons per day, it was the opinion of the Company's Consulting Geologist that additional tonnage in substantial quantities would be found. Consequently, it was decided to erect a Mining Plant with daily capacity of 2,000 tons. Events have justified the wisdom of this decision. As the result of an intensive exploration programme carried out in the last three years, ore reserves have now been developed which will support production at the rate of approximately 2,000 tons per day. A part of these reserves—those from what is called the Verna Mine which lies some 6,000 feet to the east of the Ace Mine—is on the ground of Radiore Uranium Mines Limited, a property which is contiguous to Eldorado's holdings. Eldorado has entered into an agreement with Radiore Uranium Mines Limited whereby its ores will be mined and treated as a part of the Eldorado operation. Plans are now under way for increasing the milling capacity at the Beaverlodge operation to 2,000 tons per day. This increase will also require an expansion of the Company's Diesel Power Plant. The additional mill capacity will employ a process which is a modification of the original process. This modified process was developed by the Company's Research and Development Division when it became apparent that corrosion would be a major problem in the original process. The mill expansion will permit the Company to treat its own orse and also to treat purchased ores up to a maximum of 150 tons per day. The policy of treating purchased ores at this rate was first begun in 1954. When the expanded plant is in operation early in 1957, Eldorado's Beaverlodge Mine will be one of the largest uranium producers in the world.

The Port Hope Refinery has been in operation since 1935 but the process has undergone marked changes in that period. In the pre-war period the refinery was primarily concerned with the production of radium. After the re-opening of the Port Radium Mine in 1942, a uranium refining circuit was installed. The product of this circuit, a uranium black oxide, while of high purity, required further purification before its conversion to metal, the form in which uranium is used to fuel reactors. In 1950 Eldorado began a research programme directed towards the development of a process which would make possible the production of a purified or metal-grade oxide. This new process was installed in the refinery in the early months of 1955 and went into operation in June of that year. The new product, UO_3, is of sufficiently high purity to permit its use for the production of uranium metal without further purification. With the permission of the Committee, I would like to have attached as an appendix to my statement a paper on The Port Hope Refinery prepared by J. C. Burger, Manager of the Refinery.

Three years ago the Company announced that it was undertaking studies on the feasibility and economics of metal production. A few months ago it was decided to design and build a Metal Plant with a capacity sufficient to meet Canada's present and future requirements of uranium metal, which requirements are now being supplied by the United States Atomic Energy Commission. It is expected that this plant will be in operation late in 1957. At that time our Canadian programme will be completely self-contained as regards its fuel supply. The plant is being designed with a capacity sufficient to meet Canada's present metal requirements and the requirements which we can forecast over the next five years. The size of the plant has also been influenced by another factor. There is no certainty at this time that uranium metal will be the most satisfactory form of fuel oil power reactors. In fact, the trend is towards the use of uranium oxide. As it happens, the uranium in the fuel elements of both the PWR reactor and the NPD reactor will be in the form of oxide.

I have made reference in my description of Eldorado's mining and refining operations to the Research and Development Division. This Division is responsible for developing and improving milling, refining and metal production technique. A new laboratory for the Division is now under construction in Ottawa. These new facilities will be used in particular for testing new processes. The importance of this work to the Eldorado operation and to the uranium producers can be measured when I tell you that at the present time the cost of ore treatment in uranium mines is about 50% of the total operating cost, as compared to a cost of between 20% and 25% in other base metal operations. In other words, there is room for considerable improvement in the technique of uranium ore-dressing.

The description I have just given of Eldorado's operations will, I think, indicate the nature of the Company's organization. This resembles closely the organization of other Companies engaged in mining and refining and the Company is operated in the same manner as other mining enterprises. The Company has a Board of Directors which is responsible for deciding questions of policy, including the approval of operating and capital budgets. The execution of policy in the hands of the Company's Senior Officers who have been recruited from the mining and the chemical industries. The Board of Directors consists of the following—

R. T. Birks, Q.C., President, East Malartic Mines Limited and Consolidated Howey Gold Mines Limited, Toronto, Ontario.

Eldon L. Brown, President, Sherritt Gordon Mines Limited, Toronto, Ontario.

R. J. Henry, Vice-President in Charge of Operations Eldorado Mining and Refining Limited, Ottawa, Ontario.

W. F. James, Consulting Geologist, Eldorado Mining and Refining Limited Vice-President and Consulting Engineering Yellowknife Bear Mines Limited. Vice-President and Consulting Geologist Broulan Reef Mines Limited. Vice-President and Director Mindamar Metals Corporation Limited, Toronto, Ontario.

J. A. MacAulay, Q.C., Vice-President and Director Bank of Montreal, Winnipeg, Man.

W. J. Bennett, President Eldorado Mining and Refining Limited, Ottawa, Ontario.

I have asked the Secretary of the Committee to distribute a chart showing the Head Office and Field Organization of the Company.

The total payroll of Eldorado Mining and Refining Limited, including Eldorado Aviation Limited, is 1,085. This personnel is distributed as follows:

Beaverlodge Operation	525
Port Radium Mine	255
Port Hope Refinery	216
Eldorado Aviation Limited	34
Research & Development	24
Head Office	31

of this total, 337 are salaried employees and 748 are hourly-rated employees.

I should like now to discuss Eldorado's second function—that of a Procurement Agent. The members of the Committee will be familiar in a general way with the arrangements covering the purchase of uranium, since these have been explained in the House on a number of occasions. Briefly stated, the position is as follows.

On March 16th, 1948, the Government announced its policy covering the purchase of uranium from private producers. This announcement resulted from the Government's decision to continue the wartime policy of supplying uranium to the United States in the interests of our common defence. Eldorado was designated as the Government's Procurement Agent.

Purchases of uranium can take two forms—

Purchases Which Eldorado May Make Under the Published Price Schedule.

This schedule was first published on March 16th, 1948. Revisions have been announced from time to time, both with respect to price and the period of the guaranteed market. At the present time the published price schedule provides for a sliding scale of prices, depending on grade, up to a maximum of $6.00 per pound of uranium in an acceptable concentrate with a uranium content of not less than 10% by weight. In addition, the published price schedule provides for the payment of a development allowance of $1.25 per pound during the first three years of production.

In 1953 it became apparent that the new uranium properties which had been discovered would require a type of ore treatment which had not been contemplated at the time the published price schedule was first established. These leaching processes, to which I have already made reference, require very large and costly plants and high operating expenses. However, they have the advantage of producing a high-grade concentrate. Accordingly, it was decided in late 1953 to establish a second method of purchase—

Purchase Under Special Price Contracts.

As it happens, all purchases made to date have been made under the special price formula and it is anticipated that all future purchases will be made under this formula. The termination date for deliveries under both purchasing arrangements is March 31st, 1962. Moreover, certain conditions with respect to the special price contracts were established—namely, applications for such contracts were to be filed before March 31st, 1956, and there must be a definite assurance that production will commence not later than September 30th, 1957. As of this date, special price contracts have been entered into with the following Companies:

Algom Uranium Mines Limited	$206,910,000
Bicroft Uranium Mines Limited	35,805,000
Consolidated Denison Mines Limited	182,000,000
Faraday Uranium Mines Limited	29,754,800
Gunnar Mines Limited	76,950,000
Pronto Uranium Mines Limited	55,000,000
	$586,419,800

Letters of Intent have been issued to

Can-Met Uranium Mines Limited	75,852,000
Lorado Uranium Mines Limited	44,887,500

in addition, Eldorado has entered into contracts with the United States Atomic Energy Commission for a total amount of $202,000,000 covering production from its own mines. A number of applications for special price contracts are now under consideration. On the basis of our present information it is estimated that when these applications are processed the total dollar value of special price contracts, including contracts for Eldorado production, will be well in excess of one billion and a quarter dollars.

I should like to say a few words about the manner in which these contracts are negociated. The responsibility for negotiation rests with Eldorado's Procurement Division. In each case, the applicant is required to submit full information on ore reserves, estimated capital and operating expenditures, and other pertinent data. The application of the special price formula results in a contract which calls for the delivery of a specific quantity of uranium at a fixed price per pound. There is a provision in the contract for a price adjustment related to variations in the average hourly earnings of hourly-rated employees in the metal mining industry other than gold mining, as published by the Dominion Bureau of Statistics. The special price formula provides for full write-off of preproduction and capital expense during the life of the contract but in no case shall this amortization allowance be spread over a period of less than five years. Until recently all of Canada's uranium production was being sold under contract to the United States Atomic Energy Commission. Negotiations are now under way with the United Kingdom Atomic Energy Authority whereby the Authority will obtain a part of its uranium requirements from Canada. The quantities involved will be supplied from the contracts which will be entered into under the existing special price formula. The contractual arrangements will be similar to those which now prevail with the United States Atomic Energy Commission. Eldorado's contracts with the United States Atomic Energy Commission and the contract which will be entered into with the United Kingdom Atomic Energy Authority provide for the payment of the same price that Eldorado pays in its contracts with the Canadian producer. In other words, these transactions result in no profit to Eldorado. Each contract contains a provision that Canada may reserve any part of the production for its own use.

I believe the Committee may be interested in the economic importance of this new industry and I offer the following statistics for your consideration. It is estimated that capital expenditures for plant, equipment and machinery, housing, power lines, roads, etc., will be approximately $268,828,000. Preproduction expenditures—that is, expenditures on diamond drilling, shaft sinking and mine preparation—account for an additional $56,110,000. Operating expenditures during the production period of the contracts for wages and salaries, supplies and services, will total approximately $862,772,000 of which roughly half will be for wages and salaries. This represents employment for approximately 13,000 persons, plus those who are employed in the various industries which service a mining operation.

When all of the mines under contract and the mines to be put under contract get into full protection, the value of our uranium production will be approximately $300,000,000 per year, ranking uranium in first place in the value of metal produced in Canada each year.

The statistics I have just given you suggest at once the importance of maintaining the industry as a going concern in the period after March 31st, 1962, the present termination date for deliveries under the special price contracts. There is no information available at this time as to what the level of this demand will be beyond March 31st, 1962. Obviously it is very much in the interest of the producer who now has a contract or who may receive a contract that he should obtain this information at the earliest possible date, but it is likewise obvious that it is difficult to forecast military requirements beyond a certain date. Each of the special price contracts contains an option clause which permits the buyer to extend the contract at a negotiated price. It may be expected that the situation with respect to the exercise of these options will be clarified well in advance of the expiry of the present contracts. However, the present information we have as to the limitation of military requirements through the period up to March 31st, 1962, and the uncertainty as to the amount of these requirements after March 31st, 1962, suggests that we should examine the probable demand for uranium for peaceful purposes at home and abroad, and this I propose to do at this time.

From my remarks on the Research and Development Program, I think it will be clear that we are now able to predict that nuclear power can and will be used. The extent to which it will be used and the areas in which it will be used will depend, first, on future power requirements and the conventional sources of energy and their cost, which will be available to meet those future requirements and second, on the cost of generating power in a nuclear power plant. Obviously there is a close relationship between these two factors. For example, if we asume that nuclear power can be generated at a cost in the range of 5-to-7 mils per kilowatt hour not later than 1965, it is not too difficult to predict in what areas of the world nuclear power will be used in 1965. However, even if we were able to arrive at a reasonably accurate estimate of the amount of nuclear power which will be generated in a given area by 1965, we would still be unable to forecast the amount of the uranium requirements for this power, since this will depend on the type of power reactor and the fuel system which are used. As I mentioned in my comments on the Research and Development Program, there are various types of power reactors now under development. These reactors differ in many ways but they differ particularly in the amount of energy which they can extract from a ton of uranium, or what is commonly called the difference in the burn-up factor. I think it may be useful at this point if I attempt to give you a brief description of what is meant by the burn-up factor, since this is necessary to a proper understanding of the economics of nuclear power.

A ton of natural uranium has a heat potential of twenty billion kilowatt hours—which is roughly equivalent to the heat potential of 2,600,000 tons of coal. If it were possible to extract all of this heat, the requirements of uranium for a nuclear power program would be very small. As it happens, there are physical limitations and cost limitations which stand in the way of the full utilization of the heat potential of a ton of uranium. The content of natural uranium is roughly one part of uranium 235 to 139 parts of uranium 238—or, in other words, the content of uranium 235 in natural uranium is about 0·7 per cent. The combustible, or to be more exact, the fissionable part of uranium is the U-235. When uranium is burned in a reactor, several things happen. First, some part of the U-235 content is consumed. Second, some atoms of the U-238 content are converted into plutonium, which is itself fissionable and can, therefore, be used as a reactor fuel. Third, certain new elements known as fission products are created. These fission products interfere with, or poison, the nuclear reaction. The effect of this poisoning is crudely analogous to the effect on combustion of the waste products which are formed when coal is burned. This fission product poisoning plus our inability thus far to find materials for sheathing the uranium fuel which will stand long periods of irradiation at high temperatures, without capturing too many neutrons, make it necessary to remove the uranium fuel from the reactor when only a small fraction of its heat potential has been extracted. Now we expect that fundamental and applied research in metallurgy will make possible some increase in the life of the initial fuel charge. However, even under the optimum conditions which we can now visualize, this improvement is not likely to increase substantially the amount of the burn-up. Consequently, if we are to obtain a much higher percentage of burn-up, we must find a way of using the unburned or depleted uranium and the plutonium in the spent fuel element. This can be done by extracting from the spent fuel element in a chemical process the unburned or depleted uranium and the plutonium, and by re-entering these to the fuel system of the reactor. This is called recycling. Theoretically, it is possible to continue this recycling until all of the heat potential of the original fuel has been utilized. However, the cost of chemical processing places some limit on the number of recycles which may be economic—or, to put it another way, at a certain point it may be cheaper to buy new fuel.

As I have mentioned previously, there are a number of possible approaches to reactor design, as the design affects the percentage of burn-up. These range from what is called a single-pass reactor—that is, one in which no recycling is done—to the fast breeder reactor which produces more fissionable material in the form of plutonium than it consumes. No one can say at this time which type of reactor, or which combination of reactor types, will produce the lowest cost per kilowatt hour—the decisive factor in the choice of reactor designs for a nuclear power program. This is why it has become the common practice to refer to the power reactors now under construction as demonstration power reactors—that is, reactors which will help to demonstrate economic as well as operating feasibility. The reactor which Atomic Energy of Canada Limited is building in association with Ontario Hydro is such a reactor.

From what I have said up to this point, I think it will be evident that three factors must be used in assessing the probable requirements of uranium for nuclear power programmes—first, the future power demand and the conventional sources of power which will be available to meet that demand:

second, the cost of generating nuclear power: and, third, the type of power reactor which will be used. These three factors have been applied in forecasting the range of uranium requirements for nuclear power programmes in Canada, the United Kingdom and the United States over the period of the next twenty years. I propose to give you these forecasts because they point up the difficulty of establishing at this time any accurate estimate as to the uranium requirements for a nuclear power programme.

The forecast for the United Kingdom programme is contained in a paper which was presented at the Geneva Conference by Sir John Cockcroft. In this paper it is estimated that between one million and two million kilowatts of nuclear power will be installed in the United Kingdom by 1965 and that between ten million and fifteen million kilowatts will be installed by 1975. Sir John has considered three possibilities—first, a low burn-up based on current practice: second, an improvement in burn-up by a factor of 10 as a result of recycling: and, third, a further improvement in burn-up by another factor of 10 as a result of the use of fast breeder reactors. It is not anticipated that the fast breeder reactor will be in use until some time after 1965 because of the technical problems which remain to be solved with regard to the design of this reactor. While the United Kingdom paper does not give the annual requirement for uranium in 1965, if we assume an installed nuclear capacity of two million kilowatts by that year, it is possible to estimate an annual requirement, including the inventory requirement for new stations, which might range from a high of 600-700 tons, a requirement based on present burn-up, to a low of perhaps half that amount, a requirement based on an improvement in burn-up by a factor of 10 as a result of recycling. The United Kingdom paper does give a possible range of requirement for the year 1975. Assuming an installed capacity of between ten million and fifteen million kilowatts, the annual requirement might range from a high of 400 tons, a requirement based on some recycling, to a low of 40 tons, a requirement based on a further improvement of burn-up by a factor of 10. In addition, it is estimated that there will be an inventory requirement for new stations of approximately 400 tons per annum.

The forecast for the United States programme is taken from the Report of the McKinney Panel on The Impact of the Peaceful Uses of Atomic Energy, which was submitted to the Joint Congressional Committee on Atomic Energy on January 31st last. The forecast as to the role of nuclear power in the American economy over the next twenty years differs in one respect from the United Kingdom forecast. In the United Kingdom the cost of generating power using conventional fuels has now reached the point where nuclear power, even at a cost of 9 to 10 mills, seems attractive. Obviously, such costs are not competitive on this continent except in remote areas. For this reason, it is not possible to predict the amount of nuclear power which will be generated in the United States in 1965 and in 1975 with the same degree of accuracy as is possible in the United Kingdom. In other words, the cost of nuclear power must be lower on this continent—somewhere in the range of 5 to 7 mills—if it is to be competitive for large central power stations, and until we are assured that such costs can be achieved, estimates as to the use of nuclear power cannot be too firm. In the McKinney Report, two estimates are given—an optimistic estimate and a conservative estimate. The conservative estimate shows an installed nuclear capacity of 910,000 kilowatts by 1965 and 21,000,000 kilowatts by 1975. The optimistic forecast shows an installed capacity of 3,400,000 kilowatts by 1965 and 78,400,000 kilowatts by 1975. In assessing the uranium requirements for these respective installations, the McKinney Panel has considered six possible types of reactor, and a combination of the six types.

The Report of the Panel shows the annual requirements, including inventory for new stations, year by year, for each type of reactor over the period from 1955 to 1975, and here the range between the high and low requirements is very great. The report also shows the annual requirements, including again inventory requirements for new stations, assuming that a combination of reactor types is in use—which would appear to be the probable situation. On this basis, in 1965 the annual requirement, including the inventory requirement for new stations, might range from a high of 2,500 tons to a low of 680 tons, depending on whether the optimistic or the conservative forecast for installed nuclear capacity is used. In 1975 the annual requirement, including the inventory requirement for new stations, might range from a high of 41,000 tons to a low of 11,000 tons, depending again on whether the optimistic or conservative forecast for installed nuclear capacity is used. I think you may be interested in the following conclusions reached by the McKinney Panel in its attempt to establish some realistic forecast of uranium requirements for the United States power programme—and I quote from the Panel Report—

(*a*) Forecasts of growth rate and selective assumptions concerning reactor mix and reactor cycle and pipeline characteristics are subject to much uncertainty. Such forecasts and assumptions are critical in determining the ore requirements and lead to much uncertainty in ore requirement forecasts.

(*b*) The presently world-wide increasing ore procurement rates are far in excess of any close-up power reactor requirement rates.

(*c*) A most practicable 1975 range of ore requirements for domestic nuclear power reactors is on the basis of the growth assumptions from 6,000 to about 60,000 tons of U_3O_8 per year.

The forecast for the Canadian programme is contained in the paper presented at the Geneva Conference by Dr. John Davis of the Economics Branch of the Department of Trade and Commerce and Dr. W. B. Lewis, the Vice-President in charge of Research and Development at Chalk River, to which I have already made reference. The forecast as to the percentage of nuclear power which will be generated in Canada over the next twenty years is similar to the forecast for the United States—it shows minimum and maximum figures and for the same reasons. However, the estimate of annual uranium requirements differs in one respect from the estimates for both the United States and United Kingdom programmes, in that it is based on a single rate of burn-up. This rate assumes the use of some recycling. No estimates are shown for the annual requirements which would result from the use of single-pass reactors or the use of reactors with very high rates of burn-up. Consequently, to the extent that such reactors may be used, the figures which I shall give you must be adjusted upwards or downwards. Having said this, I should point out that the rate of burn-up used represents our best judgment as to the rate of burn-up which will be required to produce power at a cost of between 5 and 7 mills per kilowatt hour—that is, a rate which will be competitive for use in large central power stations in Canada. In other words, Dr. Davis and Dr. Lewis have tried to produce a realistic estimate.

It is estimated that by 1966 the installed nuclear generating capacity will be between 200,000 kilowatts and 1,000,000 kilowatts, and that by 1976 the installed nuclear generating capacity will be between 2,000,000 kilowatts and 3,300,000 kilowatts. If there is 200,000 kilowatts of nuclear power in use in Canada by 1966, the annual uranium requirements for this capacity would be 8 tons and the annual requirement for inventory for new stations, assuming that there was an average installation of 50,000 kilowatts per year, would be 30 tons—making a total annual requirement of 38 tons. If there is a million kilowatts of nuclear power in use in Canada by 1966, the annual uranium requirements for this capacity would be 40 tons and the annual requirement for inventory for new stations, assuming that there was an average installation of 150,000 kilowatts per year, would be 90 tons—making a total annual requirement of 130 tons. If there is 2,000,000 kilowatts of nuclear power in use in Canada by 1976, the annual uranium requirements for this capacity would be 80 tons and the annual requirement for inventory for new stations, assuming that there was an average installation of 350,000 kilowatts per year, would be 210 tons—making a total annual requirement of 290 tons. If there is 3,300,000 kilowatts of nuclear power in use in Canada by 1976, the annual uranium requirements for this capacity would be 130 tons and the annual requirement for inventory for new stations, assuming that there was an average installation of 530,000 kilowatts per year, would be 320 tons—making a total annual requirement of 450 tons.

In the three forecasts I have given the annual requirements of uranium in the years 1965 and 1975. There will, of course, be a build-up to these requirements. This is likely to be at a relatively low rate up to 1965 but at an accelerated rate between 1965 and 1975. The cumulative requirements for both years are shown in the McKinney Report and in the Davis-Lewis paper. Information on the cumulative requirements for the United Kingdom programme is not available.

You will note that in the case of the Canadian requirements in both 1965 and 1975 and in the case of the United Kingdom requirements in 1975, I have shown separately the annual requirement for installed capacity and the annual inventory requirement for new stations. It will be quite evident from the figures I have given that the inventory requirement for new stations is a very large factor in the total annual requirement. This also applies to the United States requirements. In each case, this inventory requirement is predicted on the rate at which it is estimated new generating capacity will be installed.

While I must apologize for burdening you with this imposing array of figures, I am convinced that it is only by this kind of analysis that the uranium industry can arrive at some assessment of the probable demand for uranium in nuclear power programmes. I think it will be clear that at this stage in the development of power reactor technology it is extremely difficult to establish firm estimates as to the uranium requirements for nuclear power programmes. We must first demonstrate that power reactors can be operated as a reliable and competitive source of electric energy—and this is the main objective of the programme at Chalk River and similar programmes in other countries.

Admitting the difficulty of establishing at this time firm estimates of uranium requirements for a nuclear power programme, is there any conclusion which can be drawn from the information now available? I believe there is. An abundant supply of cheap uranium will undoubtedly be an important factor in determining the choice of reactor types and reactor fuelling systems. To be more specific, there will be an incentive to achieve higher burn-ups as the cost of natural uranium increases. It is possible that at some time in the distant future the scarcity of conventional fuels will be such as to warrant the use of high-cost uranium in preference to conventional fuels. However, this situation is not likely to occur over the period of the next twenty years. When it does occur, reactor design will undoubtedly favour high rates of burn-up. These considerations suggest to me only one thing—the lower the cost of uranium, the more uranium will be used.

There is a further reason why the question of cost is of vital significance to the Canadian producer. The figures I have given for the requirements of a Canadian nuclear power programme indicate clearly that these requirements will only take up a small part of our uranium production for many years to come. The maximum figure I have given for the estimated annual requirement in 1966 is 130 tons. This requirement could be met very readily by the production from one of our smaller Canadian mines. The maximum figure I have given for the annual requirement in 1976 is 450 tons. This requirement could easily be supplied by the production from one of our larger Canadian uranium mines. Apart from the question of Canadian supply and demand, it seems clear that the rates of uranium production which we can predict in the free world over the period of the next ten or fifteen years, are likely to be considerably in excess of the requirements for power programmes in that period. Consequently, price is likely to be an important factor in our ability to compete for foreign markets, should we find ourselves with a surplus of uranium after March 31st, 1962, the termination date for deliveries under the existing contracts. When I have made this statement on previous occasions I have been accused of being unduly pessimistic. I do hope that my critics prove to be right. However, the facts as I now see them suggest that every effort should be made to reduce the cost of producing uranium. In this connection it is rather significant that the United States Atomic Energy Commission in its recent announcement on uranium purchasing established a fixed price of $8.00 per pound for a high-grade uranium concentrate in the period from 1962 to the end of 1966. So far as I am aware, none of the uranium now being produced currently in the free world is being sold at a price as low as $8.00 per pound. Our policy of permitting a full write-off of preproduction and capital expense in the special price contracts will greatly strengthen the competitive position of the Canadian producer. We also believe that we can make a major contribution to cost reduction by improving ore extraction methods. This, as I have already mentioned, is one of the major aims of the Research and Development Programme in the Raw Materials field.

Appendix No. 1

Uranium Mining in Canada

URANIUM MINING IN CANADA

By R. E. Barrett

The mining of uranium in Canada under the present programme, will be largely confined to four areas, Great Bear Lake, Beaverlodge, Blind River and Bancroft. Each of those areas is outstanding for some important feature.

A quarter of a century ago, when the Port Radium deposit was being developed for its radium content by the original Eldorado Company, prospectors staked many claims in the area. The Eldorado deposit proved to be one of the richest uranium mines in the world. Although in terms of tons of ore mined per day, and number of people employed, it is considered a small mine, its impact upon the world, and the Canadian economy has been tremendous.

Strangely enough, although the Port Radium deposit has been mined almost continuously for twenty-four years, no other deposit in the area has proven economic.

The problems of operating a mine in such a remote area are increased by the long Arctic winters, effect of isolation upon the morale of employees, need for long-range planning and the cost of transportation. It is indeed a credit to the management and the directors of the Company that operations have been so successful and that employee relations have been such that competent staff and employees have always been available.

This particular mine has another problem. The ore occurs in narrow veins, much like any of our smaller gold mines, and mining methods and techniques are similar. However, these veins run out under the deep waters of Great Bear Lake, and the veins are cut by many fractures which are open enough to carry heavy flows of water. When mining reached lower horizons, the water inflow became serious, and it was necessary to seal off each ore-bearing area before mining could proceed.

This was done by "grouting", that is, by pumping a thin cement mixture into the cracks in the ore, through diamond drill holes fanned out from nearby mine workings. Each drill hole will serve to impregnate an area of vein from 50 to 75 feet in diameter. In order to force the cement mixture into the fractures, it is necessary to overcome water pressure as high as 700 lbs. per square inch, and the grouting pumps apply pressures as great as 2,200 lbs. per square inch.

Apparently nowhere else in North America had such extensive, difficult continuous grouting been necessary, and in the beginning an expert from South Africa, was retained for a year. To-day the art is well established at Port Radium and now in Canada there are a number of engineers and techniciens qualified to apply these methods to such problems.

Beaverlodge

The next area to be developed was that around Beaverlodge Lake, which lies just north of Lake Athabasca in Northern Saskatchewan. Here uranium deposition is widespread over a length of fifty miles and a breadth of about 25 miles. Well over 3,000 uranium discoveries have been recorded and during the boom of 1951-1955, thousands of claims were staked. The original important finds were made by the Eldorado Company, and these resulted in underground development on its Martin Lake claims, the Eagle claims and the Ace and Verna claims. The last two have proven to be of major importance, and production from a 500-ton per day mill began on the Ace mine in 1953. Underground developments have continued to be successful and several important ore bodies have been opened by underground work in a mine length of 7,000 feet. The most easterly is the Verna-Radiore ore body. The mine and mill are now being expanded and production from the milling of 2,000-tons per day will begin next year. Reserves will support such an operation for many years.

The Eldorado mine in the Beaverlodge area comprises a variety of types of ore bodies. Particularly important are the high grade Ace veins, which are 5 feet to 30 feet in width. The Verna ore occurs in irregular, large, lens-like masses, generally flat lying and stacked in an "en echalon" column with low grade or waste rock separating the ore masses.

One wall of the Ace ore body is badly broken and tends to cave. It is, therefore, necessary to use mining methods common to other Canadian mines where such conditions exist. By alternately mining a horizontal slice of ore and then back-filling with waste material, safe mining can be carried out, and with a minimum of dilution of the ore with the adjoining waste. Back-fill in this mine is the sandy portion of the waste material (tailings) from the mill, and these sands are delivered into the mine by flushing down through pipes and bore holes. The mixture is allowed to flow into the space to be filled, and the water is decanted off and pumped to surface.

The use of mill tailings for back-fill is relatively new in Canadian mining, and is proving inexpensive and very effective.

The fabulous Gunnar deposit, located 25 miles from Eldorado's Ace mine, was discovered in 1952 and was the first privately financed mining company to receive a special price contract for uranium production.

Almost completely hidden by shallow muskeg, diamond drilling outlined an ore body of such generous proportions that mining is being carried on by open pit methods. It is expected that open pit methods will be economical to 300 feet of depth, after which underground mining will be applied.

Construction of the surface plant started in 1953, and the mill began production on a 1250 ton a day basis in October, 1955. A shaft has been started and development of the underground mine will be carried on concurrently with the open pit work. The dimensions of the ore body, and its moderate richness, affords production at a relatively low cost.

A number of other properties in the Beaver lodge area have warranted underground development. So far none of these shows size characteristics comparable with the Ace-Verna mine or Gunnar, but as a group will produce a considerable poundage of uranium. Since small uranium ore treatment plants are disproportionately expensive, a mill is planned by Lorado Uranium Mines Limited, to treat the ores from their mine and these other small operations.

