HOUSE OF COMMONS

Third Session—Twenty-fourth Parliament

1960

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: J. W. MURPHY, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 1

NATIONAL RESEARCH COUNCIL

FRIDAY, MAY 27, 1960

THURSDAY, JUNE 2, 1960

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

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1960

23264-5—1

SPECIAL COMMITTEE ON RESEARCH

Chairman: J. W. Murphy, Esq.

and Messrs.

Aiken	Forgie	Murphy
Batten	Fortin	Nielsen
Best	Godin	Payne
Bourget	McLellan	Peters
Brunsden	McIlraith	Smith (*Winnipeg North*)
Cadieu	McQuillan	Stewart
Dumas	Morissette	

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

The Special Committee on Research has the honour to present the following as its

FIRST REPORT

Your Committee recommends that its quorum be reduced from 11 to 8 Members and that Standing Order 67 (2) be suspended in relation thereto.

Respectfully submitted,

J. W. MURPHY,
Chairman.

23264-5—1½

ORDERS OF REFERENCE

MONDAY, May 16, 1960.

Resolved,—(1) That a Select Committee be appointed to consider the policy, operations and expenditures of the National Research Council, Atomic Energy of Canada Limited and Eldorado Mining and Refining Limited, and to report from time to time their observations and opinions thereon;

(2) That notwithstanding Standing Order 67, the Committee shall consist of twenty members, of which eleven shall be a quorum;

(3) That the Committee be empowered to sit during the sittings of the House, to print such papers and evidence from day to day as may be ordered by the Committee and to send for persons, papers and records.

WEDNESDAY, May 25, 1960.

Ordered,—That the Special Committee on Research, appointed on May 16, 1960, be composed of Messrs. Aiken, Batten, Best, Bourget, Brunsden, Cadieu, Dumas, Forgie, Fortin, Godin, MacLellan, McIlraith, McQuillan, Morissette, Murphy, Nielsen, Payne, Peters, Smith (Winnipeg North), and Stewart.

TUESDAY, May 31, 1960.

Ordered,—That the quorum of the Special Committee on Research be reduced from 11 to 8 Members, and that Standing Order 67(2) be suspended in relation thereto.

Attest.

LÉON-J. RAYMOND,
Clerk of the House.

ORDERS OF REFERENCE

MONDAY, May 16, 1960.

Resolved,—That a Special Committee be appointed to consider the [illegible]

(b) [illegible]

(c) [illegible]

WEDNESDAY, May 18, 1960.

Ordered,—That the Special Committee on Hansard, appointed on May 16, 1960, be composed of Messrs. [illegible]

TUESDAY, May 24, 1960.

Ordered,—That the quorum of the Special Committee on Hansard be reduced to 8 Members, and that Standing Order 67(1) be suspended in relation thereto.

Attest.

LÉON-J. RAYMOND,
Clerk of the House.

MINUTES OF PROCEEDINGS

FRIDAY, May 27, 1960.
(1)

The Special Committee on Research met at 9.50 a.m. this day for the purpose of organization.

Members present: Messrs. Aiken, Batten, Best, Bourget, Dumas, Forgie, McIlraith, McQuillan, Murphy, Payne, Peters and Smith (*Winnipeg North*) —12.

On motion of Mr. Payne, seconded by Mr. Smith (*Winnipeg North*), Mr. J. W. Murphy was elected Chairman.

On motion of Mr. Aiken, seconded by Mr. McQuillan, Mr. C. A. Best was elected Vice-Chairman.

Agreed,— That, together with the Chairman, Messrs. Aiken, Best, Dumas, McIlraith, Payne, Peters comprise the Subcommittee on Agenda and Procedure.

On motion of Mr. Bourget, seconded by Mr. Dumas,

Resolved, That a recommendation be made to the House to reduce the quorum from 11 Members to 8 Members.

On motion of Mr. Forgie, seconded by Mr. Smith (*Winnipeg North*),

Resolved,—That, pursuant to its Order of Reference of Monday, May 16, 1960, the Committee print, from day to day, 750 copies in English and 250 copies in French of its Minutes of Proceedings and Evidence.

The Chairman announced that because of certain circumstances, the committee would proceed first with a review of the operations of the National Research Council, and forecast a possible visit to N.R.C. Laboratories located on the Montreal Road and to facilities of the Atomic Energy of Canada Limited at Chalk River.

At 10.00 a.m., the Committee adjourned to meet again at 11.00 a.m., Thursday, June 2, 1960.

THURSDAY, June 2, 1960.
(2)

The special Committee on Research met at 11.05 a.m. this day. Mr. J. W. Murphy, presided.

Members present: Messrs. Aiken, Best, Brunsden, Dumas, Forgie, Godin, McIlraith, McQuillan, Murphy, Nielsen, Payne, Smith (*Winnipeg North*) and Stewart—13.

In attendance: From the National Research Council of Canada: E. W. R. Steacie, President; Dr. F. T. Rosser, Vice-President (Administration); Mr. F. L. W. McKim, Administrative Services; and Dr. J. B. Marshall, Awards and Grants.

The Chairman observed the presence of quorum and introduced Doctor Steacie, who in turn introduced Doctors Rosser and Marshall and Mr. McKim.

The following publications were tabled and copies distributed to Members of the Committee:

1. National Research Council of Canada—Organization and Activities—1960.

2. Annual Report—National Research Council of Canada—1958-59.

3. Review of the National Research Council 1959.

4. Report on University Support for Science, Engineering and Medicine—1958-59.

Dr. Steacie elaborated on information contained in the booklet entitled "Organization and Activities" which was ordered reproduced in this day's record (*See Appendix A*) and answered questions concerning the organization and function of the National Research Council.

Membership lists of Associate Committees were tabled for inclusion in the Committee's files.

At 12.35 p.m. the Committee adjourned to the call of the Chair.

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

EVIDENCE

THURSDAY, JUNE 2, 1960.
9.30 a.m.

The CHAIRMAN: Gentlemen, we have a quorum. We are a little late starting this morning.

I would first like to say I appreciate the honour of being asked to be the chairman of this committee, which I think concerns everyone. We have all been interested in research over many years, and I hope, Mr. Forgie, we will have the opportunity of being your guests before this committee finalizes its work.

Mr. FORGIE: It is too expensive.

The CHAIRMAN: We do not expect to get too much done this session. As you know, we are late getting set-up, and we want to make a very thorough job of what we are going to do. I am going to allow a good deal of latitude to all members. I do not mean political latitude, because this committee formerly, under the chairmanship of our good friend here from Ottawa West, Mr. McIlraith, never experienced a political development, shall I say, and that is the way I want it to be; and I hope and expect that is what you want it to be this time.

We have with us this morning Dr. Steacie, the president of the National Research Council, together with some of his officials, and I will ask Dr. Steacie to introduce them.

Dr. E. W. R. STEACIE (*President, National Research Council*): We have, beside me, Dr. Rosser, who is Vice-President (Administration) of the National Research Council; Mr. McKim, who is in charge of administrative services in the administration division; and Dr. Marshall, who is in charge of the extramural program of university support—grants, scholarships, and things of that sort.

The CHAIRMAN: Gentlemen, we have for distribution some publications for each of the members. Dr. Steacie, will you explain them to us?

Dr. STEACIE: We have enough copies for the members, the secretariat and the press, if they would wish them. There is first a booklet entitled "Organization and Activities." This has been prepared especially for this committee, as a summary of our operations.

We then have the last annual report to parliament; that is, for 1958-59. The report for 1959-1960 cannot be tabled until the financial statement has been cleared up.

There is then a Review of the National Research Council for 1959. This has a quite different use from the parliamentary report. It is intended for technical people and technical organizations, to give them a more detailed account of exactly what is going on. I think in it there are some things that may interest the members, particularly towards the end, where there is a staff list. The staff list gives an indication of the number of scientific staff in each field. You might find this of interest.

Then there is the latest report, which is for the year 1958-59, on the extramural program of university support, listing details as to how this program is arranged, the committee structure, the money spent on grants and scholarships, and the actual amounts of awards to various people.

The CHAIRMAN: I think, gentlemen, Dr. Steacie would like to have the concurrence of this committee to incorporate in the minutes the organization to and activities portfolio. Then he will comment on any part of it that you would like to have him make comments upon. Is it your wish?

Agreed. (*See Appendix A*).

The CHAIRMAN: It will save reading it, and you are quite at liberty to inquire into any particular aspect.

Mr. MCILRAITH: Before you do that, I take it the minutes will show the documents provided to the members, with their full terminology, their names and description.

The CHAIRMAN: That is right. Is that satisfactory to the committee, that this be incorporated in the minutes?

Agreed.

The CHAIRMAN: Dr. Steacie, would you go ahead, please?

Dr. STEACIE: This is, in a sense, a prepared statement from me, this booklet; but I thought we could save a great deal of time and trouble and get a more carefully prepared document in the record if this is incorporated. Then, if I could go through it and speak briefly on each section that is in it?

The CHAIRMAN: Yes.

Dr. STEACIE: First, page 2 gives the legal mandate. The first few pages give the legal set-up of the National Research Council.

The Research Council Act established a committee of the Queen's privy council on scientific and industrial research, and the National Research Council reports to this committee, or to the chairman of this committee. It is a corporation; it is not a government department. The present chairman is the Minister of Trade and Commerce. We report to Mr. Churchill, as the chairman of the privy council committee. We do not report to him as Minister of Trade and Commerce. There is no reason why at some future date, if it was desirable, the government could not change the minister to whom we report. Our reporting is not to the Minister of Trade and Commerce, as such, but to the chairman of the privy council committee.

On page 3 you have the members of the privy council committee. Basically, the membership of the committee consists of those ministers whose departments have an interest in science—in other words, Trade and Commerce, Agriculture, Fisheries, Mines and Technical Surveys, Defence, Health and Welfare and Northern Affairs and National Resources. Then the Minister of Finance obviously has an interest in science, since it spends money, and the Secretary of State for External Affairs was recently added to the committee because more and more international things are involving science and there now is, therefore, considerable interest in international scientific affairs on the part of the Department of External Affairs. This committee, then, is the body to which the National Research Council reports.

Page 4 summarizes the Research Council Act. In the annual report to parliament there is a full copy of the Research Council Act, with revisions to date.

Basically, the council is set-up as a corporate body, in charge of all matters affecting scientific and industrial research in Canada, as assigned to it by the privy council committee. I may say what this means, in effect, is that certain government departments have a specific function, and the research council does not interfere in this function. In other words, the Department of Agriculture cannot be responsible for agriculture without also being concerned with agricultural research. The same is true of Mines and Technical Surveys. It is true in the case of forestry and in the case of Health and Welfare and Defence.

Broadly, the functions of the research council are to advise the committee, in general, on scientific and technical matters, but specifically on certain things. This has come to mean pure science and science that affects secondary industry. Whereas the utilization of natural resources, although this is mentioned in the act, is, in fact, broadly the function of the Department of Agriculture, Mines and Technical Surveys, Fisheries, and so on.

The work of the council is directed by the honorary advisory council. This is a body set-up and reporting to the privy council committee. The honorary advisory council consists of four government employees, myself and three vice-presidents, and 17 appointed members who are not government employees and who serve without compensation. The list of members comes later.

The officers of the council—at page 5—are the president, the vice-presidents (scientific)—there are two, one is Dr. Ballard, who has general responsibilities but a particular interest in engineering, and Dr. Farquharson, who is responsible for medical affairs; and the vice-president (administration) who is in charge of administration affairs.

Under the council—this is the honorary advisory council—one thing that is rather unfortunate is that "National Research Council" has two meanings. One is the governing body and the other is the institution. I am going to use the alternative terminology in the act of "honorary advisory council" when I refer to the National Research Council as a committee, and I will use "National Research Council" when I refer to the organization. Otherwise the terminology is rather confusing.

Under the honorary advisory council—which is our board of directors, in a sense—there are seven main committees; and there are other ad hoc committees, as required. There is an executive committee set up by the act which can act for the council when required. That consists of a small number of members.

Then there is the scholarships committee, which is responsible for the awarding of scholarships to post graduate students. And I would emphasize that in scholarships we deal solely with research, and we have no function in undergraduate scholarships. In other words, our basic responsibility is research and not education; and scholarships are, therefore, for research students and not for undergraduates.

Third, there is a grants-in-aid committee. This is responsible for grants to individual professors in Canadian universities, to assist them in carrying on research. This is not for the purpose of paying them: it is for the purpose of providing them with facilities, enabling them to hire assistants, and so on.

The selection committee is responsible for advising the council regarding the appointment, promotion and retirement of staff. The council is outside the civil service, and the selection committee exercises the corresponding function. The legal set-up is that the staff is hired on the recommendation of myself. It is appointed by council, through its selection committee, and approved by the minister. But this complex, three-armed structure means that effectively all three have to say "Yes" before anybody can be hired. The council has concerned itself, very largely, with making sure the calibre of the staff is kept high. I think that over the years the main aim of the selection committee has been to reject people it felt were not good enough.

The review committee is responsible for periodically visiting the various laboratories and issuing reports.

The journals committee is responsible for publication policy for the six Canadian journals in scientific subjects which the council publishes.

The international relations and travel committee is responsible for in a sense foreign affairs as far as we are concerned, and dealing internationally with foreign bodies.

Pages six and seven list the members of the council. These consist of first, myself, Dr. Ballard, who is vice-president, scientific, and who is an electrical engineer; Dr. Farquharson, vice-president, scientific with his interest in medicine. At the present time, Dr. Farquharson is half-time head of the department of medicine at the university of Toronto, and half time National Research Council staff. After July 1 he will retire from his position in the department of medicine at the University of Toronto and be a full time member of our staff.

Then there is Dr. Rosser who is director of the division of administration, and vice-president of administration.

The four of us are government employees. The remainder serve without compensation.

There is Dr. McTaggart Cowan who is a zoologist at the university of British Columbia; and the next two members—this booklet was prepared in the expectation that the committee might sit before April 1—the next two members are Professor Henri Gaudefroy, and Abel Gauthier, but they retired as of March 31, and on May 3 two new members were appointed, Dr. J. H. Shipley, vice-president in charge of research and development of Canadian Industries Limited, and Dr. Paul Lorrain, professor of physics and head of the department of physics at the university of Montreal.

Then we have Professor Pierre R. Gendron, Dean of the faculty of science, university of Ottawa; Professor Giguere, director of the chemistry department, faculty of science, Laval university; Dr. Hayes, head of the department of biology and director of the Institute of Oceanography, Dalhousie university; Mr. Claude Jodoin, president of the Canadian labour congress. Dr. C. J. Mackenzie, a former president of the National Research Council, and at present, president of the Atomic Energy Control board.

Dr. Misener, head of the department of physics, university of Western Ontario, who will resign on July 1 to become director of the Ontario research foundation; Dr. Sargent, head of the department of physics at Queen's university; Professor Shebeski, head of the department of plant science, university of Manitoba; Dr. Spinks, a chemist, and president of the university of Saskatchewan; Dr. Thode also a chemist, and vice-president of McMaster university; Dr. David Thomson, who is vice-principal and dean of the faculty of graduate studies and research of McGill university; Dr. Toole, head of the department of chemistry and dean of the school of graduate studies, university of New Brunswick; Dr. Unrau, professor of plant science, university of Alberta, and Dr. J. Tuzo Wilson, professor of geophysics, university of Toronto. That makes a total of 17.

These constitute a very distinguished group of people. I think they represent 17 out of the very few top scientists in Canada.

Page 8 lists the officers of the council with myself as president, the vice-president, (scientific) Dr. Ballard, vice-president (medical) Dr. Farquharson; vice-president (administration) Dr. Rosser; and senior director Dr. Marion.

The reason for the title senior director is that the Research Council Act limits us to three vice-presidents and we cannot appoint a fourth vice-president without amending the act. We need somebody with adequate reputation in pure science and of a corresponding rank, so Dr. Marion has been appointed to this rank. However he is not a member of the council and he cannot be, since the act only allows the three vice-presidents to be members of the council and to be paid at the same time.

As secretary of the council we have Dr. Marshall, whose specific function is that of being in charge of the extra-mural program, and he is here today; and then we have a secretary who is in charge of international relations, Dr. Babbitt.

The next page sets forth the organizational chart and it shows that the authority comes from a committee of the privy council under the chairmanship of Mr. Churchill, and under him is the council, with myself as president. There are then four senior officers and a number of directors.

Under vice-president, medical, comes medical research, but we do not do medicine in our laboratories. Medical research is supported in universities and hospitals.

Under the vice-president, administration, there come administration, awards, and information services.

Under the vice-president, scientific, there are responsibilities for the engineering division, building research, national aeronautical establishment, mechanical engineering, radio and electrical engineering.

The senior director has the same responsibilities for science. The divisions are those of applied biology, applied chemistry, applied physics, the Atlantic regional laboratory at Halifax, the prairie regional laboratory at Saskatoon, pure chemistry, and pure physics.