The mines in the Beaverlodge area are blessed with relatively rich ore (grading from 3 to 7 pounds U 3 0 8 per ton mined). The ore zones are usually softer than the enclosing rocks, so that the outcrops often occur in topographical depressions and are covered with sand and clay. This and the widespread occurrence of uranium mineralization (much of which is in small patches) over an area of about 1,000 square miles, has made the discovery and proving of economic deposits a slow and costly business. It seems fair to suggest that the potential of the camp may not be fully realized for many years to come.

Blind River

The Blind River area is probably the greatest single reserve of uranium mineralization of economic grade known in the world today. Structurally identical with the famous gold-bearing "banket" deposits of the Witwatrersand in South Africa, the Blind River conglomerate beds are proving to be likewise uniform in character and extend over a large area. Whereas the Rand conglomerate beds are low in uranium (although recoverable as a bi-product in the course of gold milling) the Blind River beds average about 2 lbs. of uranium oxide per ton of ore and carry only trace quantities of gold.

Conglomerate rocks are the consolidation of ancient gravel beds. The uranium in these particular ones occur as minutes particles distributed throughout the matric surrounding the pebles.

The beds dip flatly, usually at bout 10° to 20° near the surface and flatten in some of the deeper areas to as little as 10° of inclination. The mineable sections vary in thickness from about 6 feet to a maximum of 35 feet. The average thickness will be about 15 feet when mined, so that every acre of ground potentially contains more than 50,000 tons.

There have been outlined three areas of economic importance, known as the South Belt, the Middle Belt and the North Belt. The Pronto mine with a 1,500 tons per day plant is located on the South Belt and started production last October. The Algom Nordic mine, on the outcrop of the Middle Belt, is being prepared for production at 3,400 tons per day and the Algom Quirke mine, on the North Belt outcrop, is likewise erecting a 3,400 ton mill. These two mines with very large properties expect to begin production by the end of 1956.

The Consolidated Denison mine is also located on the North Belt, the ore dipping onto its ground at about 1,600 feet of depth. One shaft has already reached the ore and a second is well on its way to intersect the bed at about 2,200 feet of depth. A mill is being built that will treat 5,700 tons of ore per day. Adjacent to the Consolidated Denison are the Spanish American mine, planning a 2,000 ton mill; The Panel mine and the Stancan mine each preparing for a 3,000 ton mill, and the Can-Met mine preparing for a 2,500 tons per day mill. Likewise on the Middle Belt, the ore formation dips from Algom ground onto the Milliken Lake and Lake Nordic properties and, after extending across these, dips onto the Stanleigh claims at a depth of over 3,000 feet. Milliken and Stanleigh are planning for operations at 3,000 tons per day and Lake Nordic at 4,000 tons per day.

These are the Blind River mines expected to produce under the present uranium buying programme. By 1958 a total of 34,500 tons of Blind River ore will be mined and milled per day, much of this from shafts over 2,000 feet deep.

Meeting the production date set by the contracts will be a major problem for most of the Blind River mines. The deep shafts take months to sink and every mechanical device and scheme known are being used to save time. When the sinking is completed it is another big job, usually requiring over a year, to ready the mine for production. One apparent way to overcome the long delay for mine preparation is to use modern "trackless mining" methods.

Standard mining methods, such as presently in use at the Pronto mines, require the driving of haulageways, usually in waste rock, at vertical intervals of 100 feet or more. The haulageways are driven closely under the ore bed, which is tapped at intervals by short vertical passageways called "box-holes". After blasting the broken ore is moved by power-driven scrapers along the flat slope to these openings. Trains of cars operating on rails in the haulageway carry the ore from the chutes under the box-holes to the shaft, where it is hoisted to surface. It is the preparatory work done in the waste rock that takes so much time by this method.

The alternative mentioned uses no rail haulage and all transportation is done with special rubber-tired vehicles, aided in some cases by conveyor belts. Moreover, all excavating is done in the bed itself, and because the trackless equipment can operate on rather steep grades, the haulage equipment is loaded at the place where the ore is broken, at a considerable saving in handling. Working with the haulage units—which may be either diesel or electric powered—are other special mobile loaders, drilling machines etc. Using a form of "room and pillar" ore extraction system, a great number of working places can be established quickly.

The method suggests low costs and rapid progression to full scale production. "Trackless Mining" methods have been successfully applied to bedded iron ores, coal mining and flat base metal deposits for a number of years in many parts of the world. The problems, however, of applying the method to Blind River are (1) the grades are near the critical limit for trackless haulage; (2) the ore is too abrasive for much of the specialized machinery that has been developed to date and (3) the equipment is very expensive and delivery is slow.

All the mines concerned are studying this situation and the machinery manufacturers are co-operating by redesigning certain equipment to meet the special situations. There is no doubt that a successful solution will be found, combining both low operating cost and high early productivity.

Bancroft

The Bancroft uranium area lies in the rugged highlands of Eastern Ontario where the ancient Grenville Series of rocks have long been known as a source of a variety of minerals. From early days the region has been mined sporadically for iron, lead and zinc, mica, feldspar and silica.

The first radioactive discoveries were spectacular pockets of large cyrstals of euxenite, a low grade uranium mineral. Because of its association with pegmatite dykes—a host long recognized for its unpredictable composition—little faith was manifest when discoveries were made of the ore mineral, uraninite and other radio-active minerals in one variety of the pegmatite rocks.

However, extensive development by diamond drilling and underground work has demonstrated that some of these uraninite deposits can be economic. The Bicroft mine has a contract to produce from its 1,000 tons per day mill which will start operating this September, and Faraday, also with a contract, is building a 750 tons per day mill. Dyno, Cavendish and some others are hopeful of being awarded contracts.

The characteristic deposit of this camp comprises several parallel fine-grained pegmatite dykes with uranium minerals enriching part or all of the dykes, to form mineralized lenses varying up to several hundred feet in length and from 5 to 12 feet in average width.

Since the dip of the veins is moderately steep and the rocks are such that a minimum of support will be necessary, it is expected that mining methods will be simple and the underground costs will be favourable and comparable to Canadian narrow vein gold mining. Test work indicates that the ore will probably be the cheapest to mill of any of our camps.

The grade of these mines is expected to vary from 2 lbs. to 2·5 lbs. U_3O_8 per ton. These features, together with the central location, easy access and cheap power, give expectations of a sound local industry. The ore reserve potential of the Bancroft-Wilberforce area is difficult to assess. Radioactivity is widespread and favourable rock types are abundant. There could be many undiscovered deposits of economic grade and proportion awaiting future development.

Appendix No. 2

Canadian Practice in Uranium Recovery Plants

by A. Thunaes

April 24, 1956

CANADIAN PRACTICE IN URANIUM RECOVERY PLANTS

By A. Thunaes

Introduction

The extractive metallurgy of uranium is an important link in the long chain of processes that produce nuclear fuel from low grade uranium ores. A tremendous amount of effort has been expended during the last ten or twelve years in order to develop processes that could extract uranium with satisfactory recovery and at reasonable cost and in the form of a product that was acceptable refinery feed. (1) (2) During the same period the refining of uranium concentrates and the production of uranium metal was developed and large scale metal production plants commenced operation in the U.S.A. and in Great Britain.

The urgent requirement to meet production demands and dead lines has lead to the building of many plants without the normal amount of development and has also tended to standardize plants using processes that had already been proven. In spite of this many new developments are now incorporated in uranium plants that may be of value to the general field of extractive metallurgy. (3)

Throughout the uranium era Canada has played an important role in the production of uranium concentrates and the Canadian share in world production is rapidly growing.

The following is a review of treatment methods for the uranium plants that are now operating in Canada and of some of the major plants that are now in the construction or planning stage.

History

Only one plant was producing uranium concentrates in Canada prior to 1953. This was the well known Port Radium operation where a gravity concentration plant has been operating since 1933; (4) Eldorado Mining and Refining built an acid leaching plant at Port Radium based on a process developed by the Mines Branch Radioactivity Division 1947-1949. This plant at start of operation in *April 1952* was the first modern uranium leaching plant in North America to treat pitchblende ores.(5)(6)

The Beaverlodge mill of the Eldorado Mining and Refining Limited commenced operation in April 1953, treating 500 tons/day, (7) the capacity was increased to 700 tons/day in 1954. The Beaverlodge mill is unique in Canada, in that sodium carbonate-bicarbonate rather than sulphuric acid is employed as a leach reagent.

In *1955* the number of operating plants increased to 4 as the Pronto Mill in the Blind River Area and the Gunnar Plant in the Beaverlodge area went into production in August-September; both plants having a stated capacity of 1250 tons/day, and acid leach processes are used. These were the first privately owned plants to join in Canadian uranium production. The production of uranium from the plants that are now in operation (early 1956) is substantial but the plants that are now in the planning or construction stage will provide manifold increase in tonnage treated by late 1957.

The following is a list of assured additional producers:

Company	Area	Probable Starting	Capacity Tons Ore/Day
Algom (Quirke)	Blind River	Late '56	3,000
Algom (Nordic)	Blind River	1957	3,000
Can-Met	Blind River		2,500
Consolidated-Denison	Blind River	Mid 1957	5,700
Bicroft	Bancroft	End of 1957	1,000
Faraday	Bancroft		750
Lorado	Beaverlodge		500
Eldorado Beaverlodge Expansion			1,300
			17,700

Since further contracts remain to be written under the present buying program, several other plants may be added.

Ores

Individual plants and processes are described elsewhere in this issue. The following is a broad summary of typical Canadian ore types that are treated, or will be treated in these plants. The ores have been classified according to the principal uranium minerals contained:

I. *Pitchblende Ores—Hydro-thermal Type*

The Beaverlodge area in Northern Saskatchewan is the principal source of Canadian pitchblende ore at the moment. Important deposits occur in the Northwest territories. The pitchblende in the above areas is found in hydro-thermal veins, associated with considerable calcite and other carbonates, hemanite, chlorite, graphite and clay. These ores consume considerable acid, and oxidizing reagents are required. (The richest Canadian ores are of this type).

II. *Brannerite Ores—Conglomerate*

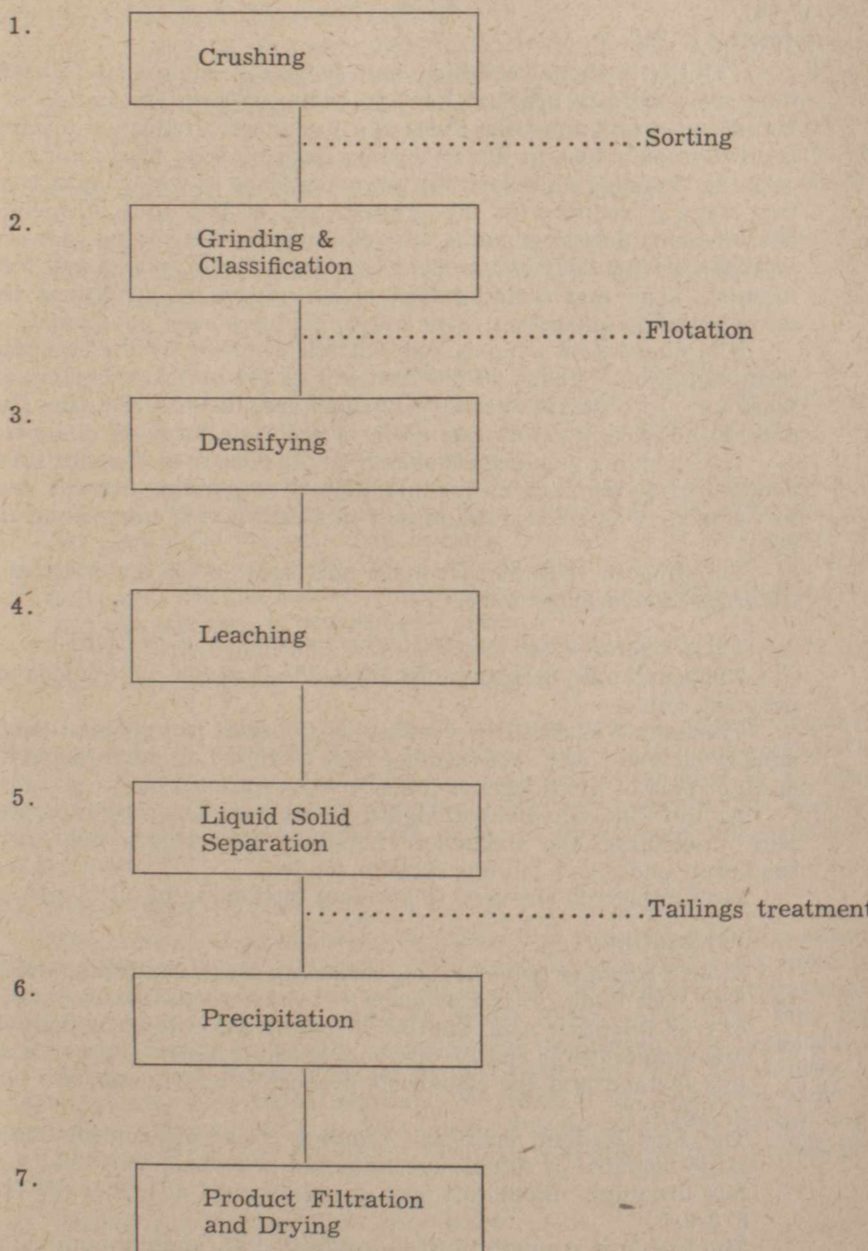
The huge Blind River field contains Brannerite as the main source of uranium, but some pitchblende and/or uranite occurs. Brannerite does not require oxidizing agents but is more refractory towards sulphuric acid. Compared to pitchblende ore a greater amount of free acid, higher temperature and longer leaching times are required to dissolve Brannerite; acid consumption is moderate. Important associated minerals are quartz, sulphides and chlorites.

III. *Uranite—Uranothorite Ores (Pegmatite dykes)*

The plants in the Bancroft field will treat this type of mill feed. These uranium minerals are readily dissolved by sulphuric acid in presence of suitable oxidizing agents. Acid consumptions are low to moderate.

Other ores that may be treated in the future include Columbium and tantalum ores and ores such as found in the Rexspar mine in British Columbia.

FIG. I


1.
Crushing
Sorting
2.
Grinding & Classification
Flotation
3.
Densifying
4.
Leaching
5.
Liquid Solid Separation
Tailings treatment
6.
Precipitation
7.
Product Filtration and Drying

Treatment Methods

An outline of the individual section of typical uranium treatment is shown in Fig. 1. This applies specifically to Canadian ores. (8) In the U.S.A. the flowsheet will frequently include roasting for the purpose of vanadium recovery. (9)

Referring to Fig. 1:

(1) Conventional crushing and screening equipment is used. The ores are generally medium hard to hard. Due to association of pitchblende with soft minerals, there is a pronounced tendency towards concentration of values in the finer sizes from blasting or crushing.

(2) Grinding and classification takes place in water, most commonly two stage grinding with the primary rod or ball mill in open circuit. Bicroft plans pebble grinding; the elimination of grinding iron is an advantage, particularly when acid leaching is the subsequent treatment method. The fine metallic iron creates reducing conditions that are detrimental to extraction rates and to stainless steel equipment.

The fineness of grind is generally determined by the equipment for leach agitation. About 60 per cent minus 200 mesh is common for acid leaching. In contrast to some sandstone ores in the U.S.A. the Canadian ores do not give good extraction by percolation leaching at coarse sizes.

Dry grinding would seem attractive for some ores since the thickening could then be eliminated, but this method of grinding has not been used in Canada. One gold-uranium mill in South Africa employs an Aerofall Mill.

Grinding in sodium carbonate mill solution is the practice at the Eldorado Beaverlodge mill.

(3) *Densifying (Primary Thickening and/or Filtration)*

The usual pulp density in leaching is that which corresponds to 55-60 per cent solids.

Thickening of classifier overflow is sufficient to produce the required density for some ores, (for instance Port Radium), in other plants filtering of all or part of the thickener underflow is required.

At the Eldorado Beaverlodge mill cyclones are used in conjunction with thickening, the thickeners handling cone slimes only, with the thickener underflow joining cyclone sands.

Settling agents are used to promote thickening in all plants.

(4) *Leaching*

In acid leaching two principal variations are in use or planned for use.

(*a*) The Port Radium type of leach (5) is characterized by low content of free sulphuric acid, the use of sodium chlorate as oxidizing agent, low temperatures and 24-36 hours leaching time. Gunnar Mines use this method and the Bankcroft properties and Lorado are planning to use it.

The Port Radium operation requires closer pH control due to the large amounts of soluble arsenate and phosphate that tend to precitate uranium. Bankcroft ores can be leached at higher pH range of 2·0-2·5.

The free acid strength must be controlled at the minimum value that will give satisfactory extraction and extraction rate. An excessive amount of free acid will cause high consumption due to attack on the gangue minerals, chlorite, clay, fluorite, kaoline, etc.

The function of sodium chlorate is to maintain a sufficient amount of free ferric iron in solution to oxidize tetravalent uranium. The chlorate does not oxidize uranium directly.

The free acid content of tailings solution is generally not sufficient to warrant the return of solution when the above weak acid leach is used. However, neutralization of waste solutions is required in certain areas.

(b) *The Blind River Type of Leaching*

The Blind River type of leaching is carried out with a larger excess of free sulphuric acid; the temperature is generally 45°C. and up to 48 hours contact time is used. Since Brannerite contains hexavalent uranium oxidizing agents are not required to dissolve this mineral. However, small amounts of oxidizing agents may be required to leach minor amounts of pitchblende and to counteract the reducing action of metallic iron from grinding.

The high acid content makes it advantageous to re-cycle solutions, but sufficient acid and acid salts are discarded to require neutralization of waste solution at a considerable cost.

(c) *Sodium Carbonate Leaching*

The Eldorado Mill at Beaverlodge is the only Canadian plant that employs alkaline leaching. The ore is ground in mill solution, the pulp is thickened and leached in heated solutions. Oxidation of uranium is carried out by dispersed air.

Bi-carbonate must be present in order to maintain good extraction rates; the bi-carbonate is formed by reaction with sulphides and by sparging with fluegas. The original 500 ton plant was based on leaching under pressure, (7) (10) the 1954 expansion to 700 tons daily rate and the current expansion to 2,000 tons/day are based on pachuca leaching at atmospheric pressure.

Sulphides are the main consumers of leach reagents; the 2,000 ton plant will include a flotation section for pyrite separation.

A general statement that applies to most leaching processes is that agitation should be sufficient to provide ample circulation but not violent enough to cause sliming of soft gangue. In order to save costly reagents it is often advisable to aim for a slow and selective leaching condition, by keeping acidity, temperature and excess oxidizing power at a low level but extending the leaching time.

5). *Liquid Solid Separation*

The methods used at present are based on two step filtration except that the Beaverlodge (Eldorado) mill uses washing thickeners followed by single filtration in the present plant; the new Beaverlodge flowsheet will use double filtration. Several Blind River plants that are now under construction or design intend to use counter-current decantation.

Settling and filtering rates are generally low due to sliming of soft minerals, flocculating reagents are used at all plants to improve capacities. String discharge filters are used to advantage at the Port Radium and Gunnar plants and this type will also be used at Beaverlodge.

6). *Recovery of Uranium from Solutions*

(*a*) *Acid Solutions*

The Port Radium leach plant employs reduction with aluminum powder with simultaneous (5) precipitation of uranous arsenate and phosphate. This method is well suited for Port Radium solutions and has been very successful.

All other Canadian plants use or plan to use anion exchange resins for uranium recovery from solution. Ion exchange is particularly suited for low grade solutions and for those ores that contain considerable amounts of acid soluble thorium minerals, such as Blind River and Bancroft types.

The Gunnar plant in the Beaverlodge area and the Pronto plant in Blind River operate ion exchange systems at present; both use sodium chloride elution methods and magnesia precipitation.

The Bancroft plants and several Blind River plants that are under construction plan to use ion exchange with varying methods of elution and precipitation.

(b) *Carbonate Solutions*

Caustic soda is used to precipitate sodium diuranate, the barren solution being re-circulated for leaching after the excess caustic is converted to sodium carbonate by contacting with flue-gas.

Alternative methods have been used successfully on a pilot plant scale, among these is a method for precipitation of uranium by hydrogen under pressure.

Clarification of solution is an important step ahead of precipitation or ion exchange; the equipment used is similar to that used in cyanide practice except for materials of construction.

7). Filter press systems are used at Gunnar, Beaverlodge and Port Radium. Pronto uses four stage filtration in order to remove impurities to specification levels. When chloride elution is used in the ion exchange process, very efficient washing is required.

Oil fired pan driers are used at Port Radium and Gunnar Mines plants, Pronto Mines use steam heated drum drying; this method is proposed for several Blind River plants but belt type tunnel driers are planned for some plants in this area.

Notes on Equipment and Auxiliary Services

Before the first Canadian acid leach plant was started little was known about corrosion behaviour of this type of acid solutions; concern about maintenance cost was expressed. The experience of four years operation has been very satisfactory. Rubber or linatex lined equipment withstand the solutions very well, as do wooden tanks and 316 stainless steel providing that temperatures are low and the solutions are not of excessive reducing power.

The Blind River type of leach has not been operated to sufficient time to obtain a picture of maintenance costs but first reports are encouraging.

Contrary to expectations, carbonate leaching operations have not been entirely free of corrosion troubles.

Refining and Metal Production

The uranium leaching plants produce a high grade precipitate which may be a di-uranate of sodium or magnesium, a uranium phosphate or arsenate.

(11) (12)

In order to produce metal the following steps are required:

1). Production of "metal grade" oxide, that is UO_3 which has been highly purified to meet the exacting specification for nuclear fuel. The refining includes solution in strong nitric acid and separation of uranium by solvent extraction processes which can be operated to give a high degree of selectivity between uranium and impurities. Tri-butyl phosphate in kerosene is a suitable solvent, although diethyl ether is also in use. Uranium nitrate is re-extracted from the organic phase by water and the water solution is evaporated to pure uranyl nitrate hexa-hydrate. The hexa-hydrate is heated to drive off nitric acid and form a very pure UO_3.

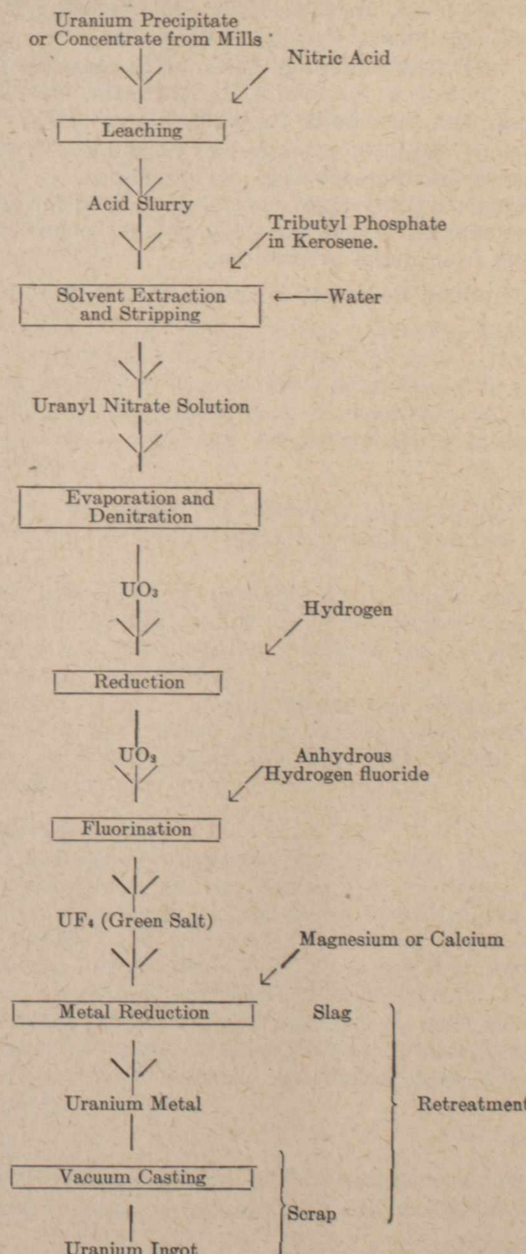
2). The next step, green salt production, involves reduction of UO_3 by hydrogen to form UO_2, then the UO_2 is reacted with anhydrous hydrogen fluoride to form green salt—UF_4.

3). Metal is produced by reacting UF_4 with magnesium or calcium; metal and fluoride slag are produced.

Many auxiliary operations are required for efficient performance. These include, nitric acid recovery, solvent recovery, retreatment of scrap and slag from metal production.

A simplified flowsheet is shown in Fig. 2.

FIG. 2



The solvent extraction process is the step where elimination of impurities is effected. While this process is selective, the demands for purity in the product are such that feed material to the refinery must be kept reasonably free of objectional impurities. These impurities fall in two classes:

(1). Those elements that must be almost entirely eliminated in the UO_3 product to meet specification for metal grade and

(2). Those compounds that cause difficulty in refinery operation, process or equipment wise.

The precipitates from a leaching mill, to be an acceptable refinery feed, should conform to impurities limits of approximately the following:

V_2O_5	Less than 2	parts per 100 parts U_3O_8
P_2O_5	2	" "
Mo	½	" "
B	1/30	" "
H_2O	10	" "
ThO_2	3	" "
Cl, Br, I	1/10	" "
F	1/10	" "
Cu	1½	" "
As	¾	" "
Co_3	1	" "
NH_3	1	" "
	100	

The above impurities are those that are of most interest to refinery operation but limits for elements such as Rare Earths may also be requested.

Specifications of uranium content will vary according to the ores treated and processes used, between 50% and 85% U_3O_8 minimum content.

The Canadian refinery is operated by Eldorado Mining and Refining Company at Port Hope, Ontario. The refinery produces at present a metal grade uranium trioxide but it is expected that "green salt" and metal will also be produced in the not too distant future.

Development, Past and Future

Canadian plants now in operation or under design are based on processes that were developed in the last ten years. Most of the early research work was carried out in the U.S.A., U.K., and Canada, and the various research groups co-operated by frequent exchange of information.

In Canada, the principal contribution to process development in the Raw Material Field has come from the Radioactivity Division of the Mines Branch. (13) The flowsheet for essentially all the Canadian plans were developed or pilot plant tested in the Ottawa laboratories. Valuable contributions have also been made by the Eldorado Mining and Refining Company and by the Universities of British Columbia (pressure leaching), (10) Queen's University and the University of Alberta.

The history of the research and development carried out in Canada on treatment of original uranium ores is given elsewhere in this issue.

The refinery and metal production processes (11) (12) that are now in use in plants in the free world, are of relatively recent origin. Solvent extraction, denitration, reduction and fluorination, metal production by thermite type reactions were parts of the original process that was developed in the years immediately preceding the first atomic bomb, and today's production is based on these methods. Some changes have been made; these include choice of solvent. Hexone and diethyl ether were tried in the earliest stages but tributyl phosphate is now the preferred solvent although ether is still used in some plants. In the reduction and fluorination steps continuous methods are replacing batch operation.

In the raw materials and in the refinery fields the pressure for increased production has been the dominant factor. The natural tendency has been to stick to a process that is already proven in plant operation on similar ores or feed materials and not to introduce process changes that might require considerable plant development and loss of production in the break-in period.

However, an impressive amount of development work has been done in the U.S.A., U.K., Canada, South Africa and Australia, (as well as in Europe, particularly in France and in Sweden), and some of the new ideas are now being used on a plant scale. An outstanding example is the anion exchange process (8) developed in the U.S.A. and further advanced in the South African plants where the recovery of uranium from very large tonnages of low grade solutions has been successfully carried out. The anion exchange process, as applied to clear solutions, has dominated the field in the flowsheets of the very large number of plants that have been started or planned in the last three to four years; in a field as new as uranium metallurgy the ion exchange method from clear solution is already a "classic" method.

Ion exchange from pulps, (RIP), has as yet been used in only a few plants when filtering difficulties were great.

The new and promising method of solvent extraction from clear sulphate solutions is gradually coming to the fore and may eventually replace ion exchange methods. (2) (14) A few plants in the U.S.A. are now operating with solvent extraction methods of recovery.

The fields of raw materials and of refining have until very recently been developed by separate groups and organizations and have been considered as separate phases in the uranium production. Developments in the future may well tend towards production of "metal grade" products at the original ore treatment plants in form of UO_3, UO_2 or UF_4. (12)

As the immediate demands for uranium production becomes satisfied, attention will be focussed on cost saving improvements using new processes that have been developed and will be developed in the laboratories.

If, and when, a free market for uranium develops only those producers that have rich ore or those producers that have the most efficient and economical process for large low grade ore reserves may be expected to be in a preferred position.

Much has been written and spoken concerning the future requirements for uranium and any "crystal gazing" on this subject is not within the scope of this paper.

Less has been said about the type of uranium compound that will eventually be used for fuel in power reactors. We do not know today if the principal demand for reactor fuel will be natural uranium metal, natural UO_2, enriched metal or enriched UO_2, enriched solutions or slurries.

The course of uranium processing in the future will be influenced to a great extent by the type of fuel element that will predominate and any significant change in reactor fuel types and in reactor efficiency will affect feed material processing as well as the tonnage requirement.

References:

1. "Principles and New Development in Uranium Leaching" by A. M. Gaudin. (Submitted to the Geneva Conference on the Peaceful use of Atomic Energy. Published by the United Nations.