One thing which I think is the most significant feature of the organization chart is the line across the chart. The fundamental feature of the administration of the research council which Dr. Mackenzie and Dr. Birchard, before me, and now Dr. Rosser and myself, have been responsible for trying to develop, is to make sure that the administration can never issue any instructions to scientists in connection with any technical subject whatever. This is a fundamental principle of our administration.

It is the exact opposite of the administration of most government departments, where the administrative head is in charge. So that in fact the scientific divisions have responsibilities to the senior director, who is an active scientist, and the engineering to the vice-president, scientific, who is an active engineer; and all the divisions report directly to me on scientific matters, whenever they feel like it.

It is up to the administration, which also reports to me, to make sure that things can be worked out with the scientific divisions, so that the administration act as services to the divisions, rather than as a control. The result is a very decentralized organization.

I think that the organization is almost unique from the point of view of scientific organizations, and I might say that almost every government research laboratory in the world is trying to copy it—in some cases successfully, and in other cases, unsuccessfully.

But this is the main principle: that you do not allow the scientific program to be directed by the administrative group, and I think this is the most fundamental principle of the whole system. That is the reason for this line running across the chart.

In other words, the senior director is not in charge of the science divisions. It is true that he has responsibilities for every one of the science divisions, but they may report directly to me whenever desirable, and the same is true of the engineering divisions, and the same is true of the relationship between the vice-president administration and the administrative officers of the divisions who are employees of the scientific divisions.

I think we have been extraordinarily successful in the last 15 years in developing a system whereby the administration acts as a service to the scientists, rather than as an obstruction.

Mr. BRUNSDEN: Who sets the pattern for the research?

Dr. STEACIE: In a broad way of course that is my responsibility. But we operate scientifically in a very decentralized way. I think we are one of the most decentralized labs that I know of. This causes some problems, but we feel that, for example, the director of the division of electrical engineering is concerned with the electrical industry, and the director of the division of building research is concerned with the construction industry, and that while the electrical industry involves mainly a rather small number of quite large firms, the division on building research deals with thousands of contractors. The result is that the problems which face these two directors are rather different problems, and for this reason the organization of the divisions differs quite considerably from one division to the other.

The way it operates is this: I have the over-all responsibility for steering, if you like, and if I feel something is not being done that should be done, I obviously would step in. And if I feel that the quality of work of a division for one reason or another is not all it should be, I would step in. But in general, the most important person is the head or director of the division, and he is allowed very great latitude in dealing with his program.

Now, his program will arise in any one of several ways: in the first place, he decentralizes it within the division to section heads; this is essential, because the only expert in a given field will be a section head, not the director.

The problems come either by the director or rarely myself feeling that a certain field needs to be considered or by the section head feeling that a certain field is of interest and that something can be accomplished in it; or by a request that may come in from industry, or from other government organizations, and so on.

In other words, the problems that are tackled arise in part from the initiative of a man in the lab, who sees the thing that ought to be done; or from industry coming along and suggesting that they need help in connection with something; or largely perhaps from both; that is to say, the man in the lab being in contact with industry, and as a result of discussion with them, the problem arises mutually.

But the problems differ very much from division to division. The extreme case would probably be that of applied chemistry as compared to building research—the chemical industry in Canada consists essentially of a dozen quite large firms, whereas the building industry consists of thousands of contractors.

In the chemical industry you will always have plenty of people to contact, but in the construction business you have no one to contact concerning research problems, and you will have to find out what is bothering them, and then use your own initiative. Does this answer your question?

Mr. BRUNSDEN: Thank you. It is fundamental to the whole question.

Dr. STEACIE: Yes, it is most fundamental in any operation.

Mr. MCILRAITH: Can you review the scientific work in progress in the council in the advisory council? Can you go one step further?

Dr. STEACIE: What happens is this: at intervals, when the council meets—it meets three times a year; these are lengthy meetings; the March one takes five days; the June one, three days; and the November one takes three days. In other words, the members give a great deal of time to it. That is in addition to the selection board. But any member of the council will put in the equivalent, I would say, of at least three full weeks during the year.

At the March meeting the university program is very heavy, and it takes up the full five days.

At the other two meetings the review committee meets. At the last meeting which finished yesterday, the review committee reviewed two out of approximately ten or eleven divisions, depending on how you count them.

The result of this is a report to the council in which the review committee states effectively what they think of the general quality of the work. And in particular it might state what it feels a division may need in the way of staff, facilities, space, and so forth; and then there are specific suggestions. In other words, in general, this will mean that the committee expresses approval of 90 per cent—we may hope—of what is going on, and any criticism it has to make.

It may suggest what has happened in this review at this meeting, that there are one or two fields which nobody in Canada is doing much about, and that a particular division might well see if it can acquire the necessary people to go into this field, and so on.

Basically the main function of the review committee consists of two things: one is the program, and here we feel it is absolutely vital that the director of the division directs, and that the reviewing committee be a scientific auditing committee. Any suggestion that the director would have to ask for permission to start something would be hopeless. It would be too time consuming, and in many cases we do not know in advance where we are going.

The review committee reviews things, if you like, in arrears; but since most of the programs are long-term, this does not mean that there is no control all along. Fundamentally, if there is a program that the director wants to start, something that he has not been doing, something which does not involve any money, or any administrative changes, he simply is free to go along with it. But if it involves money, it will involve the director of the division of administration, and the council will then look at the program to see how they think about where it is going. And this is where the scientific program concerns the council. Does that answer your question?

Mr. McIlraith: Yes, thank you.

Dr. Steacie: Well, I think, Mr. Chairman, if we could come back at some stage to almost everything I have touched on, we could get on with this list.

Page 10 lists the organization of the laboratories and services in engineering, and the names of the directors, the four engineering divisions with their directors, and then the science divisions, and the regional labs.

The one scientific division that does no research is the medical research division, because it is concerned with supporting work in universities and hospitals. We ourselves do no research internally.

Then there are the services under vice president administration, Dr. Rosser, who is also director of the administration division and his three associates, Dr. McKim, who is here, in charge of administrative services, Dr. Marshall, who is in charge of awards and grants, and Dr. Babbitt, who is in charge of information services; these include the library, and foreign relations and dealings with external affairs, and dealings with our officers in Washington, London, and with such organizations as UNESCO, NATO, the United Nations, and so on.

The staff is listed on page 11, the number of staff; this is the total staff at the end of January, and it includes everybody. In general we need more technicians and more machinists and so on for engineering research.

In scientific research there has been a tendency to have the number of research men not very different in the various divisions; but the total so far as the engineering division is concerned, is much bigger. In other words, we feel that the engineering divisions are heading for a size of 300 or 400, while the scientific divisions are heading for a size of 150 total staff.

At the present time in building research we have a total staff of 200, and it is still growing. It is a relatively new division.

The mechanical engineering division has 340; the national aeronautical establishment has 138; and the radio and electrical engineering division has 333. That gives 1,014 as a total staff in the engineering divisions.

You will notice that in the case of the Atlantic regional laboratory the number is rather small, and with the medical research it is small as well; that is a director and an assistant director, because it is only concerned with grants, and it has virtually no staff.

Under administration we have two breakdowns, internal and external. Effectively, the internal administration services number 245 who are what would normally be called administration. Then there is the legal and patents side which is related to the administrative aspect, and plant engineering; that is general maintenance of the buildings, and maintenance of the required equipment, minor construction such as installation of heavy equipment, and that kind of thing.

The services of plant engineering are in part paid for out of the allotment of the division. In other words, when the divisions have something done by plant engineering, it is subtracted from their budget, and therefore the engineering budget is partly recovered.

Then we have external services which are awards and grants, with 21 people; and information services—which is service to small industry—with 37 people, making a total of 2,427.

At the present time the ceiling on our staff is set not by estimate procedures but by recruiting difficulties. As of the end of the last fiscal year, April 1, we could have had more staff than this, but we were unable to recruit it. I shall refer to that problem when we come to the question of scientific salaries. These are a serious problem at the moment.

Later we will give an indication of staff growth. On page 12 we merely make a few remarks about the estimates. Page 13 shows the year's estimates which will come before parliament. These are broken down in the blue book in the normal method followed by government accounting procedures, but that is not very informative. If the salaries are all in one lump, it gives no indication of what you are doing. So we have prepared this breakdown for the committee and for ourselves, which we thought would be much more useful, in other words, this is a divisional breakdown not a breakdown into salaries and equipment and so on.

If you go back and compare this with staff, you will find, surprisingly enough, that there is very little difference between the divisions in the cost per person, in spite of the fact that the engineering divisions use large equipment, and large numbers of technicians; but the real thing I think here is that the scientific divisions are higher in operating supplies while in the engineering divisions once you have got a very expensive piece of equipment, the thing runs on without too much consumption of resources. So the operating expenditure breakdown is not too different per division.

Obviously if the operating expenses of divisions appear to be out of line, we will want to know why. In the services breakdown list you will notice under plant engineering a budget of $1,900,000, of which $525,000 is recovered by charging other divisions for services rendered.

There are certain other things which come under plant engineering, such as payment for water, payment for power, and that kind of thing, and all the housekeeping services are included.

Under external services, come all the office expenses of the awards office and of the Canadian journals of research, and their editorial and printing expenses, in the sum of $500,000. Actually, when you consider it you will find that the editorial costs are low when compared to other journals. Then there is the administration of the university support program which runs in the order of $9½ million. But the administration costs are extremely low. This is partly of course because other facilities of the council can be used; but it is partly due to the services that we get from the advisory council, that the costs are so low; and I think also it is due to the very efficient management of the program.

I might mention here that nobody who is a government employee, myself included, makes decisions as to who gets a grant or who gets a scholarship. We are responsible for the administration; but the honorary advisory council makes all the decisions as to the awards of scholarships and all grants.

The university support is broken down here, and you will notice that scholarships and grants so far come to about $6.8 million; this is for 1960-61, the coming estimates. On the medical side it is $2.3 million; and all this gives you a total of $9,157,000.

There is also a small grant to the Royal Society of Canada which is carried in the estimates at the request of the treasury.

Then there is an item of $2,900,000 for inter-departmental services. These are primarily things which we do and charge for the other government organizations. The major part of this would be things that we do for defence, and for which we are paid by defence. Basically we have no fundamental responsibility for research in defence. That is the function of the defence research board; but there are some things in the aeronautics and electronics field where we feel we have the people who can help, so we do things on their behalf.

It was true also for the St. Lawrence seaway where we did considerable work on hydraulics in connection with the design of parts of the seaway; and we do work for almost all government departments to some degree.

Mr. McIlraith: In respect of the item of $2,813,776, would it be correct to say it is really estimated income from other departments?

Dr. Steacie: Yes. We have broken it down this way. The second to last line on the page gives an estimate of our revenue from all sources. The reason is we do some work that is strictly departmental from our own budget. We do not charge for everything. You will notice, however, there is a fairly good correlation.

Mr. Brunsden: The $2,800,000 is an offset against the $2,900,000.

Dr. Steacie: The revenue in the $2,800,000 includes that derived from contracts from industries. We are offsetting about $2.2 million against the $2.9 million, and the rest is being done out of our own budget. One thing that is important is not to get in the position where we derive too much of our income from other departments. At one time in the United States the bureau of standards was deriving something like 75 per cent of its budget from the defence department, and at one stroke of the pen the secretary for defence decided it would be cut out. In the next few months the bureau of standards lost a considerable per cent of its staff, and the morale was pretty low. I think now they have 15 per cent of their revenue from defence and the rest is their own budget from the department of commerce. I think it would be dangerous for us to get to the stage where we charged for everything. You could argue that everything we do in aeronautics has some defence bearing, and also what we do in electronics; but if you charge all this to defence you would have our budget in the position where a decision of the defence department could practically destroy our whole staff. We feel this figure which deals with short term jobs and odds and ends is a quite safe one. If this were cut-off tomorrow the people doing the work would just go back to their normal jobs; there would be very little disturbance in the program.

Mr. Best: I may have missed Dr. Steacie's figure on the cost of the administration of university support. Is that included in the $533,000.

Dr. Steacie: Yes; plus the journals. There would be about $230,000 for the administration of the university program and $300,000 for the journals. The cost of the journals is partly an administrative cost, but mostly is the publishing cost.

Page 14 is just explanatory of 15. What we have listed on page 15 is how the expenditures are broken as between general operation and university support.

This goes up to the last fiscal year and does not include estimates for the coming year. These are expenditures not estimates. You will notice it gives details of the expansion from the average of 1948-53. In other words since around 1950, in a ten year period we have a little more than doubled our lab operations and have gone from 1.6 million to 8.2 million in university support. This is shown better in table III which is the breakdown of the dollar. You will see that salaries, allowances and so on—which is almost all salaries—has remained fairly constant at 52 per cent. Equipment and supplies has dropped from 29 per cent to 19 per cent. University support came up from 17 per cent to 28 per cent. Actually in the last three years there has been a rise in the amount of university support and to some degree this has been made possible by exercising very careful control of lab equipment and supplies in order to make as much money as possible available. We have tried deliberately to hold back our estimates on equipment and supplies in order to be able to increase university support without letting our total estimates rise too far. We have reached rock bottom on this. These is no question in my mind that in future years we will have to have a larger amount than 19 per cent of our total operation for equipment and supplies relative to our salaries expenditure. On the other hand, over such a period as the government is willing, I would like to get to the stage where 50 per cent of the expenditure is university support and 50 per cent lab operation. We have come from 17 to 28 and a little more in the coming year's estimates in 3 years. I think we are well on the way to doing this.

Mr. McIlraith: That increase in the university work—in university grants—is in accordance with the studies of the last committee and its recommendation that it be expanded as rapidly as circumstances permit.

Dr. Steacie: Yes. We are following this. We are very anxious to do this. The increase in the last three years has been from $3.5 million to $6 million, to $8.2 million, and in the current year's estimates $9.2 million. I would hope to see the rate of expansion of something like $2 million a year in the university program continued. Actually, there is the question of how much the universities can absorb. They have to pay the staff and they have to pay for the facilities, the buildings and the basic equipment.

There has been an extremely encouraging change in the financial position of the universities in the last six or seven years. The provision of the per capita grant federally has increased their resources and the increased provincial spending has been quite spectacular. There have also been signs of increasing industrial support. The result of this has been that as the flood of students is reaching the universities they have been able to do something about providing facilities and staff. The result also has been that the new younger staff has been mostly research minded so that each year in our university program we are faced with applications for grants from a large number of good young people on university staffs who were not on university staffs the year before.

I would say the expansion of science in the universities in the last five years has been very spectacular and very encouraging. If you go back forty-three years I feel the research council actually can take quite a bit of the credit for the development of university research. If these funds had not been forthcoming there is no question but that there were periods when it would have been very difficult for universities to survive in research at all. What this means, in effect, is that since the universities are providing the basic facilities we are merely providing the special things. It means that the better off the university is, the more we need to provide—not the less. As more people do research, and as the quality of research rises the demands will be larger, not smaller. I have been very much encouraged by the university development in the last five years. I also have been very much encouraged with the way in which we have been able to maintain our support and keep level with the rise in university development. I think it is vital that we should continue to do this.

Mr. BRUNSDEN: I notice this first item, salaries, allowances and special services, drops from 59%, in 1955, to 52% in 1959-60. The salaries are going down rather than up. How do you correlate that with the size of the staff?

Dr. STEACIE: What basically happens is that there is a tendency for government salaries to be maintained, fixed, and then the situation breaks. The result is, of course, that your salaries do not rise for a period, and then when they rise they tend to rise suddenly. I hope this will happen again soon.

Mr. BRUNSDEN: Do you have any idea of the number of staff, say in 1948, as compared to this year?

Dr. STEACIE: You will see it on the following page, page 16. Actually here, for simplicity, we have reported from 1947 to 1952, subtracting the atomic energy project. At that time Chalk River was a division of the research council. It was split off as Atomic Energy of Canada Limited in 1952. To make these figures comparable, we have reported from 1946 to 1953 less the atomic energy. You will see in 1948 our staff was about 1,350.

Mr. McILRAITH: At some point in the future you will be splitting off another activity because of the special nature of the scientific development. Is it fully precise to say that it makes it comparable by splitting off atomic energy?

Dr. STEACIE: No; it is not, in a sense. If you like it shows the growth of what we have. Actually, one should add the present staff of Atomic Energy of Canada Limited and show the total of two activities over the years. We chose to subtract instead of add. Actually we have done really more than this. During the war we were the scientific arm of the services. At the end of the war, at Dr. Mackenzie's suggestion, we did not retain responsibility for military defence, and the Defence Research Board was set up. In effect, therefore, you could say we split off defence research at the end of the war and atomic energy in 1952.

As things grow in the future I would hope that there will be other splits. In other words, if we had retained the atomic energy project and retained the Defence Research Board we would have a staff of nearly 9,000. That is far too big. It causes all sorts of administrative difficulties, and administration gets entangled with science. I would hope, as we inevitably expand, and as the size of the economy and everything else expands, we would get units big enough to be self supporting which we could turn over as we did in the case of atomic energy. The only way to avoid building too big an empire is to drop one field or another as time goes on. I hope we will be able to continue to do this.