2. "Recovery of Uranium from its Ores" by G. Marvin, T. Upchurch, E. Greenleaf, E. Van Blarcom and A. Morphew. Presented at the Geneva Conference on the peaceful uses of Atomic Energy (to be publshed by U.N.)

3. "Recent Developments in the Processing of Uranium Ores and their Significance in the Extractive Metallurgy of Metals". by R. R. Grinstead. AECU-3071, Technical Service, Oak Ridge, Tennessee, available from the office of Technical Services, Department of Commerce, Washington, D.C.

4. "Eldorado Gravity Plant" by R. L. Behan. Paper presented at the Western Meeting of the Can. Inst. of Mining & Metallurgy, October 1955.

5. "Development of the Port Radium Leaching Process for Recovery of Uranium. Department of Mines and Technical Surveys, Technical Paper No. 13.

6. "Leaching of Uranium Gravity Mill Tailings at Port Radium, N.W.T." by D. F. Lillie and R. Tremblay. To be published in Canadian Mining and Metallurgical Bulletin" April, 1956.

7. "Use of Autoclaves and Flash Heat Exchangers at Beaverlodge" by R. W. Mancantelli and J. R. Woodward. Transactions AIME, Volume 203, 1955.

8. "Recovery of Uranium from Canadian Ores" by A. Thunaes. Canadian Mining and Metallurgical Bulletin, March 1954.

9. "Processing Changes at the Monticello Mill" by Richard L. Philippone and Helmer A. Johnson. Paper presented at the AIM meeting, New York, Feb. 1956.

10. F. A. Forward and J. Halpern: Studies in Carbonate Leaching of Uranium Ores.

11. "Production of Uranium Metal" by D. S. Arnold, C. E. Polson and E. S. Noe. Published by the American Institute of Chemical Engineers for the Nuclear Engineering & Science Congress, Dec. 12-16, 1955.

12. "Feed Material Production—New Opportunity for Uranium Men" by Wilbur E. Kelly. Eng. and Min. Journal, Vol. 157, No. 1.

13. "The Function of the Mines Branch Radioactivity Division" by E. A. Brown. The Canadian Mining and Metallurgical Bulletin, Volume 46, No. 50, Dec. 1953.

14. "Recovery of Uranium from Colorado Plateau Ores by Solvent Extraction" by D. A. Ellis, R. R. Grinstead, R. L. Mason, J. E. Magner, R. S. Long, K. G. Shaw. DOW-131, Technical Information Service, Oak Ridge, Tennessee. Available from the Office of Technical Services, Dept. of Commerce, Washington 25, D.C.

Appendix No. 3

Research Activities
Eldorado Mining and Refining Limited

A. Thunaes
May 29, 1956.

ELDORADO RESEARCH ACTIVITIES

Extractive Metallurgy

The following concerns only research for recovery of uranium. Early research on recovery of radium was carried out by the Canadian Bureau of Mines and by Eldorado Gold Mines, resulting in the construction and operation of the old refinery.

The Port Radium Mine because of vital importance for production of uranium in 1944 and the development of the mine as well as improvement in uranium recoveries were urgently needed. The ore from this sole Canadian source of uranium was recovered by gravity concentration on jigs and tables, a method that had been reasonably successful when the very rich silver uranium ore was mined in the upper levels of the ore body. By 1944 the upper levels were mined out and ore of more moderate grade remained; the recoveries obtained by the gravity mill were disappointing in spite of careful operations and modern equipment.

Organized research on metallurgical improvement of the Port Radium operation was initiated in 1945 through the establishment of the *Eldorado Project*. A group of engineers, chemists, physicists and technicians were assembled to work at the laboratories of the Bureau of Mines, and at Port Radium.

This group was working for the first year or two on the improvements on the gravity concentration methods and methods of flotation and methods involving electronic sorting.

Some improvements were made in mill efficiency, but by 1947 it was apparent that chemical leaching methods were the only means of obtaining high recoveries, and of reclaiming the large reserves of uranium in stored mill tailings.

During the period 1947-1950 intensive research work was carried out at the Mines Branch Laboratories to develop a suitable leaching process. The Eldorado Project Group was expanded and became the Radioactivity Division of the Mines Branch. However, the bulk of the divisions' work concerned the Eldorado ores.

A successful method was developed to treat the Port Radium ore and permit re-treatment of stored tailings. This method was pilot plant tested at Ottawa in 1949 and on a larger scale, at Port Radium in 1950. The full scale plant was built and has operated successfully since early 1952. The development of the Port Radium Leaching Process for Recovery of Uranium is described in Technical Paper No. 13, 1955, issued by the Department of Mines and Technical Surveys.

The leaching process developed for Port Radium ore has been used as a pattern for treatment of many other Canadian plants that are now in operation or in the planning or construction stage. Several variations in methods have been developed to suit individual ores and these methods have all been tested by the Mines Branch laboratories on a laboratory or pilot plant scale.

As late as 10 years ago the Port Radium mine was the only commercial uranium deposit in Canada, the ore was rich enough to allow partial recovery of the uranium in a high grade concentrate that could be treated in the Port Hope refinery.

At that time the uranium deposits of the Beaverlodge, Blind River and Bancroft areas had not been explored. However, if they had been known it would not have been possible to recover uranium from their deposits because methods of treatment were not known. In other words, the deposits could not have been called ore at that time.

A new and important mining area was under development by Eldorado in 1948-1950.

When the Beaverlodge field was found and explored it was found that some ores in this area contained large amounts of carbonate minerals that consume sulphuric acid. A process had been developed at the Mines Branch for one of these ores that involved leaching with sodium carbonate solutions and precipitation of uranium by sodium hydroxide. After the uranium precipitate was filtered off, the barren solution was treated with fluegas to restore the carbonate content and then returned to leach fresh ore. This first "cyclic" carbonate leach employed sodium permanganate as an oxidizing agent.

The first major deposit to be developed by Eldorado in the Beaverlodge Area was the Ace Mine. The samples from the first two levels of the Ace Mine indicated that the ore could be treated by an acid leach process as used at Port Radium and that the content of acid consuming carbonate minerals was reasonable.

However, concern was expressed that the carbonate mineral content of the ore might increase at lower levels since other ore types in the area (Nicholson and Martin Lake) contained large amounts of these acid consuming minerals; if the latter type of ore should be mined the straight acid leach process would not be attractive.

Consequently, methods for leaching of Ace ore by sodium carbonate solutions were investigated. The Mines Branch laboratories worked out a combination process involving separation of carbonate minerals by flotation, leaching of these flotation concentrates by sodium carbonate solution containing sodium permanganate, and acid leaching of the remaining portion of the ore. About 85% of the ore would thus be treated by acid leaching with assurance of reasonable costs.

At the same time, methods for leaching all the Ace ore by carbonate solutions were investigated. The Mines Branch laboratories had done preliminary work on autoclave leaching by sodium carbonate solutions at high temperatures and pressures and these looked sufficiently interesting that the Unversity of British Columbia was asked to undertake a research project along these lines.

Laboratory results at U.B.C. and later pilot plant testing at Ottawa indicated that the pressure leach process involving air oxidation could give acceptable recoveries and costs. The process proposed by U.B.C. involved as a final step, the precipitation of uranium by hydrogen at high pressures. However, the decision was made to build a plant at Beaverlodge that employed autoclave leaching, but used the system of precipitation, carbonation and recycling of solution that was developed by the Mines Branch.

This Beaverlodge plant commenced operation in May 1953.

In the meantime the Mines Branch laboratories continued work on improving the methods for leaching in carbonate solution and developed a satisfactory method for leaching Beaverlodge ores in sodium carbonate solutions at atmospheric pressures and temperatures.

A satisfactory method was developed and pilot plant tested based on air oxidation and control of the sodium bi-carbonate content of the solution; the recoveries were equal to those obtained in autoclave leaching and the indicated capital and operation costs were lower than for pressure leaching.

By early 1953 the Mines Branch Radioactivity Division was heavily engaged in test work on ores from private companies. Eldorado decided to form its own research organization to centralize the company's research in ore dressing and refining. This Research and Development Division was formed in April 1953 and staffed with personnel from Port Hope and the Mines Branch.

One of the first projects to be undertaken was further development of the atmospheric pressure carbonate leach for Beaverlodge ores that had been developed by the Mines Branch. Eldorado built and operated a large pilot plant in Ottawa to obtain design information on this process. The pilot plant was operated during 1953 and a total of 600 tons of ore was treated. The metallurgical results confirmed earlier testwork.

When the capacity of the Beaverlodge mill was expanded in 1954 from 500 to 700 tons per day, the atmospheric leaching system was chosen to provide the additional leaching capacity. The new leaching equipment consists of Pachuca tanks which are piped for introduction of air and fluegas.

The indicated saving in power, reagents and maintenance are considerable.

In 1955 it was decided to enlarge the Beaverlodge mill to a capacity of 2000 tons per day. This project is now under way. The development of the "Verna" ore body had ensured sufficient ore reserves for the increased tonnage. The Verna ore differs from Ace-Fay ores since the former contains more sulphides; these sulphides react with the sodium carbonate leach solution and consume an excessive amount of reagents. After extensive testing by the Research and Development Division of Eldorado the flowsheet for the plant extension was revised. The sulphide minerals will be removed by flotation and the concentrate (60-70 tons/day) treated separately by acid leaching. A crude precipitate will be made from the acid leach liquor.

The remainder of the ore, after flotation will be treated by carbonate leaching; approximately $\frac{3}{4}$ of the ore will be treated by pachuca leaching and the remaining $\frac{1}{4}$ by leaching in existing autoclaves.

Certain changes will be incorporated in the new plant. Double filtration will be used to separate leached ore from solution. The solution will be treated in a steam stripping tower to remove excess Sodium bicarbonate before precipitation with sodium hydroxide and thereby make considerable saving in reagent costs.

The Research and Development Division has engaged in research on the Port Hope refinery process. A brief outline of Eldorado's work in this field follows:

The term refinery has a rather flexible meaning in uranium technology, but in the usage today the refining constitutes the step of converting concentrates or precipitates to an uranium oxide that is pure enough for processing to uranium metal. That is, all the impurities that are objectionable in atomic reactor fuel elements are removed, and the "metal grade" oxide can be converted to uranium dioxide fuel elements or to uranous fluoride and metal fuel elements without further purification.

The Port Hope Refinery that was in operation until 1955 did not produce a refined oxide of metal grade but a partially refined black oxide or U_3O_8.

Research was carried out by Eldorado during the period 1950-1954 on improvements in the Port Hope refinery process. The processes tested followed the solvent extraction principle that had been employed in British and French plants; information on U.S.A. methods was not available until 1953.

The solvent extraction process for uranium is based on dissolving the uranium concentrates in hot nitric acid and contacting the slurry, (or filtrates), with certain organic solvents diluted with kerosene. The organic solvent will extract uranium selectively from the aqueous nitrate solution and the uranium can be re-extracted by water. The water solution is evaporated to pure urenyl nitrate and this nitrate is decomposed by heating to yield the pure metal grade oxide. The principle of the process is simple but great care is required in maintaining the exact operating conditions that will produce a product of acceptable quality.

Hexone was the first organic solvent tried by the Eldorado research group, later pilot plant runs were made using diethyl ether (as used by U.K. refineries). Eventually tributyl phosphate was selected as a very satisfactory solvent and several pilot plant runs were made using this system.

In 1953 arrangements were made with the U.S.A.E.C. to exchange information on refining, and the process developed by Eldorado was found to be very similar to that in use by the American plant at Fernald. Catalytic Construction Co., of Philadelphia, the firm that designed and constructed the Fernald refinery, was engaged to design the new Port Hope refinery; date on design was made available by U.S.A.E.C.

While the refinery was being designed, additional pilot plant runs were made at Port Hope and at Fernald, using the Canadian concentrates then available as feed materials.

These runs were made to obtain additional experience prior to the start of operation.

The new refinery has on the whole had a very successful operation since June 1955; many operating problems have been overcome by research and operation but new problems arise from time to time. Particular attention has been paid to the removal of thorium since many Canadian ores contain this element and almost complete removal is required to meet the specifications of metal grade oxide.

RESEARCH ON METAL PRODUCTION

Production of metal of reactor grade is carried out on a considerable scale in U.K. and U.S.A. These processes use as a starting material refined uranium tri-oxide of the type now produced at Port Hope. The steps involved are:

1. Reduction with hydrogen at elevated temperatures to form Uranium-dioxide.

2. Reaction with anhydrous hydrogen fluoride to produce uranium tetra fluoride.

3. Reduction of the hydrogen fluoride with metallic magnesium (or calcium) to form uranium metal.

4. Vacuum casting of the metal into shapes that are suitable for rolling to the desired shape.

The Eldorado Research and Development Division commenced studies in 1954-55 towards production of metal in Canada. Data was available concerning the U.K. system of metal production but information of the U.S. process became available in late 1955 after signing of the bi-lateral agreement for exchange of atomic energy information between Canada and the U.S.A.

Test work was started by Eldorado during 1955 in the laboratories of the National Research Council in Ottawa on the production of uranous fluoride ("green salt") by alternate methods since it was felt that the existing process might be improved.

Visits were made during the last 6 months to U.S.A. plants and laboratories to gather and compare existing information. As a result of their studies Eldorado is planning a pilot plant at Port Hope to be built and operated this year. This pilot plant will test the process for production green salt that has been judged the most promising.

Also during 1955, design work will commence on a plant for production of uranium metal in Canada.

An alternative fuel element of particular interest to atomic power reactors is pressed and sintered compacts of uranium dioxide. The Research and Development Division has co-operated with Canadian General Electric and the Mines Branch laboratories in production of test lots of this material for research work in the Chalk River reactors.

ANALYTICAL RESEARCH

The metallurgical research has been greatly aided by development of fast and accurate methods for analysis of Uranium. As late as 1946 the methods available were very time consuming and the accuracy was unsatisfactory particularly for samples containing low amounts of uranium.

The Mines Branch laboratories played a prominent part in developing radiometric methods of analysis, particularly the "equilibrium" method that permits fast and concise determination of uranium values in ore samples and mill products and has been of great value to mining development.

The fluorimetric method of analysis was developed in U.S.A. about 1948-1949 and adopted and improved by the Mines Branch laboratories. This method gives fast and accurate results and was the first practical method of analysing low grade residues from leaching test work. It was fortunate that the fluorimetric method became available when the test work on leaching processes was urgently required. Without the fluorimetric method the leaching research would have been seriously delayed.

New analytical methods, particularly for plant control are under constant development.

PRESENT AND FUTURE RESEARCH

The Research and Development Division is responsible for developing and evaluating new processes and for changes in equipment or flowsheets at the Eldorado mills and refinery, also for analytical and sampling methods at the above plants. Another function of the division is to maintain close contact with research groups in Canada, in U.K. and in U.S.A.

A research team is maintained at Port Hope refinery for operational and long term research work. Two small groups are employed at the Mines Branch and at Port Hope for research on ore treatment. Testing laboratories are now maintained at Port Radium and Beaverlodge plants, mainly for operational and process control.

A pilot plant for flotation of sulphides will be operated at Beaverlodge this summer and a pilot plant at Port Radium will test solvent extraction methods of uranium recovery.

A new metallurgical research laboratory is under construction in Ottawa by the Eldorado Company, and this is expected to be in operation in February 1957. This laboratory will permit centralizing and speeding up of research on improvements in uranium metallurgy. Particular attention will be paid to testing of processes that may lower the cost of uranium production. The results of Eldorado's research in metallurgy and ore dressing is made available without cost to the industry generally.

Appendix No. 4

Eldorado Mining and Refining Limited
Refining Division
Port Hope, Ontario

REFINERY OPERATION

By J. C. Burger

Max. 1956

History

The refining of pitchblende ores was initially started on the present site at Port Hope in 1935. Until August 1952, the feed material consisted entirely of gravity concentrates produced at Port Radium, N.W.T. In May, 1952, Port Radium output was augmented with the production of an acid leach precipitate, and these two products constituted the sole feed to the refinery until June, 1955, when the process was completely revised with the installation of an up to date solvent extraction process.

Originally the refinery at Port Hope was designed for the production of radium, with uranium as the by-product. However, in 1941, with the advent of new developments in atomic energy, uranium became the main product and radium production was reduced to secondary importance. In 1948 the extraction and production of radium from ores was completely suspended, partly due to higher costs directly associated with lower grade feed materials and partly due to reduced markets brought about by the introduction of radioactive isotopes.

The main process for the production of uranium was a combination of metallurgical and wet chemical treatment which, with the exception of a few improvements and refinements, remained essentially the same from 1935 until the complete changeover in 1955. The end product was a uranium black oxide (U_3O_8) grading approximately 96 per cent. The entire production was shipped to the United States Atomic Energy Commission for further purification prior to entry to the various Atomic Energy installations.

Research over the past several years had developed new and improved techniques for the extraction of uranium, using selective solvents. In addition to cheaper operation, the solvent process also produced an end product of sufficiently high purity that subsequent entry to uranium metal operations could be made directly without further purification.

For reasons noted above, the decision was made to instal a completely new solvent extraction process at Port Hope. In addition to producing a purer product at lower cost and higher recovery, the new installation also made it possible to increase production rates by a factor of five, which was roughly equivalent to the then expected increase in uranium production from newly developed areas in Canada.

The refinery conversion was completed in June, 1955, and from that time production has been in the form of purified metal grade orange oxide (UO_3).

Feed Materials

The gravity concentrates produced at Port Radium are shipped in jute bags with inner liners via the Northern Transportation Company to Waterways and thence to Port Hope by railroad. Due to the limited navigation season, accumulated production is shipped out by water during the summer months and this is entered to the refinery in the ensuing year.

All precipitates are packaged in 25-gallon steel drums, and in the case of Beaverlodge and Port Radium areas, both air and water transportation is used to transport the product to railhead. Precipitate produced in the Blind River area can be transported to Port Hope via truck or rail transport.

The gravity concentrates range in size up to ½" and are reduced in size to minus 50 mesh prior to entry into the refinery circuit. Size reduction is carried out in the dry state by means of a rod mill. All precipitates are entered directly wtihout further metallurgical treatment.

Precipitate drums are colour coded to identify them with the respective producer. Empty drums are returned in carload lots, or upon advice from the producer, are shipped to raw material suppliers in Eastern Canada for loading with raw materials and trans-shipping to the producer.

Precipitate drums usually make several round trips before deteriorating and subsequent scrapping.

Weighing, Sampling and Uranium Accountability

Contracts with the United States Atomic Energy Commission have designated the Port Hope Refinery as the official agency for weighing and sampling of feed materials.

Each producer is required to identify his production with a coded lot number, drum number, gross and tare weights.

Upon receipt of a shipment at the refinery railroad siding the cars are unloaded by means of a fork lift truck and drums are placed on a roller conveyor. The lot number, drum number, gross and tare weights stencilled on the drums are recorded. Drums are then directed to the official weightscale and the Eldorado weight recorded. From the scale the drums are then conveyed to an automatic Auger type sampler which removes a 1¼″ core of product from the drum. After sampling has been completed, the drums are placed on pallets and conveyed by fork lift truck to storage.

The sample from each lot is reduced by means of a Vezin sampler and laboratory blenders. The final sample is packaged in four separate sealed glass jars. One sample is retained at Port Hope, the second sample is forwarded to the producer, and a third and fourth sample held as reserve.

Both Eldorado and the producer subsequently perform a uranium analysis on the sample and exchange data simultaneously by registered mail. If the analyses do not agree within specified limits, one reserve sample is sent to the Department of Mines and Technical Surveys, Radioactivity Division, for umpire. An accepted analysis is agreed upon from procedures outlined in the contract and this is used for official accountability.

Producers are officially advised of the weight and uranium content of each lot.

In the case of gravity concentrates the bags are weighed and a sample is obtained by passing the product through a Denver-Snyder sampler. The sample is eventually reduced and the same procedure is followed on exchange of analysis and official accountability.

Any producer may have a representative present during the weighing and sampling operations, if he so desires.

REFINING PROCESS

Dry Feed Handling—Refinery Entry

In order to obtain a consistent feed to the refinery, the gravity concentrates and various precipitates are blended in the dry state.

To form a pre-calculated charge, drums are brought from storage to a drum dumping hood and the product is conveyed to one of three blenders. After adequate blending the dry product is then conveyed by means of bucket elevators and screw conveyors to the digestion system.

All hoods and blenders are vented to dust collecting equipment in order to minimize losses and ingestion hazards. The products so collected are returned to the blenders on a routine basis.

Digestion

By means of automatic feeder, the dry product is fed continuously into stainless steel kettles. Nitric acid and water are added simultaneously and the product is digested under agitation through a cascade system. In this operation the uranium and other acid soluble compounds are taken into solution as nitrates. Acid insolubles remain as a suspended slurry.

From the digestion circuit the slurry is pumped to the solvent extraction area.

Solvent Extraction

The principle of solvent extraction is based on the fact that certain solvents will selectively extract uranium from an aqueous solution. The uranium so extracted can then be withdrawn in a highly purified form to an aqueous phase by using large volumes of deionized water.

At Port Hope, solvent extraction is carried out in three stages using three separate pulse columns. Each column is equipped with perforated stainless steel plates and pulsing action is transmitted by means of piston type pumps. The principle of operation is that the pulse energy is used for intimately mixing the solvent and the slurry (aqueous phase) by counter current contact through the plates.

The uranium-bearing slurry is entered at the top of the first extraction column, while the solvent, which in this case is a homogeneous mixture of tributyl phosphate and kerosene, is introduced at the bottom of the column. Due to the difference in specific gravity the solvent flows up the column while the slurry flows to the bottom.

Intimate mixing in the column transfers the uranium and some impurities to the solvent phase, while the acid insolubles and the majority of impurities are retained in the aqueous phase. Upon reaching the bottom of the column the slurry has been almost completely stripped of uranium and is pumped to the acid recovery area for further processing. The solvent, which flows by gravity from the top of the column, is saturated with uranium containing minute quantities of impurities.

The next phase of the operation is termed "scrubbing". The uranium-bearing solvent from the first column is directed to the base of the second column and deionized scrub water is introduced at the top. By using a small controlled volume of water the impurities and some uranium are transferred to the aqueous phase, which is drawn from the bottom of the column and re-cycled back to the first extraction column for re-extraction. The solvent containing the uranium, and now stripped of impurities, flows to the top of the third column.

In the third column the uranium is re-extracted to the aqueous phase by contact with large volumes of deionized water. The solvent, now stripped of uranium, is re-cycled back to storage and is again ready for extraction operations in the first column. The aqueous phase containing uranium as uranyl nitrate, in a highly purified form, is then pumped to the boildown and denitration area.

Occasional purification of the solvent, using a soda ash solution, is required to remove breakdown products.

Deionized water is produced by passing steam condensate through ion exchange resins.

Boildown and Denitration

The uranium-rich aqueous phase from the third column is pumped to a two-stage evaporation circuit where water is driven off and the concentration of uranium to a high density uranyl nitrate solution is effected.

The highly concentrated uranyl nitrate is then directed to denitration kettles in batch lots of approximately 200 gallons. Heat is applied to these kettles by means of electrical resistance coils, with the product under constant agitation. In the initial stages excess water is driven off and eventually the uranyl nitrate is converted to a uranium trioxide (Orange Oxide) by thermal decomposition. The complete denitration cycle requires approximately eight hours. The end product is a dense orange powder which is removed from the kettle by means of a pneumatic conveyor through a cyclone separator to a pulverizer, and thence to a final storage bin.

The entire orange oxide conveying system is serviced with dust collection equipment which returns all dust so collected to the storage bin.

Product Packaging

The uranium trioxide from the final storage bin is packaged in resin lined 25-gallon drums which are subsequently shipped to the United States Atomic Energy Commission. During drum loading operations a continuous sample is obtained by means of an Auger type sampler located at the bin discharge. Drums are weighed after loading and pertinent data, including lot number, drum number and weights, is stencilled on the drum.

The United States Atomic Energy Commission return empty drums to Port Hope for re-loading.

Analyses on Orange Oxide samples are carried out by both Eldorado and the United States Atomic Energy Commission. If agreement is not within specified limits, the National Bureau of Standards acts as umpire.

Orange Oxide must meet rigid specifications for subsequent entry to metal operations. Impurities are measured in parts per million, and analysis at this low range is accomplished by spectrographic methods. The Spectrographic Laboratory recently installed at Port Hope carries out these analyses on a routine basis.

Acid Recovery

The aqueous slurry removed from the bottom of the first extraction column contains excess nitric acid and metal nitrates from which nitric acid can be recovered and re-used in the digestion process.

The waste aqueous slurry from the first column is pumped to storage tanks and a small amount of sulphuric acid is added to "spring" the acid from the metal nitrates. This solution is then evaporated under vacuum and the nitric acid, combined with water, is flashed into a distlilation column where the acid is concentrated. From the bottom of the column nitric acid of approximately 50 per cent strength is pumped to storage. The water vapor, originally associated with the acid is drawn from the top of the concentrator and condensed.

In addition to the acid recovery from the slurry, all gases released during digestion and thermal decomposition of uranyl nitrate are collected and passed through an absorber. These gases consist mainly of the oxides of nitrogen which are absorbed in water to form nitric acid. The absorber operates on the principle of a bubble cap column, in which gases are introduced at the bottom and water at the top. By intimate contact with the water the gases are converted to nitric acid, and the acid so produced is pumped from the bottom of the column to storage.

Approximately 80 per cent of the acid contained in waste products is recovered for re-use in the digestion circuit.

Raffinate Disposal

The raffinate slurry from which the nitric acid has been removed is neutralized with lime to reduce excess acidity, and this mixture is then filtered.

The filtrate or water is directed to the lake and meets all specifications for disposal into International waters.

The solids from the filter, in the form of a filter cake, are discharged into bins. The bins are in turn discharged to dump trucks and the residues are transported to a remote residue area.

Samples are obtained from both the aqueous waste and solid residue for the purpose of accountability. It will be interesting to note that a recovery of uranium in excess of 99·5 per cent is accomplished in the solvent extraction process.

Instrumentation

The solvent extraction process requires exacting control on flow rates, temperatures and other various details of operation.

In order to maintain equilibrium conditions, a centrally located Control Room is equipped with various instruments which record and control flow rates and temperature.

This control centre is also equipped with associated alarm signals which will indicate upset conditions in the various operating areas.

A Control Room operator is in constant attendance and can relay information to the various operating areas by means of telephone and P.A. system. Immediate corrective action can then be taken by the operators in charge.

This Control Room has been found to be effective in maintaining the steady operating conditions which are required for such a chemical circuit.

Process Control

Uranium accountability and the maintenance of complete records is under the jurisdiction of the Process Control Department. To this end, this department is responsible for the procurement of all samples and the establishing of proper sampling techniques and procedures.

All plant samples are collected and prepared for analysis in the Process Control laboratories.

The Analytical Laboratory, as a separate department, performs all analyses on samples submitted by the Process Control Department. This department is headed by a chief chemist. Routine and special analyses are performed by laboratory technicians who are generally hired locally and trained to carry out this work.

All results are reported to the Process Control Department for distribution and posting.

Services

Coal for steam production is brought into Port Hope from the United States by coal boats. Coal contracts are negotiated on a yearly basis and the coal is stored on docks adjacent to the refinery.

The steam requirements for process amount to approximately 35,000 pounds per hour.

Domestic water is obtained from the Port Hope Pumping Station. However, the majority of water used in the process is for cooling purposes and this is pumped from Lake Ontario by means of deep-well pumps at the rate of 750 gallons per minute.

Electricity is supplied by the Hydro Electric Commission (Port Hope Branch) through 44 Kv. transmission lines to our Sub-Station. Here the supply is reduced to 550 volts and subsequently to 220/110 volts, as required.

An Engineering Department, headed by a qualified engineer, is in charge of services and all maintenance and construction.

Labour

Under present production schedules the refinery employs a total of 220 employees. Of these 53 are technical and salaried staff, the remainder are hourly rate. Hourly rated employees are drawn from the local labour market. In the case of operations, unskilled labour is generally hired and trained for specific jobs. Tradesmen for maintenance are hired locally, depending on availability.

The United Mine Workers Union, District 50, Local 13173, is the certified bargaining agent for all hourly rated employees. A cordial relationship exists between Management and Union.

The refinery operates continuously on a 24-hour, three shift, 5-day per week basis. With the increase in production of feed materials in 1956, 7-day per week operation at the refinery has been scheduled for late fall.

Health and Safety

The health and safety of all employees is under the jurisdiction of a full time Safety Engineer. A local medical doctor, who has been employed by the refinery since its startup in 1935, visits the refinery for two hours each day. Employees are given a complete medical check up, including X-Ray, on a yearly basis, or oftener if deemed necessary.

Employees are supplied with coveralls and other working clothes which are laundered in the Company-operated laundry. A complete change of clothing and daily showering of employees is mandatory.

In addition to the above, employees are supplied with goggles for eye protection, dust masks where toxic conditions might prevail, and other protective equipment as required.

Regular safety meetings are held and safety surveys conducted. In general, it can be said that our safety record is better than average for chemical industries.

Recently through the co-operation of the Canadian Red Cross, all employees were blood-typed and have been issued with cards to this effect. This information would undoubtedly prove useful in a local emergency. An advanced First Aid training course for all supervision has just recently been completed. All candidates successfully passed examinations supervised by the Red Cross.