Mr. McILRAITH: I believe the atomic energy and the research board—most of that activity— started as a very small purely scientific matter in the research council.

Dr. STEACIE: Yes. I think that you inevitably get things of this sort. One large organization in which there is joint interest in a number of fields is aeronautics. Without at the moment entering into the question as to the degree to which you want to expand aeronautics, I think obviously if you ever got aeronautics up to something very large you would then want to do as they have done in the United States, that is set up a separate establishment. In the United States it is the national aeronautics and space administration.

Our staff growth is shown on page 16. Actually you will notice that there is a dotted line at 60, and between 59 and 60 there is a solid line. The difference between the solid and the dotted line is where we fell short in recruiting. We feel that we would like a rather slow and steady growth. You do not get much work done in a scientific organization which is growing too fast. There is the difficulty in respect of facilities and getting technicians accustomed to their job and so on. We feel if we can go along quietly at an expansion of 3, 4 or 5 per cent per year and do it steadily, that it is much more efficient. The second thing is we do not want to rush into fields in a panic-stricken way. If you do, you get poor staff. We would much rather not hire a staff at all than hire staff we do not think too much of, even if it delays our expansion. You cannot always be too rigid in this because you have demands which have to be met. By and large, however, we try to keep the standards very high. Unless we can get people we regard as absolutely first class we just do not hire them.

On page 17 we have the staff broken down by work categories; that is, scientists doing scientific work, technicians, general service people—and by general service we mean things like glass blowing and we also mean administration; that is they are both regarded as service. The general service people are the people doing centralized work, such as the administrative services, the duplication, the stenographic pool and all these things. Finally, there is maintenance which is strictly plumbers, carpenters, electricians and other tradesmen.

The next table gives the breakdown by training. 9.8 per cent of the scientific staff are biologists. Of that, 8.8 per cent have a doctor's degree. In chemistry, out of 28.6 per cent, 27.3 are doctors today. In engineering out of 33.2 per cent very few have a doctor's degree at the present time. I would think we will have a very steady change in this. In the whole field, in 10, 15 or 20 years we will, I think, be at the stage where we have 4 per cent with a bachelor degree, 11 per cent with a master's degree and 85 per cent with a doctor's degree. I think this is where we are headed.

The next section, starting on page 21, is a breakdown of the kind of things the divisions do. I am sure you do not want me to read this. In respect of building research, the term building used here is used in the French sense of batiment, rather than the English sense. It covers more than buildings, e.g. dam construction, foundations and things you would not call buildings in the English useage of the word. This division is concerned with fundamental studies such as those related to snow, soil and muskeg in the north. We are also concerned with the national building code of Canada which has been adapted by a very large number of municipalities in Canada. Then there is research in the various problems in connection with building in respect of winter construction and so on. You will notice that this involves about 100 inquiries a month from engineers and architects. In addition, booklets and bulletins are published which are widely circulated.

The mechanical engineering division is interested mainly in mechanics and fluid mechanics, such things as hydraulics, engines and naval architecture. Some of the work has been in respect of the St. Lawrence Seaway, and there has been work in relation to harbour improvement at Saint John and Port Cartier. There was also work in connection with Port aux Basques which was a lively issue at the time of the last committee meeting. This section has also done quite a lot of work on materials research and various things of this sort. It is engaged in certain railway investigations. It is engaged in mechanical engineering and investigations in connection with the pulp and paper industry and various other things.

The national aeronautical establishment is really the aeronautical engineering division. It is concerned mainly with aerodynamics and problems such as fatigue of aircraft and aircraft safety, materials which will stand very high temperatures, and so on. In addition to that there is fundamental work in aerodynamics and testing of models. You do not have to be developing a new plane to need a great deal of aerodynamic work. Any small modification which you make to a plane will involve aerodynamic investigation of the effect on the plane. So long as you have planes flying, civil or military, you need facilities for these investigations. The facilities of the division essentially have passed the obsolescence stage. We have a new modern wind tunnel under construction and the facilities will be very favourable when this is in operation in about a year and a half. At the present time we are in difficulty with obsolete facilities. These facilities, however, are expensive. There was a very difficult period with reference to the subject of wind tunnels because the requirements were changing so fast that as soon as you had a new one built it would be obsolete, perhaps even before it was finished. I think the decision of a few years ago was a good one and that the new tunnel will be very efficient.

The radio and electrical engineering section does a lot of work in aids to navigation, such as unattended operation of buoys, shore lights and fog alarms and navigation facilities in general. About half its work is for the defence department. It also does some work in medical electronics and things of that sort.

Applied biology is primarily a food division; it is primarily concerned with biology in relation to food problems. There is a quite definite difference in slant here between the Department of Agriculture and our applied biology division. In other words, we try to stay away from agriculture, but get into problems involving utilization of agricultural products, refrigeration problems, and so on. There is a very close relationship with the Department of Agriculture on all this work. The division is also doing fundamental work in biology.

Applied chemistry is concerned with things related to chemical and petroleum engineering, and chemistry. The sections are analytical chemistry, which is a service section; and then there is work on catalysis, which is fundamental to the chemical industry, colloid chemistry, high polymer chemistry, corrosion, a certain amount of metallurgical chemistry—where there is collaboration with the bureau of mines—rubber, textiles, and things of this sort.

Applied physics is, first of all, the legal holder of standards for Canada. The secondary standards in Canada are the function of the Department of Trade and Commerce; that is, inspection of weights and measures, and things like that. But the primary standards against which all the secondary standards have to be checked are the responsibility of the division of applied physics. They act, in this way, like the national bureau of standards in the United States. In addition to that, there is a lot of work in other things; in particular, there has been some very successful work on industrial noise abatement, and there has been some excellent work on industrial radiography.

I might point out here that there was an unfortunate headline in the newspapers regarding our new building for applied physics. When it was announced, it was described as a "Huge new nuclear laboratory". In fact, what has been done is this: there is a small shack along by the river on Sussex Street which the National Capital Commission has been trying to get us to tear down for years. This houses a unit of this division which is doing radiography for industrial purposes, and standardization of radio-active materials. This will move, when the new building is completed, and will be one of a dozen sections occupying the new building. But I think this is rather far from being a huge new nuclear laboratory. It does not involve any conflict with Chalk River. But it does mean there will be more work done on a lot of things connected with radiology; that is, the industrial use of it.

Then we have regional laboratories. The Atlantic regional laboratory is trying to concern itself with certain things that interest the Atlantic Provinces. It is located on the Dalhousie university campus in Halifax. They have been interested in industrial use of things such as seaweed, and various things of that sort. These get into ice cream, and things of that sort. They deal with certain problems of micro-organisms connected with pulp and paper, and do a certain amount of work on the chemistry of steel-making. In other words, they are trying to concentrate on problems related to the maritimes.

The Prairie regional laboratory is similarly concentrating on problems relating to the three prairie provinces. It is located on the university of Saskatchewan campus, and, by and large, it is interested in agricultural products, rather than agriculture, as such. The boundary is a very difficult one; but there is a quite effective committee structure set up between the provincial departments of agriculture and the federal Department of Agriculture; and this organization, and everything that is done, is done in full cooperation with the Canada Department of Agriculture.

Then, finally, we have two pure science divisions. The main thing here is that we feel that for the welfare of the lab. as a whole, there should be some fundamental work going on. We feel, also, similarly to the United States, that there is a greater danger of neglecting fundamental work relative to applied work. For this reason we are operating two of the smaller divisions, pure chemistry and pure physics, which are really doing pure science. That is to say, there is no industrial objective to this work at all. The attempt is to do good work; but the reaction of this work on the applied labs. is one that is very important. It is also quite an important thing in our relationship with the universities, because it gives us a group of people who are very well known in universities. I think that in these two fields the Council has established itself as one of the leading labs. in the world in both pure chemistry and pure physics. This has had a very beneficial effect on the council's reputation as a whole.

The medical research division is engaged in supporting research. At the time the medical division was set up, there were no teaching hospitals in Ottawa. It did not seem desirable to try to do medical research in a government laboratory, divorced from medical teaching and from teaching hospitals, and so the decision was made that we would operate no laboratories and would put the money, the support for medicine, into the backing of research in medical schools. Since this time the university of Ottawa has developed a first-rate medical school in Ottawa. But we still feel the policy is right, and that if we are to spend money on medicine in Ottawa, it is better to spend it in the university. So there is no suggestion that we change this policy and start other medical research ourselves.

Then we come on to services. First there is the administration division. There are, first of all, administrative services. This is for things such as purchasing, personnel, general services for accounting, registry, transport, duplication, stenographic assistance, and so on. The only thing worth mentioning here is that duplication services are much larger than one would have for an office organization. In other words, most of the work of the duplication services is for the scientific divisions.

Then legal and patents branch, in connection with processing of patents as a result of things developed in the council. There is also the relationship with Canadian Patents and Development Limited. This is a crown company which handles patents both for ourselves, for other government departments, if they wish it, and certain other organizations; and it is set up under the Research Council Act as a crown company, wholly owned by the National Research Council.

Plant engineering services are housekeeping and maintenance. Awards and grants we have described already. Then the information branch is the library, public relations, technical information service, a small economic studies section—in fact, consisting of one man—but engaged in collaboration largely with the bureau of statistics on surveys of research expenditures in Canada, and so forth.

Then we have external activities. I think I have probably already spoken as much as I need to about awards and grants. At page 33 there are the associate committees. The council has had the function of trying to develop Canadian research. One thing, of course, that is necessary, is to know what is going on and to be sure that other people do. For this reason, since we have a rather flexible structure, we have developed a set of so-called associate committees. These are born, and die when the need passes; but they provide a method of getting people together from provincial governments, other federal organizations, industry and universities. This has been very useful, I think, in coordinating and in stimulating research in various fields.

This kind of committee mechanism is the way in which we basically keep in touch with industry, and keep in touch with all sorts of other things. The committee structure is quite an elaborate one. I think it has been a very effective one. To give some idea of the elaborateness, I may say that we have, first, national committees: we have also the associate committees, and various others. The list of names was printed in the report of the 1956 committee, as an indication of the size of this structure. I am not going to suggest that it be read or printed this time, Mr. Chairman, but perhaps I could table the list. It involves 3,306 names, and I think it would clutter the record up. But it is an indication of the extent to which the council has been responsible for the general coordination and dissemination of information.

I think it might be interesting if I were to read into the record, sir, the names of the committees—not the names of the members. First of all, I have a list of two typewritten pages of the names of the associate committees. They are, aerodynamic research, animal nutrition, aquatic biology, automatic control, aviation museum, and so on and so forth. Could those be put in the record?

The CHAIRMAN: Yes.

(The list of associate committees is as follows:)

Associate Committee on Aerodynamic Research
Associate Committee on Animal Nutrition
Associate Committee on Aquatic Biology
Associate Committee on Automatic Control
Associate Committee on an aviation museum
Associate Committee on the National Building Code
Advisory Committee on Building Research
Associate Committee on Control of Infections
Associate Committee on Corrosion Research and Prevention
Canadian Committee on Culture Collections of Micro-organisms
Associate Committee on Dental Research
Associate Committee on Electrical Insulation
Associate Committee on Engines Research
Canadian Committee on Fats and Oils
Associate Committee on National Fire Codes
Canadian Committee on Food Preservation
Associate Committee on Forest Fire Protection
Associate Committee on Geodesy and Geophysics
Associate Committee on Grain Research
Associate Committee on High Polymer Research
Advisory Committee on Medical Research

Associate Committee on Pure Mathematics
Canadian Joint Committee on Oceanography
Joint Committee on the Institute of Parasitology
Associate Committee on Photographic Research
Associate Committee on Plant Breeding
Associate Committee on Plant Diseases
Associate Committee on Applied Psychology
Associate Committee on Publications and Abstracting Services
Prairie Regional Committee
Associate Committee on Railway Problems
Interdepartment Committee on Saint John Harbour improvements
Associate Committee on St. Lawrence River Model Studies
Associate Committee on Scientific Information
Associate Committee on Soil and Snow Mechanics
Associate Committee on Space Research
Associate Committee on waves and littoral drift
Associate Committee on Wildlife Research

Dr. STEACIE: Then, if it is agreeable, I would like to table, but not put in the record, the list of the membership of these committees. This is one copy of the list of members. But, as an example, if I take aerodynamic research, you have Professor Patterson, University of Toronto; Dr. Nicholl, Laval university; Dr. Nicholls, University of Western Ontario; Dr. Parkinson, University of British Columbia; Dr. G. V. Bull, Defence Research Board; Mr. Templin, National Aeronautical Establishment, National Research Council; and Dr. MacPhail, of our division of mechanical engineering. We are in the process of changing the name of this and adding representatives from the aeronautical industry, so we will end up with a committee of about 15, half of whom will be from industry.

Animal nutrition includes University departments of agriculture, the federal Department of Agriculture and provincial departments of agriculture, and industries, such as the packing industry, various other fields, and so on.

Mr. BRUNSDEN: What is the basis of selection?

Dr. STEACIE: The basis of selection, is, as far as possible, never *ex officio*. You have to occasionally; but we try to do it on the basis of the people who are really doing something. Sometimes it is necessary to be *ex officio*, more or less. But in general, the attempt is made to say, if we are going to have a committee on aeronautical research, "What companies in Canada do aeronautical research? Who are the leading people in it? What universities do aeronautical research? What government department does some aeronautical research?"—and these people are put in after they have been chosen.

To a degree, you get forced into *ex officio* representation sometimes; but we have tried, in general, to avoid it. It usually leads to a very unwieldy committee, because to get the 10 people that know something together, if you start *ex officio* representation you might get 40 people diluting the 10. We have tried, as far as possible, never to put *ex officio* people on.

The chairmanship may come from outside or inside. There are a number of these committees in which there is no one from the National Research Council, where we have been asked by some other organization to set the committee up. Sometimes other departments find that we can do this more easily than they can.

Mr. BEST: Is the tendency to be relatively specific on the heading, or name, of these committees? They vary quite a bit. In agriculture you have animal nutrition, plant breeding, plant diseases; but do you sometimes have a larger and wider ranging committee, involving correlation of agricultural research on a provincial and federal level, on a wider basis?

Dr. STEACIE: In this case, what we were concerned with here, primarily, was research in the prairie provinces, where the universities were very closely concerned with the provincial departments and where we also have a lab.

We have an overriding committee, the prairie regional committee, for the whole agricultural biology in the western provinces—or, the prairie provinces.

Mr. BEST: Generally these committees are set up in response to a specific need, or stimulus?

Dr. STEACIE: Yes.

Mr. BEST: And, therefore, the range of them varies...

Dr. STEACIE: There are other types; but for the general coordination of research in, say, chemistry in Canada, we have not found it useful to suggest a committee. Its duties would be so broad that none of the people would really be experts in much. On the other hand, we had a committee on synthetic rubber at a time when there was a lot of activity. It has now settled down to a manufacturing process, and you do not need it. We have a committee on high polymers; we have a committee on corrosion research, because this covers various industries and fields, so we have set them up on a more specific basis.

Mr. BEST: Mr. Chairman, I think this might be a subject that we might welcome in more detail in future, perhaps, in agriculture; the coordination of the different limits of research activity.

The CHAIRMAN: Yes, I think we all agree with that.

Dr. STEACIE: Basically, if this were to be done, our normal feeling would be to regard the responsibility as coming from agriculture. In fact, there is no question that in the case of animal nutrition, plant breeding committees, and so forth, the main stimulus to set them up came from the federal Department of Agriculture and the provincial departments—not from our own labs.

The CHAIRMAN: Gentlemen, several members have appointments at 12.30, and luncheon engagements. I think this morning has been an indication of what an interesting committee this is going to be, the same as it was under the chairmanship of Mr. McIlraith. Dr. Steacie, I want to thank you, on behalf of the committee.

I wonder if we could arrange something before we leave. The house is going to start sitting, next Monday, in the morning. Will we sit at 9.30?

Dr. STEACIE: Could I raise one thing, sir?

The CHAIRMAN: Yes.

Dr. STEACIE: I have a speaking engagement on Monday morning in Kingston. It is possible to make it Tuesday?

The CHAIRMAN: Yes: I did not think of Monday, as a matter of fact; I should have said Tuesday. Is that all right?

Dr. STEACIE: Yes.

The CHAIRMAN: Is that agreeable to the members?

Mr. BRUNSDEN: Does this meeting conflict with any other committees?

The CHAIRMAN: There are many committees sitting; but we cannot worry about it. Tuesday morning, at 9.30; is that all right?

Mr. MCQUILLAN: You have to get them correlated a little bit, because the other committees cannot worry about this one. So there will have to be a little cooperation there.

The CHAIRMAN: You will just have to give up the chairmanship of your committee, and sit on ours. If it does not work out right, I will speak to Mr. McIlraith and the CCF member, and we will try and arrange something.