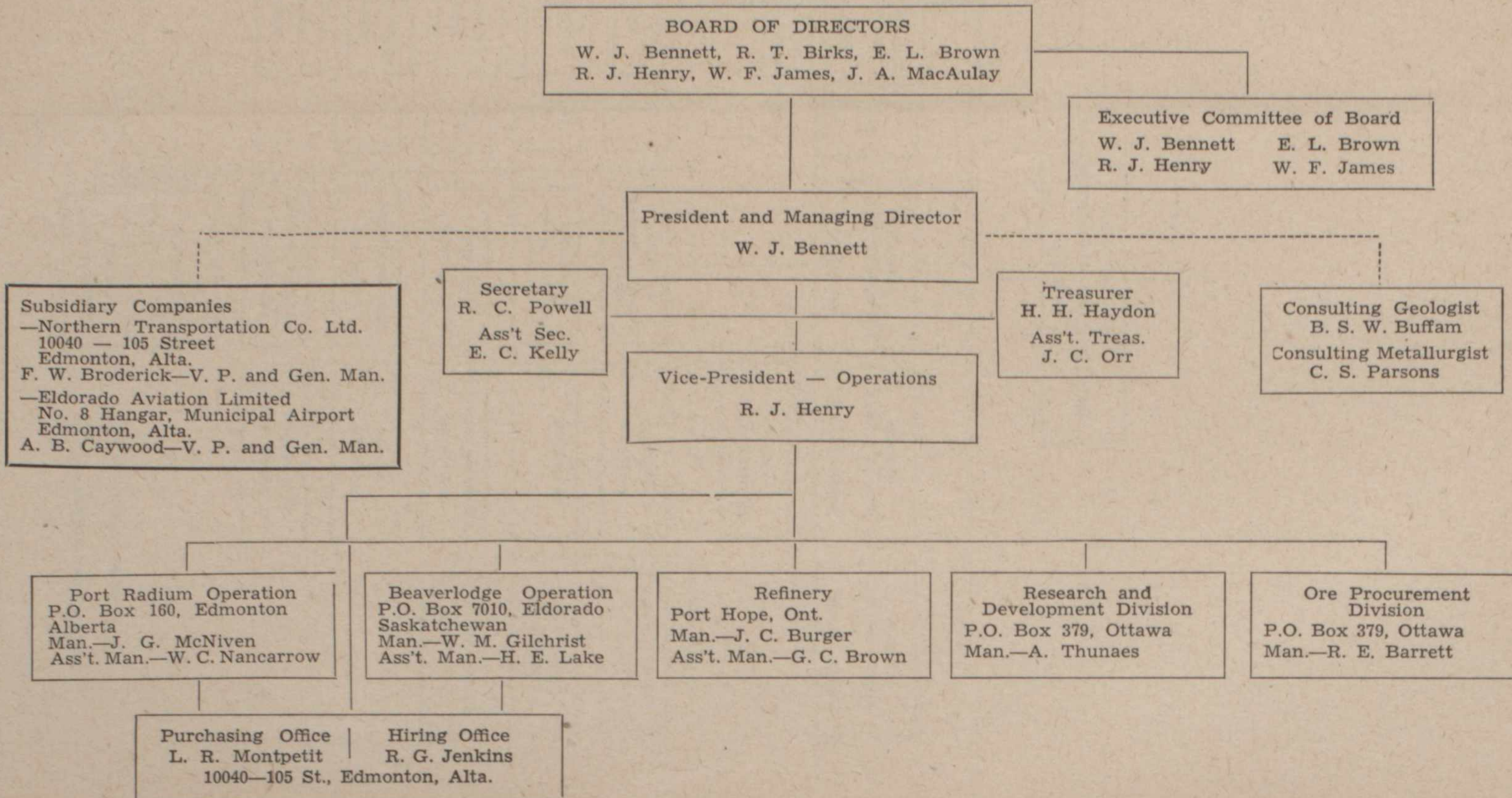
Security

Security is maintained by a force of Security Guards. In addition to general security patrols, this section also process applications and the screening of new employees. General security regulations have been established which are also enforced by the Security Officer.

APPENDIX 5

ELDORADO MINING AND REFINING LIMITED

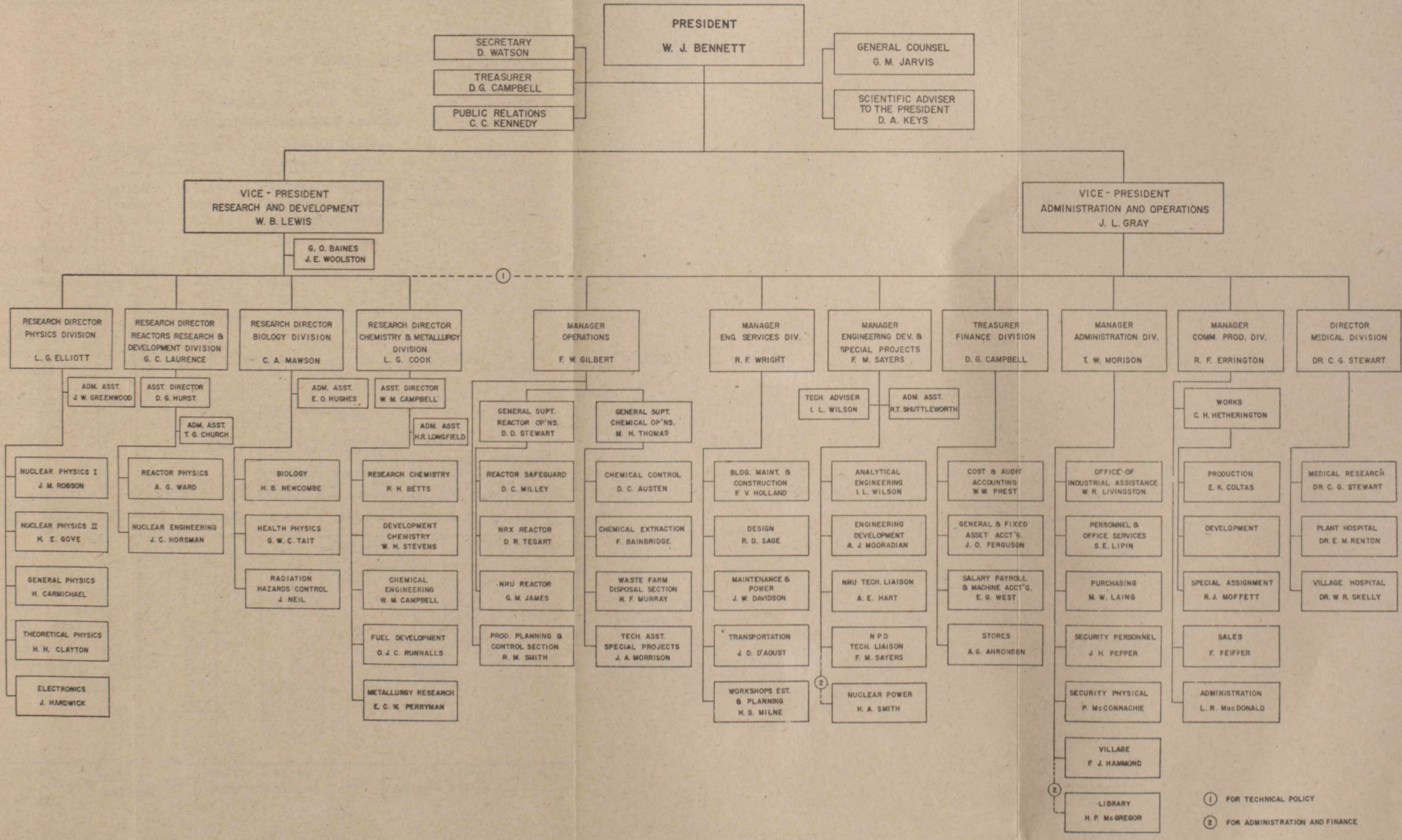
— Organization Chart —



May, 1956

APPENDIX 6

(Tabled on June 5, 1956)

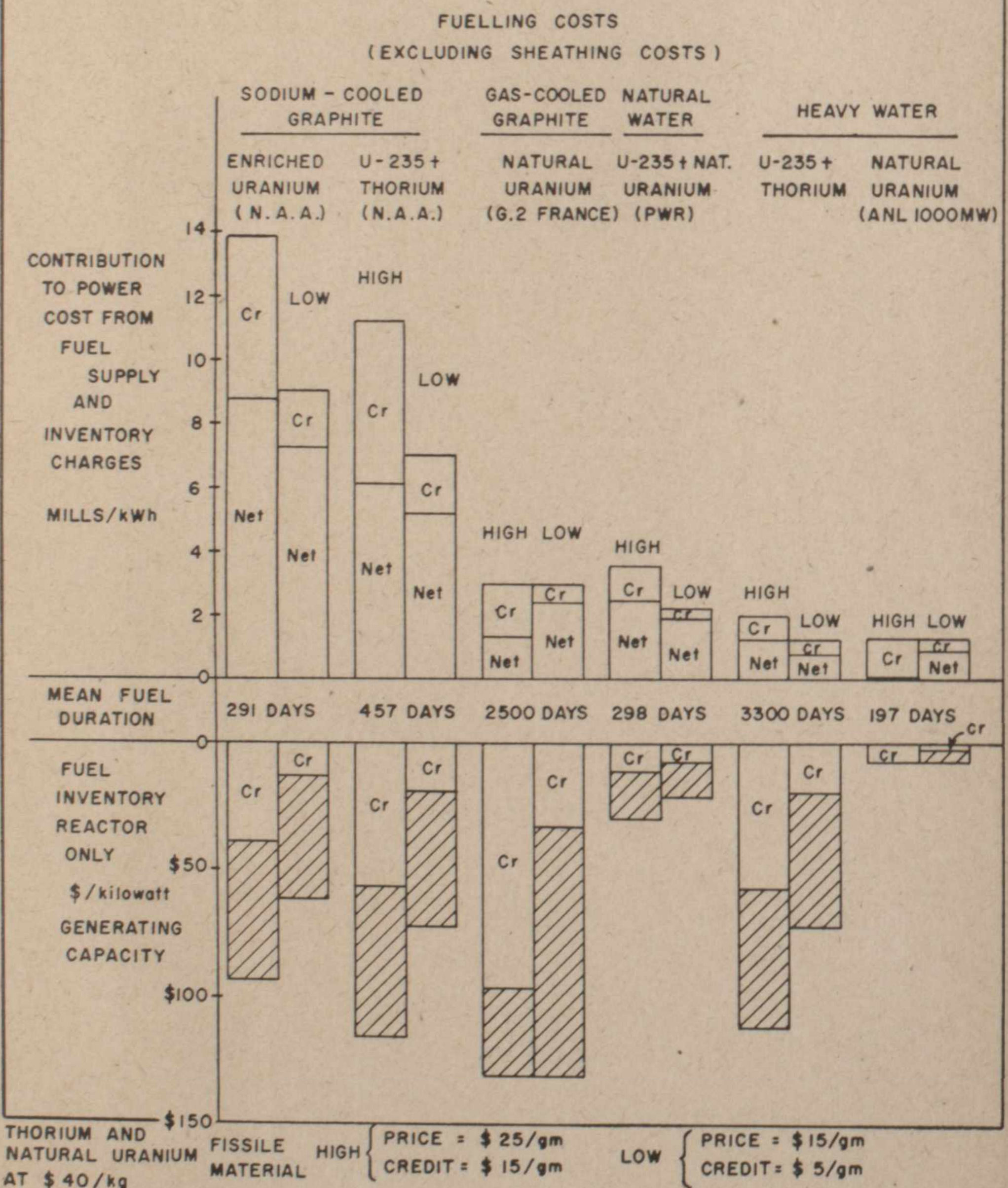


APPENDIX 7

(Tabled on June 5, 1956)

FIG. 1.

COMPARISON OF TYPICAL POWER REACTORS



HOUSE OF COMMONS

THIRD SESSION——TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 11

ATOMIC ENERGY OF CANADA LIMITED
ELDORADO MINING AND REFINING LIMITED

TUESDAY, JULY 3, 1956

WITNESSES:

Mr. W. G. Bennett, O.B.E., LL.D., President, Atomic Energy of Canada Limited and President and Managing Director of Eldorado Mining and Refining Limited; Mr. Donald Watson, Secretary Atomic Energy of Canada Limited; and Mr. R. C. Powell, Secretary, Eldorado Mining and Refining Limited.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956.

75489—1

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McIlraith, Esq.
and Messrs.

Bourget
Byrne
Cameron (*Nanaimo*)
Dickey
Forgie
Green
Hamilton (*Notre-Dame-de-Grace*)
Hardie
Harrison
Hosking
Leduc (*Verdun*)
Low
MacLean
Murphy (*Lambton West*)
Richardson
Stewart (*Winnipeg North*)
Stick
Stuart (*Charlotte*)
Weaver—(20).

(Quorum 9)

J. E. O'Connor,
Clerk of the Committee.

ORDERS OF REFERENCE

FRIDAY, June 8, 1956.

Ordered,—That the name of Mr. Hamilton (*Notre-Dame-de-Grace*) be substituted for that of Mr. Brooks; and

That the name of Mr. Cameron (*Nanaimo*) be substituted for that of Mr. Coldwell on the said Committee.

Attest.

LEON J. RAYMOND,
Clerk of the House.

MINUTES OF PROCEEDINGS

TUESDAY, July 3, 1956.

The Special Committee on Research met at 11:00 a.m. this day. The Chairman, Mr. G. J. McIlraith, presided.

Members present: Messrs. Byrne, Dickey, Green, Hamilton (*Notre-Dame-de-Grâce*), Hardie, Harrison, MacLean, McIlraith, Murphy (*Lambton West*), Richardson, Stewart (*Winnipeg North*), and Stick.—(12)

In attendance: Mr. W. J. Bennett, President and Managing Director, Eldorado Mining and Refining Limited, and President, Atomic Energy of Canada Limited; Mr. D. Watson, Secretary, Atomic Energy of Canada Limited; and Mr. R. C. Powell, Secretary, Eldorado Mining and Refining Limited.

The Chairman called the meeting to order and suggested that the first item of business be the consideration of the proposed visits by the Committee to Chalk River, Blind River and Port Hope. It was decided that as the time remaining for the Committee's work is somewhat limited, the proposed visit to the Port Hope Uranium Refineries be cancelled. The determination of dates for the Committee's visits to Chalk River and Blind River was left to the discretion of the Chairman.

Consideration of the future course of the Committee's work ensued and following considerable discussion, Mr. Stewart (*Winnipeg North*) moved, seconded by Mr. Byrne:

"That the Committee complete its work in the field of atomic energy and then resume its examination of the activities of the National Research Council."

The question was resolved in the affirmative.

The Chairman then suggested that the questioning of Mr. Bennett be proceeded with.

Mr. Bennett's examination continuing, the Committee adjourned at 1.05 P.M. to meet again at 11:00 A.M. Thursday, July 5, 1956.

J. E. O'Connor,
Clerk of the Committee.

75489—2½

EVIDENCE

TUESDAY, July 3, 1956.
11.00 a.m.

The CHAIRMAN: Gentlemen I see a quorum; perhaps we could come to order.

I think I should welcome at least one new member whom I see in the committee—there are some others.

There is some administrative business to be discussed. Is it your wish that we discuss it now or that I discontinue the evidence at 12.30 in order to discuss it then?

Mr. STICK: What did you have in mind?

The CHAIRMAN: The trip to Chalk river.

Mr. STICK: Why not discuss it now?

The CHAIRMAN: Very well. It is unanimously agreed that this part of the evidence having to do with the business of the committee need not be transcribed?

Agreed.

—(Discussion off the record).

The CHAIRMAN: Now, we have Mr. Bennett with us this morning, and he is available for examination on his evidence given here at the previous two sittings.

Mr. W. J. Bennett, O.B.E., B.A., President, Atomic Energy of Canada, Limited, President, Eldorado Mining and Refining Limited, called:

By the Chairman:

Q. There are two or three corrections Mr. Bennett would like to make in the evidence. Perhaps he could make them now.—A. First, on Thursday, June 7, in my submission, on page 321, the following sentence appears: "Now, when you get this irradiated fuel out of the reactor, if you want to use your plutonium, you must dissolve the fuel by a chemical process and separate out your unburned or undepleted uranium . . ." The "un" in undepleted should be deleted. It is "depleted uranium", not undepleted uranium. Second, on page 326, the last line reads: "In other words, the feed for the diffusion plan is enriched uranium". This should read: "The feed for a diffusion plant is uranium" with the isotopic content found in nature, that is, natural uranium. Third, I gave a figure for the heavy water requirements of the NRU reactor on page 314 which is not correct. I recall that I said first that it was 60 tons, but subsequently I revised the figure to 43 tons, I should have stayed with the figure of 60, because it is 60. That is, 60 long tons or 66 short tons.

In the middle of the page in the same answer I also mentioned the requirements for the NPD reactor. I said that they were approximately the same as the requirements of NRX. NRX appears in the evidence as "NRT". It should be NRX. On the basis of present estimates, the heavy water requirements of the NPD are 33 short tons, approximately half of the requirements of NRU.

The CHAIRMAN: Mr. Bennett is available for questioning.

By Mr. Murphy (Lambton West):

Q. Mr. Bennett, what I was going to ask you—I am sorry I must have missed it the other day, I have not read all of it—I think it was in the first part of your evidence you mentioned the three different types of reactors from which we, Britain and the United States would be getting power. Here we use heavy water and I think in the United States you said graphite and in Britain another process. I was wondering if you had any idea of the cost, that is at the moment—I do not say the ultimate cost—of what that power would be coming from those different reactors?—A. Mills per kilowatt hours?

Q. Yes.—A. That is almost impossible to answer unless you know how the research and development costs that go into these first demonstration reactors are being treated. I can give you an answer in terms of the capital cost per kilowatt installed. These, of course, are provisional figures because none of these stations has been completed. The Calder Hall station in the United Kingdom consists of two reactors and two generating plants. One of the reactors and one of the generating plants will be in operation in October of this year. The figure that is given for the estimated capital cost per kilowatt installed of the Calder Hall station is $625 per kilowatt.

The United States reactor that I referred to in my brief is known as the PWR—pressurized water reactor. This reactor is expected to be in operation in 1957. The estimated cost per kilowatt installed is $630. Our small reactor, the NPD—and I emphasize the word "small" because as the size is reduced the cost per kilowatt installed increases. On the basis of our present estimate the cost will be around $700 per kilowatt installed.

Now, I do not know how the United Kingdom and the United States are charging into costs the research and development expenditures that are required to get these reactors designed, built and into operation. In our own case we are not charging into the costs the research and development expenditures at Chalk River. We are, however, charging into cost the design and engineering development expenditures which will be incurred by Canadian General Electric Co.

At this stage I would think the cost per kilowatt installed is about as good a comparison as you can use. It is difficult to give accurate costs at this point in terms of mills per kilowatt hour. The United Kingdom has estimated a cost of 6 mills per kilowatt hour for the nuclear power stations which are expected to come into operation in mid 1961. However, we do not know what value is being placed on plutonium in the calculation of this estimate.

When nuclear power stations are being operated on a commercial scale one of the factors in the cost will be the return on investment. This varies very greatly, in the utility business—Ontario Hydro, for example, has a very low rate of return whereas some of the private utilities have quite a high rate. I do not think any of the first stations will be competitive. This is generally admitted with regard to the three stations I have mentioned; the N.P.D., the Calder Hall station in the United Kingdom and the P.W.R. in the United States.

By Mr. Murphy (Lambton West):

Q. Do you happen to know whether the democracies are more advanced than they are behind the "iron curtain"? I do not know whether this is a fair question to ask you, but what is the relative position with regard to atomic energy development?—A. Our impression at the Geneva conference was this: on the fundamental side while the Russian contribution was "spotty" —that is it was not uniformly good—generally speaking it was of a very high calibre. In the applied field there was described the small nuclear power station which the U.S.S.R. has in operation. This station has an output of 5,000 kilowatts, electric. Judging from the description given the U.S.S.R. would appear to be well advanced in their applied program. Perhaps I could answer the question by saying it would be very unwise to assume that the U.S.S.R. is not just as far advanced as we are.

I think I mentioned at the last meeting that the head of our physics division Dr. Elliott recently attented a scientific conference in the U.S.S.R. as a result of an invitation sent to the N.R.C. by the Russian Academy of Science. One of the things I propose to do while you are at Chalk river is to have Dr. Elliott give you his impression of whát he saw in Russia.

Q. Mr. Bennett, when you and the scientists from all over the world were at Geneva were not those scientists—other than those from behind the iron curtain—amazed at what the Russians knew and how far advanced they were? Did that come as a surprise?—A. No. The Russians are not entirely new to this game. Over a period of some generations Russia has produced from time to time outstanding scientists. Consequently our scientists were not too surprised at the quality of the contribution made by the U.S.S.R. at Geneva.

Q. That is, other physicists or scientists would expect that?—A. That is right. I do not think it came as too much of a shock to people like Cockroft or Lewis or the scientists from the United States.

Q. The scientists who came from Russia—were they all Russians or not?—A. As far as I know they were all Russians. The delegation was headed by a man named Skobeltzin—who, is no newcomer to this field. He is, I would say, in the middle sixties and well known for his work in physics.

Mr. RICHARDSON: It might be interesting, Mr. Chairman, to note that Mr. Bennett corroborates the evidence given by Mr. Steacie following the same question asked by Mr. Murphy.

The CHAIRMAN: Are there any further questions?

Perhaps, then, we could leave this subject open. Are there any questions on any new point?

By Mr. Green:

Q. What would be the total cost of the NRU reactor? I ask that because I think the original estimate was $30 million and at different times, when revised estimates were given, the figure has been increased. What would the total cost be?—A. We had spent as at April 30 last approximately $42 million. We expect the reactor will be finished at the end of November—by which time we will have spent an additional $8 million. These figures do not include the cost of heavy water. On this basis the total cost of the NRU reactor, excluding the cost of heavy water will be 50 million dollars.

By Mr. Stick:

Q. What did you estimate the original cost would be when you started this plan?—A. My recollection is that the first estimate is the one which Mr. Green has mentioned—an estimate of $30 million. This estimate was made before any detailed design had been carried out. Revisions in the estimate have been due to several factors. I would say the most important of these was the decision to increase the research facilities of this reactor. When the NRU was originally planned, it was intended to be used exclusively or almost exclusively for the production of plutonium. This was back in 1950-1951 when the plan of the reactor was in its conceptual stage. However, as a result of the success we have had in using the NRX reactor for loop experiments and for component and material testing it was decided that we should expand the research and experimental facilities of the NRU reactor. The feature that had made the NRX particularly suitable for this type of work was its high flux. The NRU will have a flux approximately five times as great as that of the NRX. In addition the NRU reactor will have a power rating 5 times as great as that of the NRX. The decision to increase the research and experimental capacity of the NRU was the main factor in its increased cost. I would say that roughly the division of cost would be something of the order of 60-40 in other words 40 per cent of the cost of this reactor can be attributed to the provision of research facilities.

By Mr. Stewart (Winnipeg North):

Q. Did you get your money for that reactor out of current parliamentary appropriations?—A. Yes.

Q. That would imply that there was no special grant for it?—A. We have three types of vote. First we have a vote which is called Current Operations and Maintenance. This is a nonfundable vote, that is to say it is an annual grant for research purposes. With the monies supplied under this grant we pay our salaries and our wages, we pay for the supplies which are required in the research programme and for all the other research acitivities carried out at Chalk river.

Then we have a second vote which is for the construction or acquisition of buildings, works, land and equipment. This is a non-fundable capital vote because the assets which are acquired under this vote are incidental to the research program. Third, we have a vote which is likewise for the acquisition of assets of one kind or another but this is a fundable vote—in other words the moneys advanced are capitalized and appear in our balance sheet. The moneys which are voted in this vote have been used for two purposes, first the construction of the NRU—that is part of the construction of the NRU which is attributable to its production function, and second the construction of housing. In the case of housing the rental rates reflect the repayment of capital plus interest. The capital is amortized over a period of 30 years and bears interest at the rate of 3½ per cent.

Q. Did you use any funds for the building of NRU which could legitimately have been devoted to any other research? Has research been tied down in any way by the building of the new reactor?—A. I am not too sure I understand the question.

Q. The question is this: how did you build the NRU? Did you have to use funds which would have been used for, let us say, pure research or for other purposes apart from the construction of this reactor? Was research in any way hamstrung by the decision to operate it?—A. I would not say research has been hamstrung. If you look at the operating research vote over the last four or five years, you will see that there has been a steady increase in the sum provided. This indicates that we have not put a "ceiling" on our research activities. Research activities have expanded over that period.

By Mr. Green:

Q. The cost of the NRU would be something over $50 million?—A. That is right.

Q. In addition to that you would have to purchase heavy water?—A. Yes.

Q. What will that cost?—A. On the basis of the 66 short tons at $28 a pound, it would be roughly $3½ million.

Q. And you believe that the $50 million will cover the total expense of the NRU with the exception of heavy water?—A. That is our present estimate and we feel we know enough at this stage in the project to make the estimate with some degree of firmness. Of course, a factor that could increase this estimate would be a delay in the completion date. One thing that could cause such delay would be troubles in connection with various installations in the reactor. No one has ever built a reactor like this before; there are troubles that you hope will not occur but sometimes they do. We have encountered one of these troubles already with the main polymer system. The difficulties were entirely mechanical resulting from faulty pumps. This is the sort of thing that could hold up the completion date. The major components have, for the most part, been delivered. When you visit Chalk river you will see for yourselves that this project is in an advanced state. Barring unforeseen problems we should have the reactor going at the end of November, and if we do, the cost will be close to the estimate I have given.

Q. What did the NRX reactor cost?—A. About $10 million.

Q. Have you any idea of the cost of the NPD reactor?—A. I gave the estimate, Mr. Green, in my first submission. On page 237 of the evidence of June 5 I gave a figure of $14,500,000. That is the estimate.

Q. When is it to be completed?—A. By the middle of 1959. Canadian General Electric are just getting to the point where they will be able to produce manufacturing specifications. In other words the detailed design has reached the stage where C.G.E. will be able to produce shop specifications. Of course, it is not until that point, and sometimes not even at that point, that you are able to make a firm estimate of cost.

Q. Can you tell us the total amount that has been spent to date on the atomic energy program?—A. Since the beginning?

Q. Yes.—A. My recollection is that it was approximately $160 million at the end of last March, that is March 31, 1956.

Q. Have you worked any estimate of what it will cost a year, say for the next 10 years?—A. We have not worked it out for 10 years—that is rather a long time to look ahead—but we have worked it out for five years. Our policy is to operate on a five year budget plan. If you are interested I can give you the 5 year forecast of cash requirements. What we have done in this forecast is this: we have assumed certain annual operating expenditure for the research programme. We have also assumed certain expenditure for the acquisition of assets including our share of the cost of the NPD reactor. Then we have taken into account the income which we expect to get not only from the rental of research facilities and from the rental of housing, and so on, but also from the sale of plutonium when NRU is operating. After allowing for operating and capital expenditures, and after allowing for revenues, we arrive at a net cash requirement of between 110 and 115 million dollars over the period up to March 31, 1961.

Q. Does that include all the expenditure there will be in connection with the program?—A. No, this is not the total expenditure—this is after you subtract from the total expenditure the revenues we expect to get from our internal operations—the rental of pile space, the sale of plutonium and so on.

Q. Do you remember the gross figure?—A. I do not, but I will get it for you. It is fairly close to $160 million.

Q. Does that include additional reactors? For example you told us the other day that you have under way a preliminary design and feasibility study with associated development programs for a much larger reactor in the range of 100-200 megawatts. Does this figure you have given us include expenditure for such a new development as this?—A. It includes the money that will be required to do the preliminary design study and the supporting development work. It does not include the cost of building a 100 megawatt reactor.

Q. What would that be? Have you any estimate?—A. One of the purposes of the preliminary design study, and the supporting development programmes, is to produce an estimate of what it would cost to build a 100 megawatt station. We have no reliable estimate at present.

Q. You have no idea what the cost would be for a 100 megawatt station?—A. One way to estimate the cost would be to make an extrapolation from the NPD estimate, but I would not recommend this. I would hope that as a result of the NPD project we could find ways of cutting corners which would reduce the capital cost of future reactors. In other words, if a 20,000 kilowatt station is going to cost $14½ million you certainly would not expect a 100 megawatt station to cost five times $14½ million; you would hope to get it down considerably. An estimate would only be a guess at this point.

By Mr. Murphy (Lambton West):

Q. Mr. Bennett, is our sale of plutonium in the immediate future all to the United States?—A. Our contract with the United States runs until June 30, 1962.

Q. Is there a limit to that contract? Will they take all we can produce?—A. They take all of the plutonium. They have first call on all the plutonium produced in the NRU reactor.

Q. What I was trying to arrive at is this: how is that going to affect the production and development of the uranium mines? Can you go ahead in your program and, we will say, enter into a contract with these producers or assure them that they have a sale of their product and that you in turn have a sale of your product?—A. I do not get the connection between plutonium and uranium.

Q. You get one from the other in the first place?—A. Yes.

Q. What I was trying to get at was that from the prospectors standpoint and the development angle of the mines, and the production of those mines and the sale of their products, is that going to be limited or is the development of new mines going to be retarded?—A. I have covered this question rather fully in my second submission. Very briefly, the situation at the moment with respect to uranium is that the government through Eldorado—and I am speaking now in my capacity as president of Eldorado—has a commitment to purchase all uranium that is offered under the published price schedule up to March 31, 1962. As it happens no uranium was offered under the published price schedule. Consequently in 1953 we found it necessary to establish a second method of purchasing which we call the special price contract. Under this method a special price is negotiated as a result of the application of a formula. Under the special price arrangement we have set a limit on what we will take. The limit, briefly, is this. The deadline for the receipt of applications for special price contracts was March 31 last; that was the first condition. The second condition was that there should be a reasonable assurance that the producer who got a special price contract would get his mine into production not later than September 30, 1957. So that at the present time, so far as the purchases under the special price program are concerned, we have so to speak, put the lid on.