Mr. AIKEN: Are we going to have a regular meeting day?

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The CHAIRMAN: I thought we should. Mind you, we will only have six, seven, or eight meetings in June. With so many committees sitting, I do not see how we can sit more than twice a week. Do you, Mr. McIlraith?

Mr. McILRAITH: No, I do not see any possibility of sitting more than twice a week, because we will be coming into the stage where some of the committees sitting will have specific work that they want to deal with and get back into the house; namely, the Combines Act and that sort of thing.

The CHAIRMAN: That is true. We will try and arrange for two meetings a week, and if we have out-of-town witnesses, of course, we will have to sit while the house is in session. But apart from that, we will try and arrange it for 9.30 on Tuesdays and Thursdays. But we will try, Harry, not to conflict with that important committee of yours.

Mr. McQUILLAN: You used to think it was important one time yourself.

The CHAIRMAN: Yes.

Mr. McILRAITH: It may be necessary to give way to one of these other committees that is dealing with legislation going back into the house; so we will not make it rigid.

The CHAIRMAN: I was going to say that it had been our thought that we might get some time when Dr. Steacie has to be away. We are not going to get through national research at this session; far from it, and there might be some time when he has to be away. He has to be away, as a matter of fact, on June 20, up to Penticton. I expect to go there as well, and we might make a trip to Chalk River. But I will arrange that with Mr. McIlraith.

Mr. PAYNE: If you get up there, you will never come back.

—The committee adjourned.

APPENDIX "A"

NATIONAL RESEARCH COUNCIL OF CANADA

ORGANIZATION and ACTIVITIES

ORGANIZATION

2

COMMITTEE OF THE PRIVY COUNCIL

The Research Council Act established a Committee of the Privy Council on Scientific and Industrial Research consisting of such number of ministers belonging to the Queen's Privy Council for Canada as the Governor in Council may determine, to be nominated by the Governor in Council. The National Research Council reports to the Committee of the Privy Council and an annual report is laid before Parliament by the Committee Chairman. The Chairman plays a vital role in the operations of the Research Council. Among other things the Act requires his approval for the appointment of all staff members of the Council (now numbering 2427 people), and he also approves all promotions and retirements.

COMMITTEE OF THE PRIVY COUNCIL

1959-60

Chairman

The Minister of Trade and Commerce
The Honourable Gordon M. Churchill

Members

The Minister of Agriculture
The Honourable Douglas S. Harkness

The Minister of Finance
The Honourable Donald M. Fleming

The Minister of Fisheries
The Honourable J. Angus MacLean

The Minister of Mines and Technical Surveys
The Honourable Paul Comtois

The Minister of National Defence
The Honourable George R. Pearkes

The Minister of National Health and Welfare
The Honourable J. W. Monteith

The Minister of Northern Affairs and National Resources
The Honourable Alvin Hamilton

The Secretary of State for External Affairs
The Honourable H. C. Green

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HONORARY ADVISORY COUNCIL

The Research Council Act set up an Honorary Advisory Council for Scientific and Industrial Research as a body corporate in charge of all matters affecting scientific and industrial research in Canada as assigned to it by the Privy Council Committee. It is the duty of the Honorary Advisory Council to advise the Committee on questions of scientific and technological methods affecting the expansion of Canadian industries or the utilization of the natural resources of Canada. The Honorary Advisory Council controls and directs the work of the National Research Council, mainly through the continuing officers (President and Vice-Presidents) and through seven subcommittees, each one being responsible for a particular phase of the Research Council's activities.

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HONORARY ADVISORY COUNCIL

OFFICERS

The President is the chief executive officer having supervision over, and direction of, the work of the Council and of the officers, technical and otherwise, appointed for the purpose of carrying on the work of the Council.

The Vice-Presidents (Scientific) have supervision over such scientific matters as the President may from time to time assign to them and perform other relevant duties.

The Vice-President (Administration) has charge of all matters relating to administration and performs such other duties as the President may from time to time assign to him.

COMMITTEES

1. The Executive Committee is established by the Research Council Act and acts for the Council as required.

2. The Scholarships Committee is responsible for the awarding of scholarships to postgraduate students.

3. The Grants-in-Aid of Research Committee is responsible for approving grants to university professors in the science and engineering faculties of Canadian universities.

4. The Selection Committee is responsible for advising the Council regarding the appointment, promotion and retirement of staff.

5. The Review Committee is responsible for inspecting the laboratories, for reporting on the quality of the work done and giving advice and direction as to projects to be followed or abandoned.

6. The Journals Committee is responsible for setting publication policy for the six Canadian Journals of Research which serve as an outlet for the work of Canadian scientists.

7. The International Relations and Travel Committee is responsible for relations with international scientific organizations and the appointment of Canadian delegates to international conferences.

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HONORARY ADVISORY COUNCIL

Members

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J. Unrau, B.S.A., M.Sc., Ph.D., Professor of Plant Science, University of Alberta, Edmonton, Alberta.

J. Tuzo Wilson, O.B.E., B.A., M.A., Ph.D., Sc.D., LL.D., F.R.S.C., Professor of Geophysics, University of Toronto, Toronto, Ontario.

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NATIONAL RESEARCH COUNCIL

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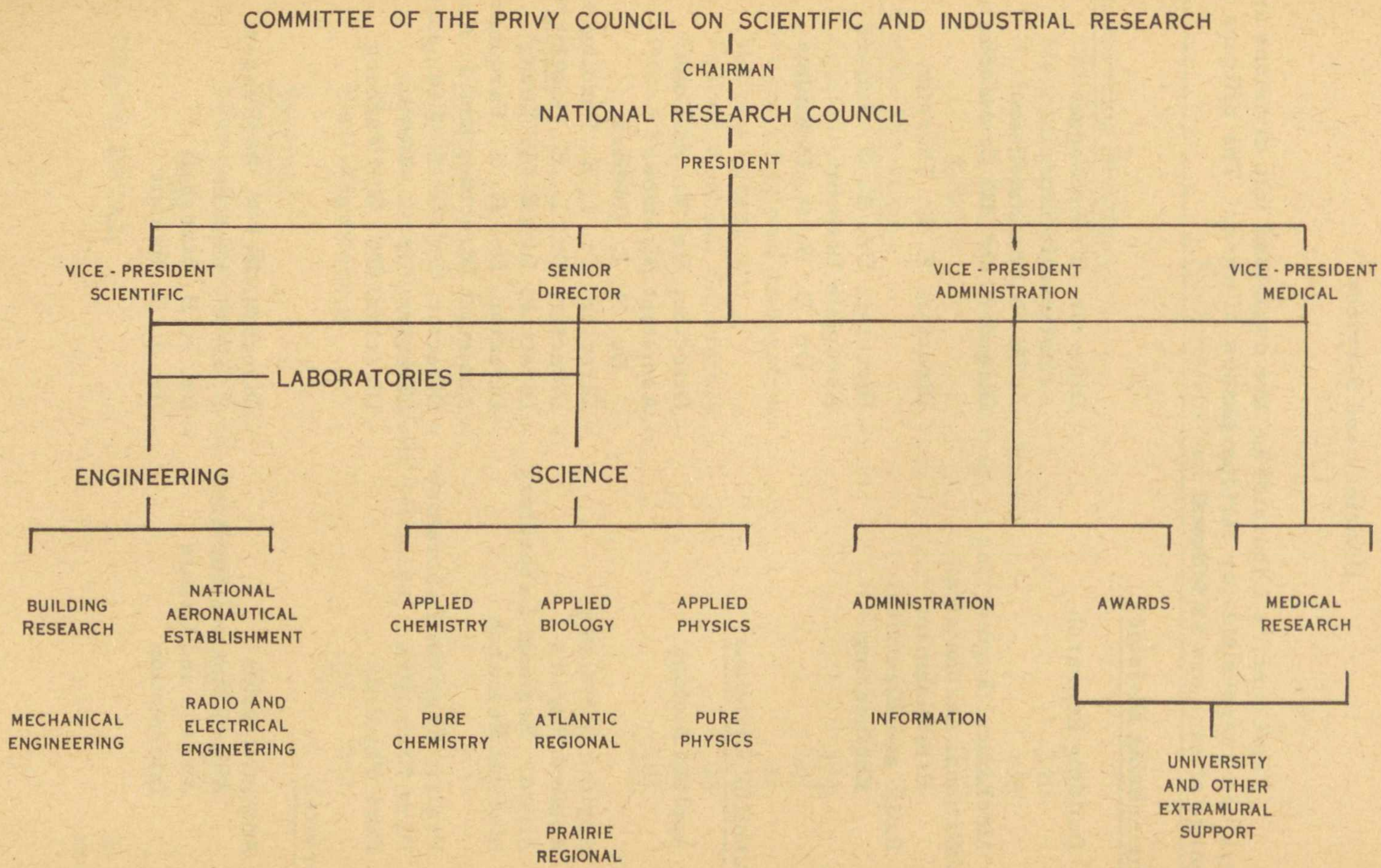
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APPLIED PHYSICS
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MECHANICAL ENGINEERING
RADIO AND ELECTRICAL ENGINEERING
PURE CHEMISTRY
ATLANTIC REGIONAL
PURE PHYSICS
INFORMATION
UNIVERSITY AND OTHER EXTRAMURAL SUPPORT
PRAIRIE REGIONAL