By Mr. Harrison:

Q. Mr. Bennett, you fly most of the concentrate out of the Eldorado and Beaverlodge developments with your own aircraft?—A. That is right.

Q. Why do you do that?—A. Why do we fly it?

Q. Why do you fly it with your own aircraft?—A. Simply because we have never been able to find anyone who can do it as cheaply as we can. Eldorado sells its product under a fixed price contract, a contract developed in accordance with the formula of which I have just spoken. The cost of transporting supplies in to Eldorado's mines is a part of the operating cost.

Q. Well, this naturally is all intertwined with the economy of the area generally and they are quite interested in this method of getting out concentrate because they feel if commercial airlines handled that—and would handle it at approximately the price you are now paying or less—that they would reap some future benefit from your using commercial airlines to transport that concentrate. The last time I was in the area I was advised that there would be some commercial airlines interested in transporting not only the concentrate of Gunnar but possibly Lorado, if they get into production there, on the basis of 2 cents outgoing for concentrate and 6 cents incoming freight. Would you be interested in a proposition of that kind?—A. I have not heard about this one. Offhand it sounds interesting but improbable.

Q. It sounded interesting to me.—A. One of the things in connection with the economy of our air operation which you must keep in mind is that we have two properties; we have the old property at Port Radium and, the new property at Beaverlodge. Port Radium, because of its location, is even more dependent on air transportation than Beaverlodge, although both of them are dependent on air transportation. This means simply that we have to maintain an air service to both places. This has the advantage, from the standpoint of the economics of air transportation, of giving us a lower over-all cost because we are able to get greater utilization out of the aircraft and because we can distribute the maintenance and other ground costs to two operations. Of course, fuel costs are in direct relation to the number of miles flown. The fact that we must service two operations is, I would say, the most important factor in the cost picture. In other words, you cannot isolate Beaverlodge, or at least you cannot consider the Beaverlodge operation without taking into account the Port Radium operation.

Q. I can appreciate that.—A. To put it another way, if we were to contract out the Beaverlodge flying and retain the servicing of Port Radium, our Port Radium costs would go up quite substantially.

Q. If you could make savings on the whole, it still might be beneficial and possible. What would interest you in the way of price? Would a 2 cent rate outgoing interest you on concentrate?—A. I would not want to say at this point. We are always ready to listen to propositions.

Q. I do not doubt that.—A. The figures you have given sound low to me.

Q. How is your volume flowing now? Have you more volume incoming or more volume outgoing?—A. At the moment we have more ingoing freight but a year from now we will have more outgoing freight because under the contracts for the sale of uranium which we have with the United States Atomic Energy Commission we must make deliveries on a monthly basis. Beaverlodge has water transportation for about four months of the year, from about June 1 to October 1, which means that for eight months to maintain these delivery requirements, we have to fly the concentrate out. When the expansion of our own plant is completed early next year, and when the expansion of the Gunnar plant is completed, this will probably mean that our outgoing freight will be considerably in excess of our incoming freight.

Q. Would that not be the time when perhaps some change in policy might be thought of whereby you could take advantage of the extra freight required by the community as a whole there in going towards balancing the loads both ways?—A. I am afraid that it is not that simple.

Q. It may not be.

By Mr. Green:

Q. Does this cost which you gave me of $160 million cover only atomic energy developments or does it also cover Eldorado and the Port Hope refinery? —A. No. Atomic Energy of Canada Ltd. only. It has nothing to do with Eldorado.

Q. What are the corresponding figures for Eldorado, Port Hope, and Northern Transportation?—A. I can give you the total. Here, I think, you will have to be a little more precise as to exactly what you want. Do you want the total investment in Eldorado, that is the investment in fixed assets and preproduction, over a period, or the gross expenditures for both capital and operating?

Q. What I want to get at is the figure of what the country has spent on Eldorado, Northern Transportation and the Port Hope refinery?—A. If you mean what has come from parilamentary votes, none of Eldorado's or Northern's expenditures have come from parilamentary votes. Eldorado and Northern are self-supporting. They have financed their expansion from their own revenues. The government has not voted any money for the Eldorado company or the Northern Transportation company.

Q. From the start?—A. Apart from the monies that were voted for the acquisition of the capital stock.

Q. How much was that?—A. Approximately $9,200,000, I think, was the figure.

Q. What is the total capital investment today?—A. Do you want the investment in fixed assets for Eldorado? I can give you this any way you want it. Do you wish to know what the value of the company's fixed assets are?

Q. The gross expenditures.—A. This would cover operating as well as capital expenditures over what period?

Q. From the start.—A. Since the government acquired the company?

Q. Yes.—A. I could not give you that offhand. It is available, but I do not have the figures here.

Q. What figures could you give us today?—A. The total value of the fixed assets as at the end of last December. The figure is roughly $25 million, and that is broken down into $42,000 land—these are in round figures—$10,900,000 buildings, and $13,900,000 equipment. Of that, we have depreciated $11,892,000, leaving an undepreciated balance of $12,995,000.

Q. Would that include the Port Hope refinery?—A. Yes, that includes all of Eldorado's properties.

Q. Port Radium and Beaver lodge?—A. Yes, It does not include Northern Transportation company properties.

Q. What about that one?—A. I should point out that I have given you capital assets, not pre-production costs. When you are looking at a mine balance sheet, pre-production expenses are generally treated in the same way for accounting purposes as capital; in other words, the cost of sinking shafts and so on is generally written off in the same way as capital assets.

The total investment of Northern Transportation in fixed assets is $7,481,456.

Q. In your original submission you mentioned the NRX reactor which you are building for India. What are the arrangements made about building that reactor and how much will it cost?—A. We are acting in this instance as a prime contractor for the Colombo Plan Administration. We have had, except in a advisory capacity, nothing to do with the negotation of this agreement. This is a Colombo plan project and the monies for it will be supplied from the Colombo plan vote. In other words, it does not come out of the Atomic Energy of Canada Limited vote. I am speaking from memory now and subject to correction. The agreement is in line with the usual Colombo plan arrangement whereby Canada absorbs the external costs and the receiving country—in this case India—absorbs the internal costs. That is to say in this case the components for the reactor will be, fabricated in Canada and, consequently, the cost of those components will be for Canada's account. On the other hand, the building, the foundations, the concrete for shielding and so on are parts of the job that will be done in India, and the cost of those parts of the job will be for India's account. The last estimate I saw was roughly $15 million for the total cost of the project.

Q. That is including what India pays as well?—A. That is including the cost to India.

Q. How much is Canada's part?—A. I think we have used an estimate of $7,500,000 for our part of the job.

Q. Has Canada done this type of thing anywhere else or is this the first time we have built a reactor on an outside account?—A. This is the first. This is the first project any country has carried out of this size. The United States has supplied small research reactors of the "swimming pool" type which, while very useful in certain phases of the atomic energy program, have a limited usefulness. Their cost, that is the reactor part of such installations, ranges from $300,000 to $400,000 depending on what type of reactor is supplied.

The United States has supplied one of these reactors to Switzerland. In this case I think the U.S. absorbed half the cost. It happened to be the reactor which was installed for the Geneva conference. The U.S. left it in Geneva, in other words. I understand the U.S. has recently given swimming pool reactors to Brazil—one or two, I forget which. The difference in the expenditure, I think, indicates the difference in the two types of project.

Q. Is there any possibility of any future in this type of business—that is, in Canada's building reactors for other countries?—A. Yes. I would like to think so. One of the things certainly which we had in mind in undertaking the Indian project was that it would be a useful thing to do from the standpoint of our relations with India—and I think it was a very useful thing to do in that respect. But we also had in mind that India is a country where nuclear power seemed to have a future, and a future that would affect us in several ways; first, Canadian manufacturers might get orders for reactors or reactor components; second, we might create a market—perhaps not a large market in the immediate future, but over a period a sizeable market for our uranium.

By Mr. Stewart (Winnipeg North):

Q. Is it possible to supply Canadian universities with very small reactors for their own experimental purposes?—A. It is possible. Do you mean is it physically possible to do it?

Q. Yes. Have you any idea what the cost might be and has there been any request for them?—A. Yes. Such a project is receiving very active consideration at McMaster. McMaster has decided to proceed with the construction of a swimming pool type reactor. I mentioned a moment ago that the cost of the reactor part of this type of installation was somewhere between $300,000 and $400,000. Of course, you must have with the reactor, a building, services and so on. I understand that the estimated cost of the entire project at McMaster is $1,300,000.

Q. Has there been any request from the University of Manitoba for such a reactor?—A. No. Before undertaking a project of this kind it is desirable that you have at least one or two people who are fairly experienced in this game. In the case of McMaster, Dr. Thode is, one of the Canadians who has been associated with the atomic energy programme for many years.

Q. Would it be possible to give men from other universities a course at Chalk River, if other universities did want such reactors?—A. During the year we have many conferences at Chalk River in various fields and the practice is to bring university professors to these conferences, depending on their interests. Then in the summer time we usually have from forty to sixty post-graduate students and members of university staffs at Chalk River. In other words, the students come when their school term is over or in the case of professors when their teaching work is over. We have generally from forty to sixty university people, either post-graduate or staff, at Chalk River every summer.

Q. Would it be a good thing for research in this country to have as many small reactors as possible at universities?—A. I suppose this depends on the point at which the duplication of research facilities ceases to be a paying proposition. I am inclined, personally, to believe in the element of competition in research. I think it has always been present. It is a good thing to have groups working in different universities in the same field; this is not a dollar competition but rather an endeavour to see who can make a discovery first. However, but I do not think you would want to proceed on the basis that every university in Canada should have a "swimming pool" reactor. How many you should have is a good question.

Q. Even at the expense of duplication might it not be a good thing from the point of view of Canada to have as many people as possible informed and aware with regard to problems associated with the development of atomic energy?—A. Let us understand that the "swimming pool" reactor is a tool which is very useful for fundamental research but it has very limited usefulness in the engineering field. For example, one of the problems in this business —if I may call it a business—and it is a problem which is not peculiar to Canada but one which exists also in the United States and the United Kingdom, is the shortage of what are now described as nuclear engineers. A nuclear engineer is a man who has a basic training in engineering, mechanical or electrical, and who in addition has an expert familiarity with nuclear physics, so that when he comes to the business of operating reactors or, more important, if he is involved in the design of reactors has sufficient nuclear background to be able to do the job competently.

For the purpose of training that kind of man a reactor of the "swimming pool" type is not too useful. It has some usefulness, but it is a very limited usefulness.

Q. Since the future will, to some extent, lie with nuclear engineers what are we doing to encourage this breed to grow?—A. I will tell you how we have approached the problem, but I do not suggest that this is the only solution. I mentioned in my first submission that when we had decided that we were ready to design a power reactor, we set up a nuclear power branch and we gave this branch the job of producing a preliminary or outline specification for a power reactor. We staffed the branch not with scientists but with engineers and, moreover, with engineers whom we obtained from certain of the utilities. In other words, this group of men came to Chalk river with practically no background whatever in this game and, as you might expect, for a period of six or seven months they were "going to school". We put on a course of special instructions to speed up the process of indoctrination. At the end of six or seven months this group of men, who were hand picked men, that is very competent people in their respective fields, were ready to tackle the preliminary design study for the NPD reactor. The group was organized at the beginning of 1954 so it has been in existence now for 2½ years. All these men are now quite knowledgeable engineers in this field and one of them has moved over to the C.G.E. organization where he is engaged in the detailed design of the NPD reactor. The head of the group is in charge of the preliminary design study for the large reactor which I have mentioned. This is the way in which we have gone about training outside engineers. In addition to the nuclear power branch which has been recruited from the utilities we have brought people in from other industries. In the metallurgical division we have a man from the Aluminum Company; we have a man from the International Nickel Company. Our general policy has been to encourage industry to place men at Chalk river. In a sense we are providing a post-graduate course in nuclear engineering. We require these men to stay for at least two years because we feel that two years is the minimum period in which they can get anything out of such training course.

Q. What sort of response are you getting from industry?—A. Industry, of course, is feeling its way in the atomic energy programme and this is not too surprising since it is only within the last few years, that we have begun to have any real appreciation of the significance of nuclear power. I would say that the response from the larger companies has been quite good. For example the response to our invitation for proposals on the design and construction of the NPD reactor was very encouraging. We received some very good proposals. We finally chose that submitted by the Canadian General Electric Company because after close analysis it appeared to be the best of those submitted. But all the proposals were interesting and they indicated that the company concerned was prepared to make a serious contribution to the programme.

Q. Reverting to the universities do you feel that their possession of what you call a "swimming pool" type of reactor would be a useful thing from the point of view of, let us say, elementary research?—A. Not elementary.

Q. Elementary, perhaps, in terms of Chalk river.—A. No, no. There is a difference between "fundamental" and "elementary". I said "fundamental". The work carried out in a swimming pool reactor is far from being elementary. I said that the "swimming pool" reactor was particularly suitable for the purpose of fundamental research but that it would have a limited usefulness as a reactor for training nuclear engineers.

Q. Do you think universities should be encouraged to enter upon this type of research?—A. I would say "yes" and, of course, certain of the universities have been in the field for some years—McGill, with its cyclotron; the work which—and I think I mentioned this in my first brief—Dr. Spinks is doing at Saskatchewan on isotopes; Dr. Thode's work at McMaster and so on.

In this field I believe the same condition applies as applies in any other program of research: what you do depends primarily on the men you have available, not on the equippment you have got. You build these research programs around people and the whole story of research in atomic energy or in any other field can be reduced to men. If you get a research genius—and they are not easy to find—you can usually find a way of giving him the research facilities he needs, but if you have not got the research genius the facilities themselves are not of too much use. I think the answer to your question would, briefly be this: it depends on what type of men a particular university has got. Universities specialize in different things in their science and engineering schools.

By Mr. MacLean:

Q. You said a while ago as I understood you that we are the prime contractor for the operating of this reactor in India.—A. That is right.

Q. Does that include the actual construction in India of the whole thing, or the Canadian contribution to it?—A. Are you talking about the division of cost, now, or of responsibility?

Q. Responsibility—not costs.—A. Initially we believed—as we still do—that we should have the responsibility for the erection of the reactor, at the same time recognizing that Indian labour should be used to the fullest extent possible. We believed that the responsibility—the supervision, let us say—of the job should be ours. Reverting for a moment to the Colombo plan scheme where the distinction is between external and internal costs, we believed that even though India was paying the internal costs we should still have the responsibility for erection, and this is the way the project is being carried out.

Q. You said you are the prime contractors. Do you imply by that that most of the work is done by subcontractors? What is the situation? Is it done, primarily, directly by Atomic Energy of Canada Limited or is some other arrangement being made for the work to be carried out?—A. What we have done is this: we have engaged a firm of engineers—the Shawinigan Engineering Company—to prepare a set of plans and specifications which would permit the calling of tenders for the various components of the reactor. We, of course, had a set of plans, since we built the NRX reactor; and as you recall, we rebuilt it after the breakdown. But it was necessary to get a firm of engineers in to put these plans and specifications in such shape that you could go out and call for bids on the major components of the reactor. The Shawinigan Engineering Company, subject to our approval, in each case, is now calling for tenders on the various components which will go into the reactor. We have laid it down as a condition—this is one of the reasons why we brought the Shawinigan company into the picture, or at last one of the reasons why we wanted it to get a good set of plans and specifications—that the bids must be firm; in other words we want firm prices for the reactor components.

Q. How are the successful bidders determined?—A. On the basis of price and delivery.

Q. It would seem to me that if this equipment were successfully made the plant concerned would gain very valuable experience and would be in a preferred position if this should develop into a greater field of opportunity.—A. I would say that that is generally true, though it must be anticipated that the reactors of the future will be different from the N.R.X. Nevertheless it is very valuable for Canadian manufacturers to gain experience in fabricating components for any kind of reactor. This is the way in which they learn about the business.

By Mr. Murphy (Lambton West):

Q. Is the reactor to be constructed in India solely for the production of power?—A. Oh no, it is an experimental reactor. India is in the process of building up a research establishment headed by Dr. Bhabha who is an outstanding theoretical physicist. We met with Dr. Bhabha to discuss his program and it seemed that the most useful thing we could do for the Indian program at this stage would be to provide an experimental reactor.

Q. Will Canada be sending any scientists there?—A. We have agreed as part of the project to train Indian operators and we expect to have the first group of operators come to Chalk river, in October.

The CHAIRMAN: That has been the practice with regard to all the Colombo plan projects in that area.

The WITNESS: I believe so. We shall probably have people going back and forth. If this reactor is like all the other reactors which have been built so far we can anticipate that we shall have people going out to India.

By Mr. Murphy (Lambton West):

Q. Have you a program under way now for the manufacture or installation or sale of power reactors other than that we have heard of in connection with the Hydro?—A. Not as a company. Of course, our reason for getting the private manufacturers into this picture was that they might gain experience in the design and fabrication of power reactors and thus be in a good position to compete for whatever business might offer.

Q. We hear a good deal about Russian endeavours to inaugurate a service in some countries which are not quite as modern as ours by installing power reactors. Do you know anything about that?—A. We have certainly heard about it. I think the thing you have to remember about this whole question of nuclear power is that no one has yet—I do not want to sound pessimistic, but I think we must be realistic—that no one has as yet built and operated a power reactor of any size, and consequently no one has been able to demonstrate what sort of power costs you can expect to obtain in the first generation of power reactors, or the second or the third.

Q. Do you know anything about the cost of the operation of the Nautilus? —A. No, except that I believe it would be quite high. This is information to which we do not have access.

Q. Would you not get that information from the United States?—A. No.

The CHAIRMAN: We have no quorum and it is past one o'clock.

By Mr. Murphy (Lambton West):

Q. On this same subject, I thought I heard a couple of weeks ago that some agreement had been reached under which the United States and Canada would be able to exchange information on these matters, and that part of this agreement concerned the power plant for the submarines.—A. We amended our bilateral agreement with the United States in order to provide for the exchange of information on reactors for the propulsion of vessels, aircraft, land vehicles and submarines, but—

Mr. RICHARDSON: Mr. Chairman, is Mr. Bennett to return to us?

The CHAIRMAN: Yes.

The WITNESS: —whether we could get the kind of information you have mentioned I cannot say.

By Mr. Murphy (Lambton West):

Q. The agreement does not provide for it?—A. It does not provide for it specifically.

The CHAIRMAN: The meeting is adjourned. We meet again Thursday at 11 o'clock.

HOUSE OF COMMONS

THIRD SESSION—TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 12

ATOMIC ENERGY OF CANADA LIMITED
ELDORADO MINING AND REFINING LIMITED

THURSDAY, JULY 5, 1956

WITNESSES:

Mr. W. G. Bennett, O.B.E., LL.D., President, Atomic Energy of Canada Limited and President and Managing Director of Eldorado Mining and Refining Limited; Mr. D. Watson, Secretary, Atomic Energy of Canada Limited; R. C. Powell, Secretary, Eldorado Mining and Refining Limited; Mr. J. C. Orr, Assistant Treasurer, Eldorado Mining and Refining Limited.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956

76562—1

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McIlraith, Esq.
and Messrs.

Bourget	Harrison	Richardson
Brooks	Hosking	Stewart (*Winnipeg North*)
Byrne	James	Stick
Coldwell	Leduc (*Verdun*)	Stuart (*Charlotte*)
Dickey	Low	Weaver—(20).
Forgie	MacLean	
Green	Murphy (*Lambton West*)	

(Quorum 9)

J. E. O'Connor,
Clerk of the Committee.

ORDERS OF REFERENCE

WEDNESDAY, July 4, 1956.

Ordered,—That the name of Mr. Brooks be substituted for that of Mr. Hamilton (*Notre-Dame-de-Grace*); and

That the name of Mr. James be substituted for that of Mr. Hardie on the said Committee.

THURSDAY, July 5, 1956.

Ordered,—That the name of Mr. Coldwell be substituted for that of Mr. Cameron (*Nanaimo*) on the said Committee.

Attest.

LEON J. RAYMOND,
Clerk of the House.

76562—1½

MINUTES OF PROCEEDINGS

THURSDAY, July 5, 1956.

The Special Committee on Research met at 11:30 A.M. this day. The Chairman, Mr. G. J. McIlraith, presided.

Members present: Messrs. Brooks, Byrne, Dickey, Green, James, MacLean, McIlraith, Murphy (*Lambton West*), Richardson, Stewart (*Winnipeg North*), Stick.—(11).

In attendance: Mr. W. J. Bennett, President and Managing Director, Eldorado Mining and Refining Limited, and President, Atomic Energy of Canada Limited; Mr. D. Watson, Secretary, Atomic Energy of Canada Limited; Mr. R. C. Powell, Secretary, Eldorado Mining and Refining Limited; and Mr. J. C. Orr, Assistant Treasurer, Eldorado Mining and Refining Limited.

The Chairman called the meeting to order and suggested that Members continue with the examination of Mr. Bennett on his evidence presented to the Committee on Tuesday, June 5, and Thursday, June 7, 1956.

Following Mr. Bennett's questioning the Committee went into Executive Session to consider fixing dates for the Committee's visits to Chalk River and Blind River. It was tentatively agreed that the Committee would proceed to Chalk River on Thursday evening, July 12, and that the tour of the facilities of Atomic Energy of Canada Limited would take place on Friday, July 13. The Committee to return to Ottawa on Saturday, July 14.

At 1:05 P.M. the Committee adjourned to meet again at 3.30 P.M. this day.

AFTERNOON SITTING

The Special Committee on Research resumed its work at 3:30 P.M. the Chairman, Mr. G. J. McIlraith, presiding.

Members present: Messrs. Bourget, Byrne, Coldwell, Dickey, Green, Harrison, James, McIlraith, Murphy (*Lambton West*), Richardson, Stewart (*Winnipeg North*), Stick, and Stuart (*Charlotte*).—(13)

In attendance: Same officers who attended morning sitting.

The Chairman, after calling the meeting to order, invited Members of the Committee to continue the examination of Mr. Bennett concerning the operation of Eldorado Mining and Refining Limited, Atomic Energy of Canada Limited; and The Northern Transportation Company.

By leave of the Committee a document setting forth, in tabular form, the Estimated Installed Capacity of Electricity in Canada (1955-1980) was tabled and ordered printed in this day's records.

Mr. Bennett's questioning concluded, the Committee adjourned at 5:45 P.M. to the call of the Chair.

J. E. O'Connor,
Clerk of the Committee.

EVIDENCE

THURSDAY, July 5, 1956,
11.00 a.m.

The CHAIRMAN: I see a quorum, gentlemen.

Can we proceed to the evidence of the last committee meeting—Mr. Murphy was questioning Mr. Bennett and I think I cut him off in the middle of a question, not too abruptly, I hope.

Mr. W. J. Bennett, O.B.E., B.A., President, Atomic Energy of Canada Limited, President, Eldorado Mining and Refining Limited, called:

The WITNESS: I wrote the answer in that transcript.

By Mr. Murphy (Lambton West):

Q. What concerns me at the moment is this exchange of information between Canada, the United States and Britain and from what you told me the other day, Mr. Bennett, it seems that we are on the short end of the stick, so to speak.—A. In what way?

Q. In getting information from the United States. For instance—I do not know whether I saw this in the paper or not—I think that when some British people were over in the United States some months ago with the idea of obtaining information about that submarine, the *Nautilus*, they were unable to get it and I notice from your statement last Tuesday that at present it does not seem that Canada can get any information along those lines, either.—A. Mr. Murphy, I did not mean to convey that impression. Canada negotiated a bilateral agreement with the United States following the amendment of the United States Atomic Energy Act. This agreement was signed on June 15, 1955, that is, a year ago last June. The United Kingdom signed a bilateral agreement on the same date. These agreements have been made public. Our bilateral agreement was tabled in the house and the United Kingdom government and the United States government both published the text of the United Kingdom-United States agreement. In the agreement entered into by Canada there were certain provisions which were different from those in the United Kingdom agreement. The principal differences were these: Canada obtained the right to purchase U235 for use in research programs and for use in power programs. The United Kingdom Agreement did not have such a provision. Second, Canada obtained the right to exchange information on package reactors which were to be used in the joint United States-Canada defence program, that is the continental defence program. In neither of the agreements was there any provision for the exchange of information on propulsion reactors—reactors for powering submarines, naval vessels, aircraft or land vehicles. The reason for this was, that the United States Atomic Energy Commission was not certain whether such an exchange could be included in a civil bilateral agreement bearing in mind that the section in the United States Atomic Energy Act covering bilateral agreements was rather specific as regards the exclusion of information having to do with military applications.

Some months ago we began negotiations on an amendment to the bilateral agreement and in parallel with our negotiations the United Kingdom also began negotiations. As a result of those negotiations both the bilateral agreements were amended. The United Kingdom amendment provided first that the United Kingdom could acquire U235. As I pointed out a moment ago this was a right we already had in our agreement so it was not necessary to amend our agreement in this respect. The United Kingdom also obtained the right to exchange information on package reactors and again it was not necessary for Canada to seek such an amendment since we already had such a provision in our original bilateral agreement. In other words, with respect to the first two of these items there was no need of an amendment to the Canadian Bilateral since the Canadian Bilateral already contained these provisions. What we did get and what the United Kingdom got was the right to exchange information, and I will quote the exact language:

> The right to exchange classified and unclassified installation on the development, design, construction, operation and use of military package power reactors and reactors for the propulsion of naval vessels, aircraft or land vehicles for military purposes shall be exchanged to the extent and by such means as may be agreed.

In other words, this is a very general provision and what I intended to convey to you at the last meeting was that I did not know whether this provision would cover information as to the cost of producing power in the *Nautilus*, which was the question you had asked.

Q. Are there not other important factors though, beside the cost that we should know in connection with that project?—A. Oh yes, but you had asked me, whether we knew that it cost to produce power in the Nautilus and I said we did not know but that it was my impression that the cost was very high; and then, you asked me if we would get this information and I said we did not have the information now and I did not know whether we would be able to get it under the amendment. This provision is, you will see.

Q. Very restricted, I would think.—A. It is general. It is not specific as to the individual items of information that may be exchanged.

Q. It leaves it open to the United States to say: we do not agree. Is that the case?—A. That is right.

Q. And if they do not feel like giving any information they do not have to. —A. That is correct but I would think that the United States government, having signed this amendment would hardly refuse to implement it.

Q. But would you know, Mr. Bennett—I do not know whether this is a fair question or not—whether Britain has obtained full information about this Nautilus project since the agreement was signed?—A. These bilateral agreements have only been signed recently and I would doubt very much whether—if I may use the verb—the new provisions have been activated. In fact I am quite certain they have not been.

By Mr. Green:

Q. Has Canada in contemplation any plan for using propulsion reactors? Apparently they will be suitable not only for submarines but also for merchant ships, motor vehicles and aeroplanes. You are now in a position where you can get this information from the United States and I wish to ask whether you have any plans for using it.—A. The amendment to the agreement which I have referred to specifies that this information shall relate to propulsion reactors for military purposes, which restricts the exchange of information to military uses.

Q. No, but if you have the information it will be useful for military vehicles or ships or planes—would that same information not be useful for civilian purposes?—A. It might in some areas. Let us for example look at the question of the use of reactors for the propulsion of merchant ships—I am giving you, now, my current thinking about this type of this application. One of the advantages of using nuclear power plants in a naval vessel is that it eliminates the need for frequent fueling—in other words a ship can stay at sea for very lengthy periods without fueling. When you come to consider merchant ships this need is not as great because the bulk of the merchant shipping apart from passenger liners is tramp steamers operating between various world ports. The normal practice is to take on fuel when these ships go in port to load or unload cargo. There is not the same requirement in the case of merchant ships for staying at sea for long periods without fueling. The other problem in connection with the use of propulsion reactors in merchant ships has to do with the possible hazards resulting from the operation of nuclear power plants. Without wishing to exaggerate these hazards we must recognize that they do exist. Merchant ships usually dock in the middle of, or at least near, large centres of population. There is some question at this point as to whether you would want to bring a nuclear power plant inside a ship into a centre of population. I would imagine that as technology improves we will be able to minimize these hazards—this might be a problem which would disappear eventually, but it is nevertheless something that has to be taken into account at this time.

Q. Is there not another advantage inasmuch as a nuclear engine would take up much less space than the present type of engines and that therefore there would be so much more space available for cargoes?—A. You have to consider not only the space but the carrying capacity of the ship. While the volume that a nuclear power plant would occupy would not be as great as the volume that would be occupied by a conventional power plant plus fuel storage you would have the problem of shielding and shielding involves weight. I do not believe as yet that types of shielding have been developed which do not involve considerable weight. It is therefore conceivable that what you might save on volume you might lose on weight. Incidentally the development work on reactors for the propulsion of vessels is still at a very early stage.

Q. The Americans are experimenting on that now, are they not?—A. Yes. As I understand the situation the United States is proposing to put up a land-based prototype at Arco, Idaho. From this prototype the U.S. would hope to develop a type of reactor which would be suitable for naval vessels, but the program is at a very early stage.

Q. Is it only for naval vessels or is it also for merchant vessels?—A. The United States' program at the moment, as I understand it, is confined to the use of reactors in naval vessels. There is another point which you have to take into account in considering the possible use of reactors in merchant ships. In naval ships, that is ships that are to be used for military purposes the cost of fuel or the cost of power to propel the vessel is not necessarily, the paramount consideration—in other words it is possible that you might be prepared to incur higher costs in order to avoid frequent fueling. In the case of merchant ships, where frequent fueling is not a problem I would expect the shipping companies would be very much interested in cost—in other words I would not expect the shipping companies to install nuclear power plants in merchant vessels if they could develop power at a cheaper rate by using coal or oil as a fuel source.

By Mr. Brooks:

Q. Is not Great Britain experimenting on those lines at the present time? I saw an article not long ago saying they were.—A. My understanding is that work in this field in the United Kingdom is at an even earlier stage than in the United States and it is also my understanding that the United Kingdom program so far is also confined to the use of propulsion reactors in naval vessels.

By Mr. Byrne:

Q. Getting back to this possibility of hazard. What about the danger of contamination from the waste and exhaust in respect to naval vessels or other vessels using atomic power?—A. If the reactor is operating as it should operate, and assuming you are using a secondary coolant that you exhaust—either light water or gas or whatever is may be—the secondary coolant that is exhausted does not present a problem from the standpoint of contamination. For example, we are exhausting our light water coolant from the NRX reactor into the Ottawa river. The problem would not arise with regard to the coolant. The problem arises with regard to fission product disposal and there, of course, no difficulty is involved until you begin to process the spent fuel.

By Mr. Murphy (Lambton West):

Q. Mr. Bennett, what about the Nautilus—it is graphite, is it not?—A. We have no information at the moment as to the design details of the Nautilus. My understanding is—and I am speaking without full information on this subject—that the design of the reactor in the Nautilus is based on the technology which was developed by the United States at Hanford. Is that not so, Mr. Watson?

Mr. DONALD WATSON (*Secretary, Atomic Energy of Canada Limited*): The reactor in the Nautilus uses enriched fuel.

The WITNESS: That is the difference. The coolant at Hanford is light water under pressure.

Mr. WATSON: Not under pressure.

The WITNESS: The moderator at Hanford is graphite. The coolant is light water. This basic design is I understand the one that has been used in connection with the Nautilus. However, in the case of the Nautilus, since it was necessary to have a very small reactor a very highly enriched fuel is being used in contrast to Hanford where natural uranium is being used as a fuel.

By Mr. Stewart (Winnipeg North):

Q. What are your problems with regard to waste at Chalk river?—A. We are processing the fuel elements from the NRX reactor. This is roughly what happens: the fuel element when it has been irradiated is taken from the reactor and put through a chemical process. The spent fuel element is in solid form. In this chemical process the spent fuel element is put into solution and when it is in the solution—

By Mr. Murphy (Lambton West):

Q. I cannot quite follow you. Is that after it comes out of the reactor?—A. After it comes out of the reactor, yes. When it is put into solution you separate out the plutonium content, the depleted or unburnt uranium and the fission products which have been created in the element as a result of fission. The plutonium and the depleted uranium—can be used again. At Chalk river we are storing the fission products in a storage area which we have provided for this purpose.

By Mr. Stewart (Winnipeg North):

Q. How big an area are you going to need? I imagine the area must be growing to some extent each year.—A. I should point out that we are not talking in terms of large volumes—

Q. I am just trying to find out——A. —when we speak of fission products. Mr. Watson, I do not know whether you have any figure as to the total annual volume of fission products produced from the operation of the NRX reactor?

Mr. WATSON: No.

By Mr. Murphy (Lambton West):

Q. Is this material buried?—A. The highly concentrated solutions are stored, the extremely dilute solutions are buried.

By Mr. Byrne:

Q. In lead containers?—A. No. We are not using lead containers. We are using stainless steel tanks.

By Mr. Green:

Q. To get back to this question of propulsion reactors. This seems to be an entirely new thing and what worries me is whether Canada is taking any steps to get into this field. We do not want to be left behind.—A. Now that this amendment has been agreed to we would certainly expect, as I said, to get access to the information that is already available. That is the purpose of the amendment.

Q. But you have no plans for using it?—A. What I said the other day in reply to Mr. Murphy's question was that up to the present time we have not been able to get access to the information with the one exception of the package reactor.

By Mr. Stewart (Winnipeg North):

Q. Mr. Bennett, what are the provisions regarding secrecy at Chalk river? What necessity is there for secrecy, if there is any?—A. Mr. Stewart, if you have no objection to my referring to earlier evidence, on the assumption that the committee would be interested in the question of declassification I put a couple of paragraphs in my first submission explaining the procedures which are followed in connection with declassification.

From the inception of our participation in the program with the United Kingdom and the United States beginning in 1942 we agreed on a common procedure with respect to declassification. In order to give effect to this agreement there was set up a declassification committee. On this committee there are representatives of the United States, the United Kingdom and Canada. The committee meets at least once a year although it may meet more frequently. At these meetings the committee reviews quite thoroughly the existing situation with respect to classification and it determines what areas of information may be declassified. It it decides that a certain area of information may be declassified it makes a recommendation to that effect. As a result of such a recommendation the information is declassified.

By Mr. Murphy (Lambton West):

Q. On that same question, before you finish answering, would you tell us whether we have liaison men at the atomic plants of these other countries, and whether the United States and Britain have liaison representatives at our plants? I think when we were at Chalk river on the first occasion there was an American there—a scientist, I believe. He was a colonel and, I assume, he was a scientist. Would he not know pretty well everything you were doing? That was just before you came into the picture at Chalk river.—A. Let me answer first that both the United Kingdom and the United States maintain liaison establishments at Chalk river. We have the right to have our people visit American establishments—

Q. Do we do that?—A. —with one exception and this exception, I believe, was set out in our original bilateral agreement. The one exception is Los Alamos where the fabrication of the atomic bomb, the hydrogen bomb and other atomic warheads is carried out. We have not as a matter of policy placed men permanently at American establishments but we do have men going to these establishments quite frequently. We have not thought that there was any need for setting up offices, say at Oak Ridge or at Savannah River or the Argonne National Laboratory but we do have the right to visit these establishments and our people do visit them quite frequently.

By Mr. Stewart (Winnipeg North):

Q. In terms of theory is there anything we know that is not common knowledge among scientists in other parts of the world?—A. Oh yes. Here you have to make a distinction between fundamental knowledge and applied knowledge.

Q. I am thinking of fundamental knowledge at the moment.—A. What would you say Mr. Watson?

Mr. WATSON: I would say: yes.

The WITNESS: Even in the fundamental area.

Mr. WATSON: It would depend on the definition of "fundamental".

By Mr. Stewart (Winnipeg North):

Q. That is a hard distinction to make, I recognize.—A. The distinction I would try to make—and it is difficult to establish a rigid line of demarcation—would be between research that theoretical physicists might carry out and work which a reactor design and development groups might carry out with respect to a specific project.

Q. That is the practical end of it. I can see there, perhaps,—and I speak with a vast degree of ignorance—a reason for a degree of secrecy from a commercial point of view. I was wondering whether the theoretical knowledge we have was not fairly general property.—A. You are speaking of course of the use of atomic energy for civil purposes?

Q. Quite so.—A. As distinct from weapons.

Q. Oh yes. I am not bothered about weapons just now. But, after all, the country which has got some advantage over the others with regard to civil use would obviously be in a good competitive position and I do not think that advantage ought to be shared with other countries.—A. In that connection, at the Geneva conference two papers were presented describing specific power reactor projects. One of them was a Russian paper and one of them was a United Kingdom paper. There were of course many other papers on power reactor projects but in these particular papers a description was given of plants that were actually in operation or under construction. In the case of the Russian paper the description was of a plant in operation while in the case of the United Kingdom paper the description was of a plant which is still under construction but which is expected to be in operation shortly. These descriptions were given in great detail but there was one item on which no detailed information was given and that was the design of the fuel element. Questions were asked from the floor on this point. The man who presented the Russian brief succeeded in evading an answer without stating that he was not prepared to answer the question. When the question was asked following the presentation of the United Kingdom paper, Sir Christopher Hinton, who presented the paper, was quite frank in saying that this information was regarded as "commercial know-how" and that he did not feel that it should be divulged on that ground.

Q. The point is that it is conceivable that your people in Chalk river who are delving into the commercial aspects of this matter might have knowledge at their disposal which other countries do not possess and which would be commercially useful to us, and, therefore, it should be classified.—A. That is quite right but it would not be classified on the ground of security but on the ground of commercial advantage. This, by the way, is a trend which I would have expected and I imagine it will continue.

By Mr. Byrne:

Q. What field can there possibly be in the interchange of ideas, in that case, when everything must be either of military or commercial value?—A. I gave the example of the Russian and the United Kingdom papers to illustrate the point that for the most part there was a full description of power reactor; the only reservation had to do with the fuel element which, of course, is only one part of power reactor technology.

Q. It seems to me that nations are willing to divulge any information that everyone else has, but that when they are ahead of someone else they are not prepared to divulge it. All these things must be either of commercial or military value, and must involve one country being put in a better position than another.—A. I think you should keep in mind that the basic designs of the power reactors which are now being developed differ. As I pointed out in my first submission the United Kingdom is concentrating on a reactor using graphite as a moderator and CO_2 as a coolant. The United States is exploring a number of routes. The PWR reactor which is the first large power reactor to be built in the United States also uses graphite as a moderator but light water under pressure as a coolant. In our case we are using, the design of the NPD reactor, the technology which we have developed at Chalk river, that is, we are using heavy water as a moderator and as a coolant. So that so far as core design is concerned—and by the core I mean the part of the reactor where the reaction occurs—there are these differences in basic design. However, when you come to the fuel element you do not necessarily have these differences.

By Mr. Stewart (Winnipeg North):

Q. How much access have representatives from other countries to your research along commercial lines?—A. I gave in my first submission the number of visitors.

Q. That is not what I meant. How much knowledge do they have?—A. At the present time, we are exchanging unclassified information with a number of countries—I do not know the exact number—but certainly any country that asks for an exchange of information in the unclassified field receives it.

Q. Do we possess information in Canada which we regard as classified and as commercially useful knowledge that we do not impart to representatives of any other country—in other words have we our own secrets as the British obviously have theirs?—A. I think we have. There are some areas of information—I do not know what they are precisely where we have discovered some tricks which we are not passing on at the present time.

By Mr. Brooks:

Q. In connection with that is it not possible that when you exchange this information which you regard as more or less secret you find that the other party already has it? Take the case of this fuel element where the Russians did not divulge their knowledge regarding its construction and neither did the representative of Great Britain. Is it not possible that they each had the same type of information but were not divulging it?—A. It is hard to know unless they divulge it.

Q. I know, but when they do divulge information under the present agreement do you not find you already have the information which they are forwarding?—A. Perhaps I might answer that question in this manner: certainly at the Geneva conference there was information presented in papers by countries other than the United Kingdom, the United States and Canada which had, prior to the Geneva conference, been classified.

By Mr. Murphy (Lambton West):

Q. Would it not just be a matter of time before scientists in other parts of the world had that information anyway?—A. Again it is a question of where you draw the line between what I call fundamental scientific information and information in the applied field.

Q. I would like to follow up the question that Mr. Brooks asked about fuel. Have you done any experimenting with any fuel other than the standard fuel?—A. I do not think there is any standard fuel for reactors. We have of course had a major program under way on the development of fuel elements for the NRX and for the NRU reactors and both of these programs are still going on. I do not know how many times we have changed the design of the fuel element for the NRX but we have changed it many times. I do not mean by that that we have changed the basic form of fuel—we are still using uranium metal—but the design of the fuel element has been changed many times. We have continuing program on fuel element development; it is one of the priority jobs at Chalk river. As I say, we have changed the specification of the fuel element for the NRX reactor many times as a result of improvements we have discovered following loop experiments carried out in the NRX reactor. In the case of the NRU reactor which is not yet in operation, again we have had under way a major program of fuel element design and development. We also have underway a major program in the design and development of fuel elements for the NPD reactor. I might give you an example of the sort of discovery which results from continued experiments and research. Initially, all of the fuel which went into the first reactors which were built—that is the NRX reactor, the reactors at Windscale in the United Kingdom and the reactors at Hamford in the United States was uranium metal. However the shape of the metal differed. In the case of the NRX reactor the fuel element is in rod form. In the case of the Windscale reactors the fuel element is in the form of short slugs. One of the new developments which has occurred quite recently, and which resulted from experiments carried out in the NRX reactor, is the use of uranium in the form of oxide rather than metal. This appears to have advantages. Our present plan is to use oxide fuel elements in the NPD reactor.

As a result of the work which we have done at Chalk river in a joint programme with the U.S. the United States will also use some oxide fuel elements in the PWR reactor.

By Mr. Murphy (Lambton West):

Q. Is that the form in which this product comes from the mine—I mean after it is processed?—A. No. The mine product is a concentrate or precipitate which generally ranges from 70 to 75 per cent U308 content. This product has to be refined first and in the refining process the uranium content is brought up to 99 per cent plus.

Q. Is that done on the other side?—A. No, that is done at Port Hope.

Q. Oh, I see.—A. It is also done in the United States and in the United Kingdom. The product of these refineries is U03.

If you are going to make metal for use in a fuel element you convert this product to UF4, which is commonly called green salt. Green salt, in other words, is the feed for a metal production plant. If you are going to make oxide, for use in a fuel element, you convert the UO3 to UO2. One of the advantages of using oxide, is that it is cheaper to produce UO2 than it is to produce metal.

Q. Your plutonium is made after your bars or slugs come out of the reactor?—A. Plutonium is created or made in the fuel when fission occurs. You extract it when you take the spent fuel element out of the reactor and put it through a chemical process.

By Mr. MacLean:

Q. I wonder if we might refer to the propulsion units for a moment. I have a question to ask. Does it seem likely that with the knowledge which we might obtain in the United States due to their very considerable research on propulsion units—might it be useful to apply it to the small units for the production of power in isolated units such as in northern Canada?—A. A propulsion reactor is different from a reactor which you are going to use as a plant for supplying power and space heating. Despite this difference, I would expect that you would obtain information from propulsion reactors which might be useful in the design of a package reactor. The two types of reactor are alike however in this respect that you must use enriched fuels in a small package plant and of course the same applies for units which are designed for propelling submarines or naval vessels. In other words you are trying to get the size of the plant down, and one of the ways you get the size of the plant down is to use enriched fuel rather than natural uranium.

Q. I want to ask a question in a different field.

The CHAIRMAN: You may, go ahead.

By Mr. MacLean:

Q. What is the liaison existing between Canada and other countries in respect to biological research and uranium activity. I am not thinking so much about the use of tracers, but of the undesirable creation of mutation.—A. The information on radiation hazards and the genetic effects of radiation is, so far as I am aware, completely declassified and has been so for some time. The most important development in this field in recent times has been the decision of the United Nations to set up a committee, the function of which will be to collect information from the various sources where it is available and to evaluate it. We are represented on this committee.

By Mr. Stewart (Winnipeg North):

Q. When you say "we" who do you mean?—A. Canada.

By Mr. MacLean:

Q. Was research being done along this line at Chalk River?—A. Yes.

Q. I do not want to prolong this, but we shall have an opportunity to see something of what is being done up there?—A. If you look at the organization chart you will note that there is a Biology Division. This division is concerned with this problem. As you probably know we had an outstanding man in this field in Dr. "Cipriani" the former Director of the Biology Division. His death was a very severe loss to us.

The man we have in charge of the division now is also very competent. One of the talks which we propose to give you at Chalk River will be concerned with this subject.

Q. That is fine, I shall be very interested in hearing it.

The CHAIRMAN: Are there any more questions on this point?

By Mr. Green:

Q. Mr. MacLean mentioned the propulsion reactor. What is the situation with regard to the use of such reactors in planes? We discussed ships, but what about planes in your view?—A. I can give you only a layman's opinion, but it is an opinion based on conversations I have had with experts in the field. The use of nuclear power plants in aircraft is some distance away. There is work being done on aircraft propulsion reactors in the United States; and I would hope again that we would, by reason of the amendment to the Bilateral obtain access to information about aircraft reactors. I do not know from discussions I have had with various officers of the United States Atomic Energy Commission that this particular development is at a very early stage, and from that I would assume that the production of nuclear propulsion plants for aircraft is some distance away.

Q. What about motor vehicles or land vehicles?—A. So far as I am aware the work that has been done on the propulsion of land vehicles has been directed to the propulsion of military vehicles. So far as I am aware, nothing has been done about developing or designing a unit for the propulsion of trucks and automobiles.

By Mr. Stewart (Winnipeg North):

Q. In view of the number of crashes which seem to take place almost daily, might it not be a good idea to refer this to a discussion of atomic propulsion?—A. That is a very good point. I mentioned earlier the problem of sending a merchant ship into a harbour with a nuclear power plant, and the eventuality that if something went wrong you might spew contamination all over the harbour. You might also contaminate the atmosphere. Of course this is an even more serious problem when you consider an aircraft that is powered with a nuclear plant. Certainly if the aircraft crashed, you would have contamination.

By Mr. Green:

Q. Whose job is it to do research work on these propulsion reactors? Apparently they are used primarily for defence purposes, and I wonder if that establishment would be responsible for it, or the Defence Research Board in Canada, or whether it would be your responsibility.—A. The responsibility for initiating a defence program rests of course with the Department of National Defence. However since we have the expert knowledge in this particular field we would expect that once a program is initiated we would certainly be involved in it. We might carry out the program or we might be in it in an advisory capacity.

By Mr. Richardson:

Q. I wanted to ask a question earlier, and perhaps it has already been answered by this time, but it has to do with the bi-lateral agreements. Did the suggestion for the amendment to this bi-lateral agreement come from Canada or from the other party.—A. It is hard to answer that question accurately. When we were negotiating the bi-lateral agreement we believed that there should be included in the reactor section an exchange of information on all types of power reactors, that is reactors for the production of power for large power systems, and also reactors for propulsion purposes.

At the time of the negotiation of the bi-lateral agreement—the original bi-lateral—the United States Atomic Energy Commission was not clear as to whether the United States Atomic Energy Act would permit the exchange of information on propulsion reactors which were being designed primarily for military use. If you look at the wording of the bi-lateral, you will find these words.

Q. Have you a copy of it by the way? I do not believe it has been tabled.—A. Oh yes. I am referring to the original bi-lateral. Under section B, which deals with reactors, there is a general provision which reads as follows:

> (1) Information on the development, design, construction, operation and use of research, production, experimental power, demonstration power, and power reactors, except as provided in paragraphs A and (2) and (3) of this paragraph.
>
> (2) The development of submarine, ship, aircraft, and certain package power reactors is presently concerned primarily with their military uses. Accordingly, it is agreed that the parties to this agreement will not communicate to each other restricted data pertaining primarily to such reactors, until such time as these types of reactors warrant civil application and as the exchange of information on these types of reactors may be mutually agreed. Restricted data pertaining to the adaptation of these types of reactors to military use, however, will not be exchanged. Likewise, the parties to the agreement will not exchange restricted data pertaining primarily to any future reactor types the development of which may be concerned primarily with their military use, until such time as these types of reactors warrant civil application and as exchange of information on these types of reactors may be mutually agreed; and restricted data pertaining to the adaptation of these types of reactors to military use will not be exchanged.

This was the exception contained in the original bi-lateral. The recent amendment opens up these areas.

Q. This was after there had been an agreement between the United States and the United Kingdom?—A. The fact that the agreements were signed on different dates does not mean that we went in and negotiated after the British. Our negotiations were carried on in parallel with the negotiations of the United Kingdom. There is no particular significance in the fact that our bi-lateral was not signed on the same date as was the United Kingdom bi-lateral.

By Mr. Stewart (Winnipeg North):

Q. It is now a quarter to one, and some of us would like to know about Chalk River.

(At this point a discussion took place off the record.)

The CHAIRMAN: Mr. Richardson has a question.

By Mr. Richardson:

Q. I take it that Mr. Bennett cannot tell us if the suggestion for the amendment came from one party or the other?—A. It came from Canada. We made the suggestion during the negotiation of the original bi-lateral, but the United States Atomic Energy Commission did not believe at that time that they could include an exchange of information on propulsion reactors in the original bi-lateral.

By Mr. Green:

Q. My question has to do with fuel elements and I cannot get this situation through my head. You said in your original statement:

> Bearing in mind our large supplies of uranium, we think there is a real future in the fuel element business. All reactors require fuel elements, regardless of their type. We think it makes good sense to aim at a situation where at least some of our uranium will be exported in the form of fuel elements. We would anticipate that the company which takes on the job fabricating the NRU fuel elements will in due course build up its own design and development organization and thus be in a position to exploit the domestic and export markets.

You said this morning that there are changes being made all the time in the fuel elements you use at Chalk River. Apparently you keep improving them. How do you plan to get the Canadian branch of the business selling fuel elements?—A. I was looking to the future. I have tried to say and—I admit that I may not have said it too clearly that we should be thinking in terms of exporting uranium in the most advanced state of processing possible. We will be dependent on export sales if we are going to maintain a high level of uranium production.

By Mr. Murphy (Lambton West):

Q. The oxide agreement?—A. I am going even beyond oxide. I am talking about exporting fuel elements which are ready to go into a reactor; and a fuel element ready to go into a reactor consists not only of uranium; it consists also of the clodding which covers the uranium to prevent its coming into contact with the coolant.

The CHAIRMAN: Those were the sheets which we were shown in such detail during the evidence before the former committee. We were also shown the different types of improvements up to that time.

The WITNESS: What I have tried to say is that Canadian Industry should get into the fuel element business. To do this you must start with a specific fuel element. Our thought was that the best place to start was with the fabrication of the fuel elements for the NRU reactor. This does not mean that the type of fuel element which is used in the NRU reactor will necessarily be the type of fuel element which is used in other reactors. But there are certain features common to all fuel elements. By working on the fabrication of the NRU fuel element, a company would become familiar with fuel element problems. But of course, if a company is going to stay in the business and more particularly if a company is going to take advantage of other markets, that company must at the same time build up a research, and development organization which will enable it to keep abreast of new developments in the field.

By Mr. Green:

Q. Is there any company in Canada now building these fuel elements?—A. No.

Q. You are doing that yourself at Chalk River?—A. Yes. Some of the rods for the NRX fuel elements, have been rolled by Atlas Steel. We have also had the Aluminum Company do some experimental work on sheathing. The Aluminum Company got into the picture due to the fact that the sheathing material we have used so far is aluminium. But I would say, by way of a general answer to your question, that there is no company in Canada today which is too familiar with the techniques which are involved.

Q. You are buying your fuel element in the United States now?—A. No, we are not buying our fuel elements. What we are buying from the United

States is metal, in billet form. We bring the billets to Canada and we roll, machine and sheath them in Canada.

Q. You think the whole thing could be done in Canada and an export market built up?—A. That is what I would hope would happen.

Q. That is what you have in mind?—A. Yes.

—*(Discussion in Executive Session.)*

The Committee adjourned at 1:05 p.m. to meet again at 3:30 p.m. this day.

AFTERNOON SESSION

THURSDAY, July 5, 1956.
3.30 P.M.

The CHAIRMAN: Gentlemen, I see a quorum.

Mr. STEWART (*Winnipeg North*): I have one or two questions about the annual report which we just received today.

Mr. W. J. Bennett, O.B.E., B.A., President, Atomic Energy of Canada Limited; President, Eldorado Mining and Refining Limited, recalled:

By Mr. Stewart (Winnipeg North):

Q. What is the reason for the greater accident rate at Port Radium as compared to Beaverlodge?—A. Accident rates vary from year to year. Two or three years ago Port Radium won the Ryan trophy, which is a trophy awarded to the mine in western Canada which has the lowest accident rate. As it happens, the Beaverlodge mine won it this year.

Q. Yes, but was that greater accident rate due to labour turnover or due to inexperienced labour?—A. I do not think so. I do not think there is any specific reason other than, as I said earlier, accident rates seem to vary. You go along for a while and the rate is low, then you get a series of accidents which contribute to higher rates.

Q. So there is no consistent reason?—A. There is no relationship between the accident rate and the turnover.

Q. What sort of turnover do you have up there in labour?—A. If you will leave that question with me I will get the percentage.

Q. I just wondered what was the reason for the turnover. Is it the remoteness of the area?—A. We always hire people at both these places on a twelve month basis, or rather for a three hundred shift contract. Three hundred shifts correspond roughly to a year, when you take Sundays and holidays into account. We do this because in places that are as remote as are these two places—and this applies particularly to Port Radium—we think it desirable that the men—salaried men as well as hourly rate men—should go out every twelve months.

The pattern over the years at Port Radium as far as the hourly rate men are concerned has been something like this: we do get some men who work for us two or three years consecutively. We have a few who have been with us for nine or ten years. But, generally speaking, men go in and they stay for the period of their contract and then they go and work someplace else. We very frequently get the same man back. We may not get him the next year, but we may get him in the third or fourth year.

In the case of Port Radium, I think this can be attributed to the fact that it is a very isolated spot. There are no other mines in the neighbourhood. The closest settlement is Coppermine which is 140 miles away on the Arctic coast, and the closest mines are at Yellowknife, 300 miles south, on Great Slave lake.

We do, of course, provide everything in the way of recreational facilities, but you still have the problem of isolation. You also have the problem of severe climate, although, of course, this is a problem in many places in northern Canada.

I think the conditions are aggravated somewhat too by the fact that we have periods of the year when the days are very short. Beginning in September, the days become shorter and in late November and December the period of daylight is very brief. The combination of these conditions is responsible for the fact that men do not want to stay for long periods as they do in some other mining camps.

Q. Do you supply living quarters?—A. Yes.

Q. At what rental? I am speaking of the ordinary worker.—A. We supply living accommodation for single personnel at Port Radium. There is no accommodation for married personel except for certain members of the staff; not all of the staff, but the key members of the staff. We have from twenty-five to thirty families at Port Radium. There is a daily charge for accommodation and board for single personel. The charge is $2.50 a day, which is considerably less than what it costs us.

Q. What is the basic wage rate?—A. I do not have our wage scale with me. We will obtain that for you this afternoon.

Q. What about the children of those families who are there? Are there any educational facilities?—A. Yes. We have a small school with a qualified teacher. The school is part of the Northwest Territories school system and is inspected by the school inspector for the Northwest Territories.

Q. You supply the teaching staff, do you?—A. Yes. We also have a hospital with a resident doctor and resident nurses. The doctor is a surgeon and is able to perform emergency operations. In the case of serious or major surgery, where time is not an important factor, we fly the sick person out to Edmonton. Our surgeon does not attempt major surgery if the patient can be moved to Edmonton.

Q. Does the same thing apply at Beaverlodge?—A. Beaverlodge is quite a different community from Port Radium because you have in the district one other large mine in production, Gunnar; you have three small mines in production, and you have five or six properties which are in an advanced stage of development. A local improvement district has been established and there is a central townsite called Uranium City. The total population of the district, according to the last figure which I have seen, was, five thousand.

There is a road connecting the Eldorado property with all of the other properties with the exception of the Gunnar property. This makes for more of a normal community. We originally operated a school and a hospital. A new hospital has been built at Uranium City with 30 beds. There are several doctors in the area. There is a large school at Uranium City and we still have a school at the Eldorado property; but it is now a part of the Uranium City school system.

Q. Can you tell me why the income tax is apparently so low?—A. In the second paragraph of the written section of the report, in the second sentence, you will note the following: "At the present time this company continues to enjoy, with respect to the Beaverlodge operation, the usual free exemption from taxation on profits derived from new mines." In other words, we are not at the present time paying income tax on the profits from the Beaverlodge operation.

I am sorry to say that this exemption will expire on November 1. We will have been on November 1, in operation for three years and six months. The practice of the income tax department in connection with new mines is to allow a six-month tune up period in addition to the three years.

Q. It is a very nice profit and loss account.

By Mr. Coldwell:

Q. There is no road into Uranium City?—A. Not from the outside.

Q. Is one projected at all?—A. Not as far as I know. It is quite a long distance from the nearest highway and the country is quite rugged.

Q. I believe some aerial surveys have been made. I wondered if anything had been projected —A. As far as I know, there are no plans for a road.

By Mr. Murphy (Lambton West):

Q. We have the evidence of Dr. Steacie regarding the remuneration paid. Are you on pretty much the same scale as perhaps the National Research Council?—A. For scientists?

Q. Yes.—A. Our practice is to maintain, to a large extent, parity with the National Research Council with respect to salaries for scientists.

Q. Would they still be lower than industry? My objective, which you will know if you have read the other evidence, is to keep our top scientists here. Do you find that there is a loss of these top men?—A. We have not had any serious turnover in senior scientists. In fact, I think we have had a rather remarkable record in holding our senior scientists.

Q. Is that because they are so absorbed in the work?—A. I think it is due to a number of things. One is that our salaries compare favourably with the salaries which are paid for similar kinds of work in other parts of the country. Second, there is no doubt that what you might call job interest is a big factor. Third, I think that the provision we have made for a healthy community life, particularly with respect to housing and recreational facilities at the village of Deep River, has been a major factor in holding our people.

The CHAIRMAN: And good schools.

By Mr. Murphy (Lambton West):

Q. Would you have a breakdown of the number of scientists who have gone, say, to the other side because of the inducement of higher pay?—A. I have a percentage breakdown which relates to professional staff, and by professional staff I mean not only scientists but engineers, that is personnel who have university degrees.

Q. Would you include in your answer, Mr. Bennett, the people I have in mind who perhaps did not qualify but who were pretty sharp chaps who would come down there and after a year or two go elsewhere for further study?—A. They are included in this breakdown. This covers the period April 1953 to March of 1956. These statistics, like most statistics, do not give the whole picture. What you would like to have, as I understand it, is the number who left.

Q. The percentage would be all right.—A. What I have here is not the number who have left, nor the percentage who left. What I have is a breakdown showing where they went.

Q. That would be interesting.—A. This is the period April 1953 to March 1956. 38·4 per cent of those who left went to Canadian industry. Now, most of those I would expect would be engineers rather than scientists. 8·3 per cent went to Canadian government service. 5 per cent went to Canadian universities.

Q. Would that be for further study?—A. No. They would be people who went to take staff positions. 8·3 per cent went to United States industry. 3·3 per cent went to United States universities, again to take staff positions. 6·7 per cent went to United Kingdom industry. 16·7 per cent left to do post-graduate work. I do not have any figures as to whether the post-graduate work was being done in Canada or in the United States or in the United Kingdom.

Q. You likely are aware, Mr. Bennett, that— —A. Could I finish the answer. Then, we have one group that is described here—and I will have to ask Mr. Watson to explain what this means—as "married or at home" and this was 10 per cent.

Mr. WATSON: These are girls who get married, or leave to go home.

The WITNESS: They do not marry someone who is employed at Chalk River. I presume that is what it means.

By Mr. Murphy (Lambton West):

Q. The other question I would like to have your opinion on, Mr. Bennett; some of the larger industries in Canada in the last few months have been making surveys to determine what increases they would have to make for engineers in order to hold them. Do you face that problem?—A. In the last 12 months, we have put into effect two increases for the professional staff. One of these increases was put into effect on December 1st last. It was a 4 per-cent increase. The effect of that increase was to put the salaries of our scientific staff somewhat higher than the salaries of the National Research Council.

When the increases went through for the National Research Council, and other establishments in Ottawa— I believe it was in March or April—the effect was to raise the salaries of the National Research Council somewhat above our salaries. To maintain parity we put through a further increase of 4 per cent, effective April 1st last.

Q. Those two increases were in respect to scientific staff?—A. They were for all the professional staff.

Q. That is all engineers?—A. All graduates, all persons who had degrees. Similar increases also applied to all other salaried employees with the exception of those employees who are covered in union agreements.

Q. Along the same line what benefits do you have that other industries have in the way of pension funds and that sort of thing?—A. The salaried employees come under the government superannuation fund.

Q. And sick leave and vacation?—A. The usual arrangements in that regard.

By Mr. Dickey:

Q. You have no insurance scheme, or anything like that covering the other employees who are not on salary?—A. The prevailing rate employees do not come under the government superannuation plan.

Q. No pension plan?—A. Yes, there is a pension plan but it is not the government superannuation plan.

By Mr. Murphy (Lambton West):

Q. I just did not get the last.—A. We also have for all employees a plan which provides some life insurance, and arrangements covering sickness benefits.

Q. Would that be the same system that they have at Polymer, is that the idea?—A. I am not familiar with the Polymer situation. I am speaking now of Atomic Energy of Canada, I am not speaking of Eldorado.

Q. No.

By Mr. Bourget:

Q. Do they raise the living allowance besides their salary in those areas? —A. In the north—are you speaking now of the north?

Q. In the north, yes.—A. No. Because we find that in respect to the employees at Port Radium and Beaverlodge you have to provide a salary and wage differential.

By Mr. Murphy (Lambton West):

Q. It would be higher there?—A. Yes. We prefer to do it that way rather than to pay a living allowance. In any case the living allowance is taxable, so you might as well make it part of a man's salary.

Q. There is another question Mr. Bennett: Dr. Steacie, I think in his evidence, said that the National Research Council's salaries were still, for the starting engineer, $300 to $500 less than what industry is paying. The point I am raising, this is such an important industry I do not see why there should be this differential.—A. I do not have it with me, but we have plotted the salary curve for engineers at Chalk River in relation to the curve which shows the average rate for engineers in industry. This indicates where our rates stand in relation to the average rates in industry. I can show you the graph when you visit Chalk River.

Q. Now, do you have any of these bright young men that you sort of sponsor for further university courses with the idea of their coming back to your company?—A. I am not aware that we have financed any post graduate work at Chalk River.

Mr. WATSON: We have in two instances in the past.

The WITNESS: We have not done it on any large scale.

By Mr. Green:

Q. Mr. Bennett, when you were down at St. Andrews by the Sea two or three weeks ago you made quite a speech in respect to the production of uranium, and you predicted that eventually uranium would be more valuable than any other metal, could you amplify that statement?—A. I made that speech—

Q. Could you tell us how you were going to get rid of the uranium?—A. I made that speech to the parliamentary committee before I made it at St. Andrews.

The CHAIRMAN: It is all in the evidence.

The WITNESS: It was in my second submission. You recall, I did not read it.

By Mr. Green:

Q. It was a very good speech.—A. I thought the committee should have the information first.

Mr. BYRNE: It sounded better down by the sea.

The CHAIRMAN: Perhaps we all had better go to St. Andrews by the Sea to hear the evidence.

Mr. BYRNE: We cannot even get to Chalk river.

The CHAIRMAN: Oh, yes we will.

The WITNESS: What I said was, and I have my exact words here; "When all of the mines under contract and the mines to be put under contract get into full production, the value of our uranium production will be approximately $300 million per year, ranking uranium in first place in the value of metal produced in Canada each year." I am quoting from page 335 of my evidence of June 7.

What I said was simply this, that on the basis of the present information as to the annual gross value of other base metals, an annual gross value of $300 million would put uranium in first place.

By Mr. Green:

Q. Is there any possibility of there being an open market for uranium or will the government have to continue to be the sole purchaser?—A. The problem here is one that arises from the fact that uranium can be used for military purposes. The establishment of any export policy which would permit the producer to sell direct must take that fact into account. How soon will we arrive at a time when the international situation will permit normal commercial trading in uranium is very difficult to say. The plan for the establishment of an international agency for atomic energy, as presently conceived, provides for a system of control. This means that fissionable materials, or equipment in the form of reactors, or reactor components, that is supplied through the agency, would be subject to some form of inspection and control. I say, this is provided in the plan as presently conceived. The present status of the agency is this: a draft statute for the agency was discussed by 12 countries last March. Canada was one of those countries. The purpose of this discussion was to try and arrive at agreement on a statute that could be submitted to the full membership of the United Nations. You may recall that the idea of an international agency was first propounded in the general assembly of the United Nations in a speech delivered by President Eisenhower. Subsequently a resolution was passed in the General Assembly that such an agency should be established. But, it was decided that as a first step a small group, rather than the whole membership, should tackle the problem of writing a statute. The meeting of last March was held with that in mind. The 12 participating countries were: United States, the United Kingdom, Canada, U.S.S.R., Czechoslovakia, France, Belgium, South Africa, Australia, Portugal, India and Brazil.

For the most part, agreement was reached. But there were some sections of the statute to which certain countries took objection. Reservations were made by both the Soviets and by India. My recollection is that these were the only two countries that made reservations. The plan now is that this draft statute will be submitted to a general conference, made up of the full membership of the U.N. plus, the membership of the specialized agencies of the U.N., 84 countries in all. This general conference will be held at the United Nations in New York, beginning on September 20th. We will have a better idea after the statute has been discussed as to what the prospects are for normal trading in uranium.

Q. That agreement will only provide for inspection and control, I understood you to say?—A. That is right.

Q. In Canada all the uranium ore has to be sold to— A. At the present time, yes.

Q. But you said this morning that you encouraged some of the Canadian firms to undertake the manufacture of the fuels for the reactors. Now, does that not of necessity involve some of this material getting into the hands of private companies?—A. I said, this morning, that I was looking some distance ahead. I was envisaging a situation where you would have an acceptable international framework—which would permit trading not only in natural uranium, but also in U-235 and in the equipment, including reactors, that is needed for an atomic energy programme. We certainly have not arrived at that stage yet.

Q. At the present time is there any private industry at all in the business, or any other country? Is it all handled exclusively by governments, or governmental agencies?—A. If you mean, are there any private companies producing uranium, there are, of course, private companies producing in Canada.

Q. Yes, but in Canada the government buys all—A. Also in South Africa, Australia and in the United States. In each producing country the arrangement with respect to purchases corresponds to the arrangement we have here at the present time. In other words there is a government agency: in some cases a commission, in our case a government owned company, through which these sales must be channelled. That is the present situation.

Q. Then if you are going to buy all the uranium you of necessity have to sell it to somebody?—A. That is right.

Q. How are you going to manage to sell this $300 million?—A. This $300 million is contracted for now. This $300 million represents the value of uranium which we will purchase each year under the special price contracts. We have contracts, with the United States Atomic Energy Commission, and with the United Kingdom Atomic Energy authority, for the purchase of the quantity of uranium represented by this money.

Q. It is all contracted for?—A. It is all contracted for. There is, however, a reservation in each contract, that we may keep, for our own use, any quantity that we may wish.

Q. What amount could Canada produce and sell? Is this the maximum that we can handle? I ask that because there will probably be an expansion in the uranium mining field if there is a chance to get rid of more ore than we can at the present time.—A. Mr. Green, the present special price purchasing plan does provide for the purchase of all production which is now in sight, that is the economic production which is now in sight, over the period up to March 31, 1962.

Q. There are a lot of people running around with geiger counters looking for more uranium. Now, what about that?—A. My impression is that the interest in uranium exploration has fallen off very considerably in the past year and for several reasons. First, as I pointed out on Tuesday, there is a limit on the quantity of uranium that we will buy under the special price arrangement. The second reason—and this is a point that I dealt with at some length in my submission of June 7th is because of the fact that it is now quite evident that the demand for uranium for civil use, that is for use in power programs, is not likely to be of great magnitude in the period, up to 1965 and possibly up to 1970. So that the people who invest money in exploration development are naturally concerned with where the market will come from after March 31 1962; if the military demand is cut back at that time. We do not know, at this time, whether the military demand will be cut back. On the other hand we do not know that it will continue beyond March 31, 1962. Assuming that it does not continue, we are going to have a period after March 31, 1962 when the civil demand will not take up all of the available production, in the free world unless, of course, governments undertake stock piling programmes.

Q. How does Canadian production compare with American?—A. I do not have the figures for American production. There was a statement made recently to the effect that the U.S. production at the moment was the highest in the world. But, I would think that when all of the Canadian mines get into production we will have the largest uranium production in the world. I do not think there is any question about that.

Q. Is there not likely to be a market in other countries besides the United States and the United Kingdom?—A. I believe there will be. But I think it will build up gradually.

Q. How about the military market?—A. At the moment, there are only three countries, so far as we know, that have a weapons program; the United States, the United Kingdom and the U.S.S.R. Whether other countries will decide to get into weapon production, I cannot say. So far as the civil demand in other countries is concerned it will build up slowly for the simple reason that a great deal of work must still be done before it can be demonstrated that nuclear power is economic. I gave, in my first submission, some indication of the time period that is involved in designing, building and obtaining results from a demonstration power reactor. I pointed out that the only way one can demonstrate economic and engineering feasibility is by designing and building a power reactor.

You are faced with this sort of time period. You generally require from one year to two years to complete your preliminary design study. There is required, in addition to the design studies, development programs of various kinds. Then you have a period of three years from the point when you commence detailed design until the point when you have the reactor in operation. You then need at least two years for operation, in order to get the type of information which would be of use in designing further reactors.

Q. If this agreement between the nations is eventually completed, will that mean any change in the method of buying the uranium ore in Canada?—A. That I cannot say beyond pointing out again that the present view is that because of the military significance of uranium it is desirable that it should be marketed within a international framework.

By Mr. Richardson:

Q. In your statement, Mr. Bennett, in respect to these resale contracts to the United Kingdom and to the United States, you say that Eldorado does not make any profit?—A. That is right.

Q. Does Eldorado not take some loss?—A. No. We do have administrative charges, but we absorb these in our normal operating costs.

Q. What would be the nature of those charges?—A. They would not amount to a great deal. We have one officer in our head office who is exclusively concerned with the handling of purchase contracts. He has an assistant. The rest of the head office staff also get into the picture from time to time. I will not attempt to cost my own time other than to tell you I have spent considerable time on this particular phase of our work.

By Mr. Murphy (Lambton West):

Q. I would like to get back to the reactor question. There is still some confusion in my mind. The one which you are sending to India under the Colombo plan is for scientific experiments?—A. Yes.

Q. Have you in mind any power project for India?—A. We have not as yet. We believe that we should do the job here first, that is demonstrate in Canada that nuclear power is feasible and economically sound before we begin supplying power reactors to other countries..

Q. Have you any idea how far ahead we are with respect to Russia on these power projects?—A. I do not think we are behind. Of course, the only reactor about which we have any information in the Russian program is the small reactor which was described at the Geneva conference. There was no hesitation on the part of the Russians in admitting that this reactor did not produce power at competitive cost. It was a demonstration reactor.

Q. How would the cost compare with our own, if you have tentatively figured our own cost?—A. They did not give a figure in terms of cost per kilowatt hour.

By Mr. Stewart (Winnipeg North):

Q. In any event, they would not be comparable.—A. This question of competitive cost, depends very largely on where you put the reactor; in other words, with what type of power does it have to compete. There are areas in the world—and we have some of them in Canada—where present power costs are quite high, that is the cost of power developed from conventional thermal sources. This is the case in the north, for example, at Port Radium and Beaverlodge, we have quite high power costs because we are using diesel oil as a fuel and the transportation cost is quite high.

Q. Are you considering putting in a reactor in one of these northern areas?—A. I mentioned that this was one type of program to which we were giving serious consideration.

As a first step you have to decide what size of reactor is likely to have the most widespread use. The size of the reactor has quite a bearing on the design. If you get into small sizes, as I pointed out this morning, you must use enriched fuels. We are in the midst of doing an economic survey to determine what are the requirements. When we have completed the survey we will be in a better position to say what type of reactor we should develop for use in the north.

Q. Do you think it will be possible since we are relying so much on the plentitude of Hydro power that we may fall behind some of the other nations in the development of power reactors?—A. If you look at the Canadian picture as a whole, it is possible that you could become complacent about the power situation; but when you examine the country region by region you find, even at the present time, certain areas where, because of the exhaustion of Hydro resources and the lack of indigenous thermal fuels, there is a rather urgent need for a new source of energy.

Southern Ontario is one of the areas where such a condition exists. This explains why Ontario Hydro has taken such an active part in our program.

Q. How far ahead do your power need projects go?—A. Our power need projections?

Q. In other words, would you envisage the needs in 1981?—A. I gave the committee, in my first submission, a table showing a projection of power requirements for the period up to 1981.

In this table I broke down the sources of power into three categories, Hydro, conventional thermal and nuclear. The table which I gave you was one which was used in a paper presented at the Geneva conference by Dr. Lewis and Dr. Davis. After I appeared before you on June 5, Dr. Davis, who is our economic consultant, gave me a revised projection. I have had a copy made of this and I think you may be interested in having it.

The CHAIRMAN: The original table appears at page 241 of the evidence.

By Mr. Stuart (Charlotte):

Q. Is it true, at the present time, that they are building ten or twelve atomic power plants.

The CHAIRMAN: Is it agreed that we will place this table on the record?

Agreed.

ESTIMATED INSTALLED CAPACITY OF ELECTRICITY IN CANADA
(figures in millions of kilowatts)

DATE—December	Total Installed Capacity	From Hydro	From Other Sources	From Nuclear* Sources
1955	15·7	13·8	1·9	0·0
1960	21	18·6	2·4	0·02
1965	28	24·5	3·5	0·2
1970	38	30·6	7·4	0·6—2·0
1975	50	37	13	2·0—4·0
1980	67·5	46·4	21·5	4·0—7·0

* Included in "Other" Sources.

The WITNESS: Before I answer your question, I would like to say one or two words about why this revision has been made. You will note, that, in the first table the power requirements are shown for the period beginning 1956 and ending 1981. In the second table the power requirements are shown for the period beginning 1955 and ending 1980. Apart from this one difference, the tables are comparable. The significant thing about the second table is that when you look beyond 1965 you will note that there is a substantial increase in the projected total installed capacity.

In the first table the requirement for 1971 is shown as 34 million kilowatts and in the second table it is shown as 38 million kilowatts for 1970. In 1975, in the second table, the projected installed capacity is shown as 50 million kilowatts whereas in 1976, in the first table, it is shown as 41 million kilowatts. In 1980, in the second table, the projected installed capacity is shown as 67½ million kilowatts as compared to 48 million in 1981 in the first table. In other words, there has been, as a result of this further survey which Dr. Davis has carried out, a substantial increase in the estimated future power requirements. In the first estimate it was assumed that the annual increase—the national annual increase—would be at the rate of approximately 5 per cent per annum over the 25-year period. On the basis of the most recent information which Dr. Davis has obtained, he has increased this annual growth rate of 5 per cent to 6 per cent. This accounts for the differences in the two estimates. These percentages are compounded, so as time goes on the disparity as between the two increases.

I would like to make one comment about the second table. You will note that in the first table, under the column "nuclear power" there is shown a range of nuclear installations from 200,000 kilowatts to 1 million kilowatts for the year 1966. In the second table for the year 1965, nuclear installation is shown as 200,000 kilowatts.

When you come to 1971, in the first table, the range is shown as 600,000 kilowatts to 1·7 million kilowatts. In the second table for the year 1970 the range is shown as 600,000 kilowatts to 2 million kilowatts. In 1976, in the first table, the range is shown as 2 million kilowatts to 3·3 million kilowatts, and in the second table for 1975 the range is shown as 2 million kilowatts to 4 million kilowatts.

In the figures shown in the tables for 1980 and 1981 period, there is no difference. I questioned Dr. Davis on this and he stated that in preparing both tables he had assumed that in 1966, in the first table, and in 1965 in the second table it would be possible to get nuclear power for not more than 6 mills per kilowatt hour. In the succeeding years he had not made any allowances for the possibility that you might be able to get a better cost than 6 mills. In other words, the estimates of nuclear installations are based throughout on a 6-mill cost. I would like to express my personal view that this is a rather conservative approach because I would certainly expect that if you can get 6-mill power by 1965, you are certainly going to get power at a lower cost than 6 mills by 1980-81.

If my prediction proves to be correct, the percentage of the total power generated which will come from nuclear sources will be higher than the figures shown in these tables.

By Mr. Murphy (Lambton West):

Q. When you are on that same question, will you tell the committee how much the costs of production have dropped over the past three or four years? Then I have another question.—A. What is the question?

Q. The first question is: has the cost of your production which you have to sell dropped?

The CHAIRMAN: Are you referring to isotopes?

Mr. MURPHY (*Lambton West*): Whatever is sold from the plant.

The CHAIRMAN: Mr. Stuart had a question, first of all, on the power plant subject.

By Mr. Stuart (Charlotte):

Q. I have read about the ten or twelve atomic power plants being built in Britain. Do you know if they are on the same design or if they are experimenting to see if they can get a better cost with a better design?—A. The design of these plants is based on what is known as the Pippa design. This is a design which uses graphite as a moderator and gas as a coolant.

The first nuclear power station which the British will bring into operation is known as the Calder Hall station and is a graphite moderated air cooled reactor. This station will be in operation this October. The United Kingdom atomic energy authority has taken the design of this station and has asked four companies, with associates, to try to improve the design without changing its basic characteristics. This request was made about a year and a half ago. The design of the first group of stations to be built for commercial operation will be based on the work which these companies do. All of these stations will use graphite as a moderator, and gas as a coolant. This first group of stations is expected to come into operation about the middle of 1961.

Q. I have one other question; I am curious; once these reactors are completed, once the twelve are completed, is there any hope of cutting down the cost of these twelve in the years to come?—A. In the particular reactors?

Q. In these particular reactors?—A. I would think that you would expect some improvement in operating costs. But I would doubt that you would be able to do anything about the capital cost without tearing down the reactor and changing its design. But you could anticipate improvements in operating costs through experience in operation. You might also get a higher rate of burn-up in the fuel as experience in fuel element performance is gained. This of course would affect your operating costs.

Q. It seems strange to a layman that while this atomic energy for power purposes is in its infancy, why they had contracted for ten or twelve stations at the same time instead of experimenting?—A. This brings me back to the point I made a moment ago that when you speak of nuclear power as being competitive, you have to consider nuclear power within a given economic context. My information is that power costs in the United Kingdom today are averaging 9 mills at the bus-bar; this cost is not likely to go down because coal costs are increasing. The United Kingdom is now importing substantial quantities of coal and this is on the increase. There is also the problem of a reliable source of oil. At the present time the main source of oil is Iraq and there is some question as to how reliable a source that is. Consequently the United Kingdom is in the position where some alternative source of energy must be found immediately. The atomic energy authority is confident that with the type of reactor now planned power costs will not be higher than or not appreciably higher than present power costs. Or to put it another way, the costs will not be higher than the sort of power costs that can be projected if the U. K. continues using conventional primary sources.

By Mr. Dickey:

Q. What is the competition in that situation? It must be competition and they do not know?—A. That is right; and that is the justification—and I think it is a sound one—for the decision of the United Kingdom atomic energy authority to put most of its eggs into one basket.

Q. When you speak of using gas or air as a coolant, do you mean that it is by means of air or gas that you take the heat out of the reactor and put it to use in creating something?—A. That is right.

Q. That is the medium for a heat exchanger?—A. Whereas in the NPD reactor we are going to use heavy water, in the PWR in the United States light water will be used.

Q. What about the comparative cost of natural uranium and enriched fuel?—A. I shall ask Mr. Watson to calculate the cost of a ton of U235, using as a basis the price announced by the United States Atomic Energy Commission namely 25 dollars a gram.

Mr. WATSON: It is $25 million a ton.

By Mr. Murphy (Lambton West):

Q. Is that for pure uranium?—A. That is for U-235; this is a product of a diffusion plant. The figure which Mr. Watson has given, will give you some appreciation of the wide difference in cost between natural and enriched uranium. An advantage of enriched fuel as compared to natural uranium is that you are able to reduce the size of your reactor vessel; but whether the advantage of lower capital cost will offset the disadvantage of higher fuel cost has yet to be determined.

Q. Do you contemplate making enriched fuel here?—A. We do not at the present time.

By Mr. Byrne:

Q. What are the properties of graphite which make it a good coolant?—A. It is a moderator not a coolant.

Mr. WATSON: It slows up the neutrons; the neutrons which are released in fission are very fast. One might liken them to bullets. If you shoot a bullet through a pane of glass you will make a small hole; but if you throw a ball at the glass it will shatter it. So in the reactor we slow the neutrons in order that they may break up other atoms. Graphite is one of the good things for slowing them down.

Mr. BYRNE: It is a fluid?

Mr. WATSON: They are slowed down by the neutrons banging against the graphite. That is the meaning of the word "moderator". We use heavy water which is the best moderator, but the most expensive.

By Mr. Byrne:

Q. In the process of heating up water to supply steam?—A. This has nothing to do with the moderator. The coolant is quite distinct from the moderator. The purpose of the moderator is to moderate the speed of the neutrons which are released when fission occurs, while the purpose of the coolant is to carry away the heat which is produced when fission occurs. They are quite separate and distinct.

Q. The British system uses graphite?—A. As a moderator, and gas as a coolant.

Q. What are we going to use as a coolant?—A. Heavy water, both as a moderator and as a coolant.

By Mr. Stewart (Charlotte):

Q. What would be the wasteage of heavy water as a moderator, or is there any?—A. If all of the mechanical components of a reactor operate as they should there should not be any leakage, as it happens in all of the heavy water reactors that are in operation today there are minor amounts of leakage from time to time due to faulty mechanical components.

By Mr. Murphy (Lambton West):

Q. Are we getting our heavy water from the other side?—A. That is right.

Q. Do we have scientists over in Britain to observe what is taking place with respect to their power plant?—A. First by way of general answer to the question, I might point out that we have an annual meeting with a technical team from the United Kingdom Atomic Energy authority; one year the meeting is held in Canada and the next year it is held in the United Kingdom. Last year it was held in Canada, while this year it will be held in the United Kingdom; and at these meetings there is a very free and open exchange of information and ideas.

Q. What countries would be represented?—A. Just the two countries. In addition to these meetings we have a very active exchange of information going on all the time. We also have Canadian individuals and teams going to the United Kingdom and we have United Kingdom individuals and teams coming to Canada. For example, at the present time Dr. Laurence who is head of our reactor research and development division is in the United Kingdom.

Q. After you rebuild the reactor at Chalk River will you be able to make more isotopes such as have been produced before, or do you contemplate with this new one to step up production of any new isotopes?—A. When we rebuilt the NRX, we got the power rating up from 30 megawatts to 40 megawatts. This enabled us to produce more isotopes in the NRX.

In the NRU we will have a power rating of 200 megawatts. It will produce more isotopes than the NRX.

Q. Take the case of the cobalt bomb by way of illustration. How would this production improve bomb production as compared with the old one?—A. That of course depends on how much natural cobalt you irradiate in the reactor. You can determine the rate of production simply by the amount of cobalt, that is the number of cobalt sources, which you put into the reactor to be irradiated. The rate at which we will produce cobalt 60—for use in therapy units depends on the markets we have for the sale of those therapy units. I do not know that I can give you in terms of curies what the maximum production capacity of the NRU would be.

Q. Have you a demand for more than you can produce now?—A. At the present time I think that our demand is still running ahead of our supply.

Q. Are you the only one who is making a cobalt bomb?—A. No, cobalt 60 is being produced in the United States. Cobalt 60 is the source material for the therapy units which are used to apply radiation. The therapy units, as distinct from cobalt 60, the source material, are also being made in the United States and I believe in some other countries. We still have some advantage in this particular line. As you know we got into it first.

Q. Has it been a good source of revenue?—A. I think the fact that we have installed so many of these therapy units in other countries is good evidence that we have been able to hold our position.

By Mr. Harrison:

Q. In the NRU reactor will you be able to produce cobalt to the desired strength? Will it be obtained faster in that unit than in the old ones?—A. It would be, yes, because of the higher flux of the reactor.

Q. Was there any consideration given in the Beaverlodge area for your requirements for power, was there any consideration given to hydroelectric installations between Black Lake and Stoney Rapids?—A. From time to time we have had engineering surveys made of the hydro resources in the area. At the present time, we are getting close to 3,000 horse power from a small hydro plant that was established in the district by the Consolidated Mining and Smelting Company some years ago. This does not supply all of our present requirements. It supplies about half of them.

As you will observe from the annual report, we are now in the process of expanding production at Beaverlodge, and the additional power that we require we are going to get from a diesel plant. We found first that there was not sufficient water to enable us to do anything about increasing the capacity of the present hydro plant. We took a look at a site on the Fond du Lac river which is the stream that drains Black lake into Lake Athabasca. But, the capital cost including the cost of the transmission line, something like 115 miles in length, was such that we decided to go to diesel.

Q. The economics were against it?—A. The economics were not against it if you could amortize your capital on the normal basis. Hydro plants are generally amortized over 40 years. But, it was impossible to decide whether a 40-year amortization was acceptable in this particular case.

Q. Along that same line; these workers in that area naturally talk to me from time to time. One of the questions they ask me, along that same line, with respect to risk elements in the mines, is whether they should not have a concession on their income tax for people working in the northern areas to offset the high cost of living for one thing, but mainly to encourage home building by mine workers in the risk mining areas, by allowing accelerated depreciation, or other concessions for income tax. That runs along the same line of thinking as the power development at Fond du Lac. Have they made any representations with respect to that at all?—A. No, not so far as I am aware.

Q. I have not talked to Walter Harris about that, but it might be a point.

Mr. STICK: What committee are you on now?

By Mr. Murphy (Lambton West):

Q. You do not give scholarships, do you?—A. No, not as far as I know.

Q. Mr. Stewart opened up, I thought a very interesting question. Would there be professors as well as students going to Chalk River for courses during the summer months?—A. Yes. We have from the universities from 40 to 60 people every summer. Some of these are professors, some are post graduate students. The proportions vary from year to year. Then, during the year we also have university professors at Chalk River attending conferences on subjects in which they have a particular interest.

Q. You mentioned the other day about the swimming pool types. Is it just McMaster University that is interested in that?—A. So far.

Q. What about McGill or Toronto?—A. McGill, is in a somewhat different field. McGill has a cyclotron, and its research program is built around the cyclotron.

Q. When these students, or professors go to your plant, I was wondering how you make their services available to you. It is like a course, is that the idea?—A. Strictly speaking it is not a course in the sense that you have lectures on given days and so on. These men do work with our scientists.

Q. Would they be mostly physicists?—A. Not all of them.

Mr. WATSON: Physicists, chemists, biologists and engineers.

Mr. MURPHY (*Lambton West*): I was wondering, Mr. Chairman, if maybe that point could be elaborated on. I think that is a very important subject; in respect to getting more from the universities including professors, because I think we all agree that the more scientific minded even youngsters are, the greater is the likelihood that we will have an increase in the number of engineers who are going to graduate, and the number of physicists. I was wondering if consideration could be given to enlarging on such a course as that. I would think it would be very valuable.—A. There are limits to the number of people that you can accommodate, that is house and feed. There are also limits to the number of people that you can absorb in an organization. This twofold limitation would be the only thing that would stand in the way of expanding our present programme of co-operation with the universities. I am entirely in agreement with your suggestions that we should do this sort of thing.

The CHAIRMAN: Mr. Murphy, just before we leave that subject, we could perhaps get more specific information about it during our Chalk River visit.

Mr. MURPHY (*Lambton West*): All right. I was wondering, Mr. Bennett, if you have some bright, intelligent technicians we will say that have a good education who leave your plant to take university courses because of their interest in that particular work?—A. This would apply to the very young ones, but not to the older ones. When I say "older", none of them are very old. I think the average age at Chalk River of the professional staff is 33, and it has been 43 for some years.

By Mr. Stewart (Winnipeg North):

Q. What is your definition of a young one?—A. The younger ones, I suppose, would be 23.

The CHAIRMAN: One of the things that I think is most impressive about Chalk River is the youth of all the highly skilled scientific staff, and indeed the engineering staff.

By Mr. Bourget:

Q. Have you got facilities for students to work out there?—A. Yes, we have. As I said earlier, we have from 40 to 60 from the universities every year, and a considerable part of that number are post graduate students.

By Mr. Murphy (Lambton West):

Q. Mr. Bennett, do people like Dr. Spinks in Saskatchewan, and other highly qualified scientists give ideas to you about certain isotopes that they would like?—A. Dr. Spinks, visits Chalk River—I will not say frequently, but certainly once a year. He is also in correspondence with our people. We follow the practice of supplying the universities and professors like Dr. Spinks, with the isotopes which they require for their research programs. We do have the sort of arrangement I think you have in mind. When a man like Dr. Spinks decides that he wants to do research work in a particular field, and when he decides as well that a particular isotope may be useful he discusses with us whether or not that isotope can be made available.

Q. I suppose that you have some information that could be acceptable and should be used by a lot of people in Canada, and I was wondering if you could tell the committee how you get that across to them?—A. Have you anything particular in mind?

Q. No, but I have always thought that we have a lot of information available to the public that is not being used. For instance, a good deal of Dr. Spinks' information is not being used by the public. I know this would not be in your category.—A. The most effective means we have of getting information to the people who are interested is through the list of publications which we put out at regular intervals. Incidentally, we are proposing this year to table, with the annual report of Atomic Energy of Canada Limited, a list of our publications.

This list is, in a sense, a catelogue. It contains a description of the papers and scientific reports which are available at Chalk River. In these papers, and in these reports, you have a description, in some cases, of the results of a particular research program, or of a particular experimental program. This, we have found is the best way to keep people informed as to what we are doing.

What would happen normally if a man like Dr. Spinks, in going through this list of publications, found a subject listed in which he had a particular interest, is that he would write for the paper. He might also arrange to meet with the man, or the team which had done the particular work described in the paper, and as a result of such a meeting he might launch out on some particular line of research.

Mr. RICHARDSON: In addition, Mr. Chairman, Mr. Bennett might remind the committee that if we read appendix 13 we will see a great variety of visits that have been made, and the mailing list under which many publications have been sent. That is on page 301.

By Mr. Murphy (Lambton West):

Q. I had in mind, Mr. Richardson Dr. Spinks. He has done so much work in the agricultural field. For instance, in the different types of wheat, in the fertilizer required, and that sort of thing. Is he on your staff?—A. No.

Q. He works by himself?—A. He is on the staff of the University of Saskatchewan.

Q. Then my question would be irrelevant in respect to what I expect.

By Mr. Harrison:

Q. Mr. Bennett, in talking to those miners at Beaverlodge, they were interested in the proposed use of aluminum dust in mines in combatting silico poisoning in the mines, and they wondered if there had been any research in respect to its use, in respect to its benefits, or otherwise in using it for that purpose.—A. My impression is that we do not have an acute dust problem in the Beaverlodge mine.

Q. I do not think they were so much interested in that particular thing, but they were interested in knowing whether there was some research department that is— —A. That type of research is generally carried out under the direction of the provincial mines departments or the provincial departments of health, or the federal Department of Health or all three. The Provincial Departments of Mines, as you know, establish the regulations with respect to mine safety. The Provincial Departments of Mines also inspect mines at regular intervals to see that the safety regulations are being observed.

Q. They are also interested in whether you are doing research, as you likely are, in respect to the effects of handling these hot metals.—A. No hot metal is being handled in the mines.

Q. Not up there in the mines, but I am talking about the handling of hot metals in other parts of your operations.—A. One of the responsibilities of the biology division at Chalk river has to do with "radiation hazards". When the committee visits Chalk river we propose to present a paper on the work of the biology division. In that paper Dr. Mawson will touch on this question of radiation hazards.

The CHAIRMAN: Any other questions?

By Mr. Richardson:

Q. Mr. Chairman, a very trivial question, and I thought our accounting expert, Mr. Stewart, would raise it when we were looking at the report, is in respect to the $300,000 in debentures, hospital and sewer—where do they appear on the balance sheet?—A. They do not appear in this balance sheet, because this is for the year ending December 31, 1955. They will appear in next years balance sheet.

By Mr. Green:

Q. Mr. Bennett, you are the president of the Northern Transportation Company Limited, are you not?—A. That is right.

Q. We hear quite a few complaints about the freight rates you are charging in that company. I see in your annual report for 1955, last year, you made a net profit, after income tax, $466,450, as compared with the profit of the year before of $156,798.

The CHAIRMAN: Can you tell us what page you are reading from?

Mr. STEWART (*Winnipeg North*): Northern Transportation annual report, page nine.

By Mr. Green:

Q. Then, according to your statement of income and expenses for the year ending December 31, 1955 we find that your income was $3,456,408, and your expenses were $2,510,013, leaving an operating profit of $955,395, out of which you paid income tax of $488,945, leaving a net profit the same, within a few dollars, of the figure quoted on page 5.

Now, the report also says that there is to be a reduction in freight rates this year, 1956. Is there some way in which you could make a further reduction in the rates?—A. The approach to the question of freight rates depends first of all on what the operating terms of reference are for the company. The present terms of reference are that we should operate this company, as a commercial common carrier, and that it should earn a rate of profit which is reasonable for commercial common carriers. Now, you mentioned two or three points. Perhaps I might deal with them.

First of all about the profits of the company, I should point out that over the period from 1944, the year in which the Northern Transportation Company became a crown company, until the end of 1955, the company has earned a total profit of $3,800,000. In that same period the company has had to invest in new equipment, handling facilities, etc., $6,695,000. These are round figures. The requirements for capital purposes, which arise almost every year, are generally not taken into account when people attack the company's rates, and use the argument that the company is making too much profit. This company has never paid a dividend. If it were a private company I am sure that the shareholders would have insisted on the payment of dividends long since. In other words, all of the company's profit, plus a sizeable part of its depreciation reserve, and its marine insurance reserve has been required for expanding the company's fleet and share services. In other words, we have not had any earnings, or any surplus from which we could pay a dividend.

Q. You have indicated that you will have to pay income tax for 1955 of almost $500,000. Now, this company is a development company, and it has a very important part in opening up the north country. Now, why should it be paying out big sums of income tax rather than giving lower freight rates to people up there?—A. All crown companies are required to pay income tax.

The CHAIRMAN: Is the question whether crown companies should pay income tax not a matter of policy which has been argued in the house many times? My sole purpose in raising it here is not to deal with the merits of it one way or the other, but to question the propriety of having an official give evidence on a matter of policy. That is the only point.

By Mr. Green:

Q. What is the total amount that has been paid in income tax?—A. The total amount since we began to pay income tax?—A. Yes.

Could I go on while we are getting you that figure? There is another aspect to this question which I think has to be taken into account. While the Northern Transportation Co. is carrying the bulk of the freight that is moved north from railhead at Waterways the company has two competitors: The Yellowknife Transportation Company, which operates north of Fort Smith; and the McGinnis company, which operates both out of Waterways, and north of Fort Smith. You may recall that when we announced last year a reduction in freight rates we were attacked on the ground that the purpose of our reduction was to put our competitors out of business.

By Mr. Stick:

Q. I was going to raise that same question.—A. If it were decided, as a matter of policy, that this company—and I will have something to say in a moment about my thoughts on such a policy—if it were decided, as a matter of policy, that this company should not operate at a profit, and if its rate structure were revised to reflect that policy, this would have a most serious effect on the other two operators. We are all operating under the Board of Transport Commissioners, and all tariffs must be approved by the Board of Transport Commissioners. We did, as is pointed out in the report, at the beginning of the season of 1955 put into effect a rate reduction.

We have announced in this year's report a second rate reduction and I believe we have mentioned also that on the basis of the present estimates we have as to the amount of freight that will be moved, this year's reduction will result in a gross saving to the shipper of approximately $425,000. These reductions indicate that as volume of business increases we are passing on to the shipper some of the benefits that result from lower handling and operating costs due to larger volume. If I may revert to the question of operating policy, if you establish a policy of operating on a no profit basis apart altogether from the effect on our competitors of such a policy you must anticipate that the company will have to come to the government frequently for funds. On the basis of our experience in the last seven or eight years we would have had to come to the government each year for the funds, necessary to carry out the expansion programme.

Mr. BYRNE: On a point of order I am wondering what connection transportation actually has with the peaceful use of atomic energy? So does the C.P.R. carry freight to Chalk river.

Mr. GREEN: They are both in our terms of reference.

The CHAIRMAN: I would prefer at this stage not to have to rule on the point of order. There is a nice point of order but in any case we have dealt with Eldorado pretty fully.

Mr. BYRNE: Of course, Eldorado, Mr. Chairman, is a mine mining uranium. Canadian Pacific and Canadian National carry freight to Chalk river too.

The CHAIRMAN: Our reference is related to the role of government in the field of non-military research but we have gone on examining the Eldorado and I would prefer to avoid having to rule on the point of order.

Mr. MURPHY (*Lambton West*): Didn't we go into this before? Nobody wants to make any capital out of it.

The CHAIRMAN: We had a different term of reference in the former committee but in any event I am not making a ruling on it.

Mr. BYRNE: Who wants to sit here and talk about transportation?

The CHAIRMAN: I am a little concerned about the other point that is asking a witness to express an opinion on matters of government policy which are involved in whether the Northern Transportation should lower its rates and thereby wipe out its opposition or whether it should continue to pay income tax and be on a competitive position with them.

By Mr. Green:

Q. Apparently last year the Northern Transportation did some work in connection with the Distant Early Warning. Is that continuing this year?—A. That is right. Last year we were asked to supply all the stations in the western section, 24 in number. When we had a look at the problems involved in doing this and bearing in mind that there was very little information available as to water conditions at the sites etcetera we decided we could only take on the supply of the six stations which were in closest proximity to the mouth of the Mackenzie river. We carried out this operation with a tug and barges. Because of the proximity of these six stations to the Mackenzie we were able to do this with a barge operation. This year we are supplying an additional two stations making eight in all.

Q. Do you have any competition into Port Radium?—A. No.

Q. That is exclusive?—A. That is exclusive, yes.

Q. What about Yellowknife?—A. Yes, we have competition into Yellowknife.

Q. What about into Beaverlodge?—A. There is an operator the McGinnis Co., which has a licence to operate, from Waterways but this operator has not carried any commercial freight to Beaverlodge.

By Mr. Murphy (Lambton West):

Q. Mr. Bennett, I want to be fair about this thing and not get it out of hand. You have competition on most of the route?—A. We have no competitor who is operating over the entire route. If you will look at the back page of the Annual report you will see that there is a map of the routes.

Q. How many miles?—A. From Waterways which is the railhead, to the mouth of the Mackenzie is 1,700 miles. If you take in the off main line routes we are operating over a total distance of approximately 2,400 miles.

Q. Then, do you charge the same rate as your competitors for distances that may—no, that is not quite right. You have no competitor going the same distance?—A. That is correct.

Q. Well, assuming one goes half way and the other fellow goes half way,, would your rate be the same as the two of them combined?—A. The rate structure is similar to a rail rate structure in the sense that you have published tariffs between given points and these are the same in the tariffs of all the companies.

Q. I wonder, Mr. Chairman, if I could ask one question here. If you turn to page 8, the capital assets and costs including lands, buildings and equipment, boats and barges, including equipment, automotive equipment the total is $7,481,000-odd and less provision for depreciation, $5,610,000. I mean this is a very conservative amount, I would say.—A. We have been depreciating, at the rate that is permitted by the income tax department.

By Mr. Green:

Q. Your depreciation last year was $683,834 as against operating expenses of $1,665,156 and administrative expenses of $152,022. Is that not very heavy? —A. We are using the depreciation rates that we are permitted to use under the income tax regulations. This works both ways of course

When you have obtained full depreciation you certainly expect to pass on to the shipper the benefits that result from having written off your plant. The only difficulty with this operation is that we never seem to be able to get finished with expansion. The figure shown here of $7,481,000 does not include the cost of our expansion program this year which is set out on page 6 in the third last paragraph of the Annual Report. We have had to spend this year for additional floating equipment $2,750,000 and $388,400 for the improvement and expansion of shore services. This has been the story of this operation.

Q. You will be buying more equipment all along?—A. This depends, Mr. Green, on whether or not there continues to be an expansion of business. It depends on whether the volume of freight continues to increase. You might be interested in the tonnage figures. These indicate what has happened over the period of past 12 years. I will read the figures and perhaps they could be put in the evidence.

1944	28,000 tons
1945	12,000 "
1946	24,000 "
1947	35,000 "
1948	49,000 "
1949	38,000 "
1950	42,000 "
1951	53,000 "
1952	69,000 "
1953	79,000 "
1954	90,000 "
1955	122,000 "

The estimate for this year, 1956, is 180,000 tons.

Now, you will notice that was a very sizable increase in the period beginning in 1953. This can be attributed in large part to the uranium development at the east end of lake Athabaska. Of the 180,000 tons to be moved this year approximately 65 per cent will be moved to this area. There has not been any sizable increase in the volume of freight moving north of lake Athabaska. There has been no increase in the tonnage moved to Yellowknife in recent years and there has not been any great increase in the tonnage moved to other points north of lake Athabaska.

Q. Did you get those figures on income tax?—A. Since we began paying income tax and including the tax paid last year the total tax paid is $942,006.

By Mr. Murphy (Lambton West):

Q. What is that figure again?—A. $942,006.

Q. Is the capital stock that is issued, Mr. Bennett all held by the government?—A. All held by Eldorado.

Q. Just the same thing?—A. Yes.

Q. Whas it Mr. Sellar's statement that we have not agreed whether crown companies should be having more surplus than they do have? I see you have a surplus of over $3 million. I was wondering if you needed that much. I hope that is not embarrassing.—A. My recollection is that Mr. Sellar was referring to surplus cash.

Q. That is right, he was.—A. Which is, of course, something different than surplus as reported in a financial statement. Our cash as at the end of December 31, 1955 as shown in the balance sheet was $2,435,658.

Q. Do you need that much?—A. Yes, to finance our expansion programme.

Mr. STEWART (*Winnipeg North*): Over $3 million for new assets.

The CHAIRMAN: The third last paragraph of page 6.

The WITNESS: There is another point in connection with this operation which I should point out. Our cash requirement for operating purposes varies greatly—our heavy cash requirement for operating purposes—falls in the period from April 1 until the end of October—the season of navigation. That is the period in which we are operating and in which we have a payroll to meet and operating supplies to buy. Then, we have a period, when the operation shuts down, which extends from about November 1 until April 1. In this period our cash outlay for operating purposes is very small. It so happens that our fiscal year ends December 31 so we always show a sizable cash balance in the annual report.

By Mr. Murphy (Lambton West):

Q. Is it because of your capital expenditures that you have not paid the government anything except income tax?—A. I would say so. The normal practice is to pay dividends out of profits, not out of depreciation reserves or marine insurance reserves. We have had, as I mentioned a moment ago, a total profit over a 12 year period of $3,800,000 and we have had capital requirements of $6,695,000 in the same period so that we have not only used all of our profit but we have had to dip into our depreciation reserves and our marine insurance reserves to finance the expansion of the companies' facilities.

I referred to the marine insurance reserve. Perhaps I should clarify this. We carry our own insurance and we maintain an insurance reserve for this purpose. It is shown in the report.

Q. Do you do that in Eldorado too?—A. No, in Eldorado we insure with underwriters and we have a great variety of insurance—fire and so on.

By Mr. Stewart (Winnipeg North):

Q. Why do you not act as self insurers in Eldorado?—A. Because we have been able to get rates that are attractive from an actuarial standpoint.

Q. Would it not be possible to insure yourself and set it up as a fund and have the use of the money?—A. It would be possible but there are other reasons why we have used underwriters in the case of Eldorado. If you place insurance, fire for example, with underwriters you get the benefit of their expert advice on fire prevention. We have felt that this was desirable.

The CHAIRMAN: Any more questions? We will adjourn. The clerk of the committee will be in touch with you about the Chalk River trip on Friday and I hope also about the other trip if we can get it arranged before the session ends.

HOUSE OF COMMONS

THIRD SESSION——TWENTY-SECOND PARLIAMENT

1956

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McILRAITH, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

NO. 13

SECOND AND FINAL REPORT

Wednesday, July 25, 1956

Friday, August 10, 1956

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956.

76694—1

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: G. J. McIlraith, Esq.

and Messrs.

Bourget
Brooks
Byrne
Cameron *(Nanaimo)*
Dickey
Forgie
Green
Hahn
Hamilton *(Notre-Dame-de-Grace)*
Harrison
Hosking
Leduc *(Verdun)*
MacLean
McWilliam
Mitchell *(Sudbury)*
Power *(St. John's West)*
Richardson
Stewart *(Winnipeg North)*
Weaver—(20).

J. E. O'Connor,
Clerk of the Committee.

ORDERS OF REFERENCE

TUESDAY, July 10, 1956.

Ordered,—That the name of Mr. Hamilton (*Notre-Dame-de-Grace*) be substituted for that of Mr. Murphy (*Lambton West*);

That the name of Mr. Power (*St. John's West*), be substituted for that of Mr. Stick;

That the name of Mr. McWilliam be substituted for that of Mr. Stuart (Charlotte); and

That the name of Mr. Bennett be substituted for that of Mr. James, on the said Committee.

THURSDAY, July 12, 1956.

Ordered,—That the name of Mr. Hahn be substituted for that of Mr. Low on the said Committee.

TUESDAY, July 17, 1956.

Ordered,—That the name of Mr. Mitchell (*Sudbury*), be substituted for that of Mr. Bennett (*Grey North*) on the said Committee.

FRIDAY, July 27, 1956.

Ordered,—That the name of Mr. Cameron (*Nanaimo*) be substituted for that of Mr. Coldwell on the said Committee.

Attest.

LEON J. RAYMOND,
Clerk of the House.

76694—1½

MINUTES OF PROCEEDINGS

WEDNESDAY, July 25, 1956.

The Special Committee on Research met at 11.30 a.m. this day *in camera*. The Chairman, Mr. G. J. McIlraith, presided.

Members present: Messrs. Dickey, Forgie, Green, Hosking, Leduc (*Verdun*), Mitchell (*Sudbury*), McIlraith, McWilliam, Power, and Weaver.

The Chairman, in opening the meeting, expressed regret that due to a labour dispute in certain mines, it had been necessary to cancel temporarily the visit by Members of the Committee to Blind River.

He suggested that if Members were still interested in touring the Uranium mines, the visit would now be welcomed.

It was agreed that if a substantial number of the Members of the Committee were available during the week commencing July 30th, the visit would be scheduled for August 1st.

The question of the drafting of the Committee's final report to the House was discussed and it was decided that the problem should be referred to the Subcommittee on Agenda and Procedure.

At 12:00 A.M., the Committee adjourned to the call of the Chair.

FRIDAY, August 10, 1956.

The Special Committee on Research met at 4:30 P.M. this day *in camera* for the purpose of considering its "Second and Final Report" to the House. The Chairman, Mr. G. J. McIlraith, presided.

Members present: Messrs. Bourget, Cameron (*Nanaimo*), Dickey, Harrison, Mitchell (*Sudbury*), McIlraith, McWilliam, Richardson, and Weaver.—9.

A draft of the "Second and Final Report" to the House containing the Committee's observations and recommendations was read, and following discussion and amendment, was unanimously adopted and ordered to be presented to the House.

The Chairman thanked Members of the Committee for their active participation and assistance.

At 5:00 P.M., the Committee adjourned.

J. E. O'CONNOR,
Clerk of the Committee.

REPORT TO THE HOUSE

The Special Committee on Research begs leave to present the following as its

SECOND AND FINAL REPORT

Your Committee was appointed on Wednesday, April 18, 1956, under the following Order of Reference:

Resolved,—That a Special Committee be appointed to examine into the role of government in the field of non-military research in Canada, including:

(*a*) operations in the field of atomic energy,

(*b*) operations of the National Research Council.

That the Committee be empowered to sit during the sittings of the House and to print such papers and evidence from day to day as may be ordered by the Committee and to report from time to time; and that notwithstanding Standing Order 67 the Committee shall consist of twenty members.

Your Committee held thirteen meetings, the proceedings of which were recorded. In addition your Committee met *in camera* for organization purposes and for the purpose of preparing and adopting this Report. During the course of its work your Committee visited the Montreal Road Laboratories of the National Research Council and the Chalk River project of Atomic Energy of Canada Limited.

The Committee heard the following witnesses:

National Research Council: Dr. E. W. R. Steacie, O.B.E., Ph.D., D.Sc., F.R.C.S., F.R.S., President; Dr. E. R. Birchard, O.B.E., B.A.Sc., D. Sc., Vice-President (Administration); Mr. B. G. Ballard, O.B.E., B.Sc., F.I.R.E., Vice-President (Scientific); Dr. F. T. Rosser, Ph.D., Director, Building Research Division; Mr. J. H. Parkin, C.B.E., B.A.Sc., Ph.D., Director of Awards; Dr. N. B. Hutcheon, M.Sc., Ph.D., Assistant Director, Building Research Division; Mr. J. H. Parkin, C.B.E., B.A. Sc., M.E., Director, Mechanical Engineering Division; Dr. L. E. Howlett, M.B.E., Ph.D., F.R.S.C., Director, Applied Physics Division; assisted by Dr. W. H. Cook, O.B.E., M.Sc., Ph.D., F.R.S.C., Director, Applied Biology Division, and Mr. W. H. Ball, B.Sc., Associate Research Officer;

Atomic Energy of Canada Limited: Mr. W. J. Bennett, O.B.E., B.A., LL.D., President, assisted by Mr. D. Watson, Secretary, whose evidence is recorded; and Dr. W. B. Lewis, C.B.E., Ph.D., F.R.S., F.R.S.C., Vice-President, Research and Development; Dr. D. A. Keys, Ph.D., D.Sc., F.R.S.C., Scientific Adviser to the President; Mr. I. F. MacRae, Vice-President, Canadian General Electric Company; Dr. H. A. Smith, M.B.E., D.Sc., Director, Nuclear Power Project, Ontario Hydro-Electric Power Commission; Dr. L. G. Elliott, Ph.D., F.R.S.C., Research Director, Physics Division; Dr. W. M. Campbell, Ph.D., Director, Chemistry and Metallurgy Division; Dr. C. A. Mawson, Ph.D., Research Director, Biology Division; Dr. G. O. Baines, Ph.D., F. Inst. Phys., Assistant to the Vice-President, Research and Development, assisted by Mr. F. W. Gilbert, B.Sc., Manager, Operations; Dr. D. G. Hurst, Ph.D., F.R.S.C., Assistant Research Director, Reactors Research and Development Division; Mr. R. F. Wright, B.A.Sc., Manager, Engineering Services Division, who gave certain unrecorded evidence on the occasion of the Committee's visit to the Chalk River project.

Eldorado Mining and Refining Limited: Mr. W. J. Bennett, O.B.E., B.A., LL. D., President and Managing Director, assisted by Mr. R. C. Powell, Secretary, and Mr. J. C. Orr, Assistant Treasurer.

NATIONAL RESEARCH COUNCIL

The governing body of the National Research Council is the Honourary Advisory Council, consisting of seventeen Members, who are not Government employees, together with the President and two Vice-Presidents, who are public servants. This governing body has the responsibility for the operation of the National Research Council's functions, and the President is the executive officer carrying out the instructions of that Council.

Much of the scientific work in Canada is co-ordinated through some twenty-eight Associate Committees of the National Research Council. The following is a list of these Associate Committees:

Associate Committee on Applied Psychology.
Associate Committee on Research on Aquatic Biology.
Associate Committee on Corrosion Research and Prevention.
Associate Committee on Dental Research.
Associate Committee on Forest Fire Protection.
Associate Committee on Geodesy and Geophysics.
Associate Committee on High Polymer Research.
Associate Committee on the National Aviation Museum.
Associate Committee on the National Building Code.
Associate Committee on Navigation Facilities on the West Coast.
Associate Committee on Photographic Research.
Associate Committee on Grain Research.
Associate Committee on Plant Breeding.
Associate Committee on Plant Diseases.
Associate Committee on Animal Nutrition.
Associate Committee on Publication and Abstracting Services.
Associate Committee on Radio Science.
Associate Committee on St. Lawrence River Model Studies.
Associate Committee on Soil and Snow Mechanics.
Associate Committee on Survey Research.
Associate Committee on Wildlife Research.
Canadian Committee on Fats and Oils.
Canadian Committee on Food Preservation.
Joint Committee on Oceanography.
Joint Committee on the Institute of Parasitology.
Prairie Regional Committee.
Canadian Committee on Culture Collections of Micro-Organisms.
Associate Committee on National Fire Regulations.

Your Committee is of the opinion that the organization of the National Research Council, and in particular the method of constituting the Honourary Advisory Council and the Associate Committees, is a most effective and efficient way of carrying out the functions of the Council. It has proved practical and effective in co-ordinating the several fields of essential research. This is noteworthy in a country which presents such a variety of needs and problems over an unusually wide range of climate and geography and over an unusually wide range of both primary and secondary industry. The intimate exchange of ideas between the members of the Advisory Council, who are drawn from Canadian industrial and scholastic fields, in addition to its permanent corps of distinguished public servants, assures a flow of ideas between the responsible government scientific body and the industrial and scholastic life of the country. This results in the widest dissemination of scientific thought on the one hand and the development of the appropriate research as the need appears on the other. It provides flexibility and effective co-ordination with other scientific activity in the country. Your Committee commends and desires to encourage the continued efforts of the National Research Council.

Your Committee desires to draw attention to the need of maintaining a sufficient proportion of Research in pure science as compared with applied science. With the wide scientific horizons apparent today and the rapid development of Canada's industrial strength, your Committee desires to point out that industry ought now to be capable of taking a greater responsibility for industrial research in applied science, and that, therefore, the role of government in research in pure science should be emphasized.

Your Committee is of the opinion that the National Research Council is deserving of special commendation for the progress made in the field of construction research, with special reference to the field of construction in Northern Latitudes. Progress made in this field will continue to promote the effective development of our vast resources, which is essential to our future development.

Evidence before your Committee indicates that the Council's programme of grants in aid to Universities, and the awarding of bursaries, fellowships and scholarships to graduate students has done much to encourage the development of scientific research in Canada. Your Committee highly commends this phase of the Council's work and expresses the hope that it will continue to receive the close attention of the Honourary Advisory Council and be expanded as rapidly as the circumstances permit.

ATOMIC ENERGY

Your Committee examined into the role of Government in research in Canada in the field of Atomic Energy. In addition to hearing the evidence given before the Committee, and having the benefit of the papers prepared for the Committee, it had in the course of its visit to the Chalk River project an opportunity of visiting the laboratories of the Scientific Divisions there, of examining the NRX Reactor and seeing the type of experimental work being conducted through its use; the NRU Reactor, presently in an advanced stage of construction, the small Zeep Reactor, and of hearing evidence outlining the work on design and construction of the experimental power Reactor NPD being built through the co-operation of Atomic Energy of Canada Limited, Ontario Hydro-Electric Commission and the Canadian General Electric Company.

Your Committee is in accord with the policies being followed in the field of atomic energy research and commends the work being done by Atomic Energy of Canada Limited and by Eldorado Mining and Refining Limited.

Your Committee expresses the hope that Atomic Energy of Canada Limited will press forward its work in the development of atomic energy as a source of power and that it will provide such co-operation as the circumstances warrant, for the purpose of adding to the power resources of Canada.

Your Committee had planned to visit certain uranium mining operations and to visit the Port Hope Refinery of Eldorado Mining and Refining Limited but regrets that it was not able to complete this part of its intended programme. Your Committee, therefore, expresses the hope that it may be possible for groups of Members of Parliament to visit these projects during the course of the next Session of Parliament.

Your Committee expresses its appreciation of the assistance and co-operation given it by the witnesses, by the various officers who were responsible for the preparation of the documents filed with the Committee, and by the members of the staffs who assisted in the work of the Committee.

A copy of the printed minutes of the proceedings and evidence together with a list of the documents filed with the Committee is appended.

Respectfully submitted,

GEORGE J. McILRAITH,
Chairman.

LIST OF DOCUMENTS FILED WITH THE COMMITTEE BUT NOT PRINTED

1. Thirty-eighth Annual Report of the National Research Council of Canada, 1954-55.
2. National Research Council of Canada Organization and Activities.
3. The National Research Council Review 1955.
4. National Research Council of Canada, Division of Administration, Fellowships, Studentships and Bursaries Who's Who 1953.
5. Better Building Bulletin No. 1 Condensation in the Home.
6. Better Building Bulletin No. 2 Insulation of the Home.
7. Better Building Bulletin No. 3 Concrete.
8. Bien Batir No. 4 La Condensation dans la Maison.
9. Better Building Bulletin No. 5 Permafrost and Buildings.
10. Better Building Bulletin No. 6 Winter Construction.
11. National Building Code of Canada 1953—Fire Resistance Ratings.
12. National Building Code of Canada 1953.
13. National Research Council Division of Building Research—Publications.
14. An Economic Forecast of the role of Nuclear Power in Canada.
15. Some Economic Aspects of Nuclear Fuel Cycles.
16. Atomic Energy of Canada Limited—Organization Chart.