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NATIONAL RESEARCH COUNCIL

Divisions and Services

The Council's Laboratories are organized into divisions and services responsible for various phases of work. The officers in charge of each are as follows:

Engineering Divisions

Building Research	- Director, R. F. Legget
	- Assistant Director, Dr. N. B. Hutcheon
Mechanical Engineering	- Director, Dr. D. C. MacPhail
National Aeronautical Establishment	- Director, F. R. Thurston
Radio and Electrical Engineering	- Director, Dr. B. G. Ballard
	- Associate Director, Dr. D. W. R. McKinley

Scientific Divisions

Applied Biology	- Director, Dr. W. H. Cook
	- Assistant Director, Dr. N. E. Gibbons
Applied Chemistry	- Director, Dr. I. E. Puddington
Applied Physics	- Director, Dr. L. E. Howlett
Atlantic Regional Laboratory	- Director, Dr. E. G. Young
Medical Research	- Director, Dr. R. F. Farquharson
	- Assistant Director, Dr. J. Auer
Prairie Regional Laboratory	- Director, Dr. G. A. Ledingham
Pure Chemistry	- Director, Dr. L. Marion
Pure Physics	- Director, Dr. G. Herzberg

Services

Administration	- Director, Dr. F. T. Rosser
Administrative Services	- F. L. W. McKim
Awards and Grants	- Dr. J. B. Marshall
Information	- Dr. J. D. Babbitt

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NATIONAL RESEARCH COUNCIL

Table I

STAFF
1 January 1960
By Divisions and Branches

		Staff	
Engineering Divisions			
Building Research		203	
Mechanical Engineering		340	
National Aeronautical Establishment		138	
Radio and Electrical Engineering		333	
Total			1014
Scientific Divisions			
Applied Biology		114	
Applied Chemistry		126	
Applied Physics		141	
Atlantic Regional Laboratory		41	
Medical Research		2	
Prairie Regional Laboratory		95	
Pure Chemistry		117	
Pure Physics		102	
Total			738
Services			
Administration			
Internal			
Administrative	245		
Information (Library & Public Relations)	71		
Legal and Patents	10		
Plant Engineering	291	617	
External			
Awards and Grants	21		
Information (Liaison & Tech. Inf. Serv.)	37	58	
Total			675
GRAND TOTAL			2427

NATIONAL RESEARCH COUNCIL

Estimated Operating Costs

Funds for operation of the Council's Laboratories and other activities are provided largely by annual Parliamentary appropriation. This appropriation is supplemented by revenue realized from work performed for other government departments and outside organizations and from sale of publications.

Estimated requirements for the fiscal year 1960-61 are detailed on the opposite page.

The requirements for laboratory operations cover all normal operating expenses. The larger items are salaries, supplies and equipment. Charges are made to Scientific and Engineering Divisions for work performed by Plant Engineering and Mechanical Engineering Workshops and the returns are credited to these Services. There is a considerable amount of indirect administration cost provided in Laboratory Operations for the External Activities of the Council in promoting Canadian science.

NATIONAL RESEARCH COUNCIL

ESTIMATED REQUIREMENTS 1960-61

Engineering Divisions			
Building Research		$1,677,994	
Mechanical Engineering		2,679,568	
National Aeronautical Establishment		1,186,757	
Radio and Electrical Engineering		2,673,346	
Total			$8,217,665
Scientific Divisions			
Applied Biology		$ 873,184	
Applied Chemistry		1,125,063	
Applied Physics		1,315,364	
Atlantic Regional Laboratory		334,261	
Prairie Regional Laboratory		692,102	
Pure Chemistry		942,653	
Pure Physics		931,247	
Total			6,213,874
Services			
Internal			
Administration		$1,441,818	
Information (Library & Public Relations)		511,592	
Legal and Patents		67,550	
Plant Engineering	$1,891,570		
Less Estimated Returns	525,000	1,366,570	
Total			3,387,530
External			
Awards and Grants			
Office and Canadian Journals Research		$ 530,755	
University Support			
Science & Engineering			
Scholarships & Fellowships	$1,321,350		
Grants	5,228,150		
International Affiliations	15,000		
Special Activities	293,250	6,857,750	
Medical			
Fellowships & Associateships	$ 330,000		
Grants	1,965,000		
Special Activities	5,000	2,300,000	
Royal Society		17,000	
Interdepartmental Services		2,921,293	
Information (Liaison & Tech. Inform. Serv.)		333,766	
Total			12,960,564
TOTAL ESTIMATED REQUIREMENTS			$30,779,633
Less Estimated Revenue			2,813,776
NET TOTAL ESTIMATED REQUIREMENTS			$27,965,857

NATIONAL RESEARCH COUNCIL

Actual Operating Costs

The accompanying Tables II and III record the changes that have taken place in the disposition of the Council's funds. Substantial salary adjustments have been made from time to time without corresponding increases for other objects of expenditure and in recent years it has become most important that support for science in Canadian universities should be strengthened.

NATIONAL RESEARCH COUNCIL

Table II

Summary of Expenditures
In thousands of dollars

	Average 1948-53	Average 1953-58	Actual 1958-59	Forecast 1959-60
General Operations	8,252	14,019	18,861	20,585
University Support	1,681	2,855	6,113	8,174
	9,933	16,874	24,974	28,759

Table III

Disposition of the Dollar

	Average 1948-53	Average 1953-58	Actual 1958-59	Forecast 1959-60
Salaries, Allowances & Special Services	52	59	55	52
Equipment, Supplies, Printing & Miscellaneous	29	22	19	19
University Support	17	17	25	28
Travel	2	2	1	1

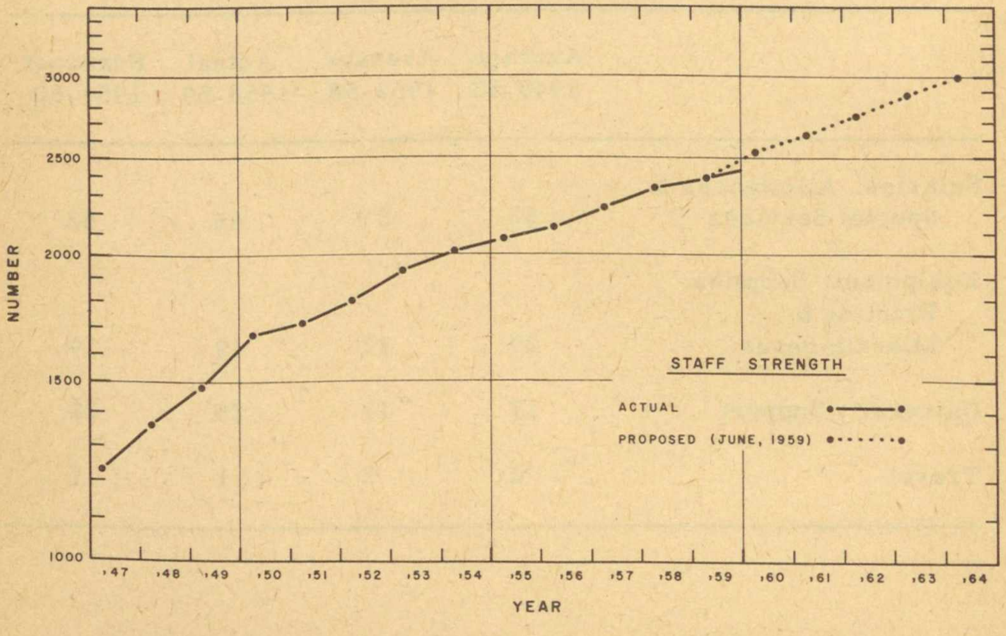
NATIONAL RESEARCH COUNCIL

Staff

The following graph shows the actual increase of staff since the close of World War II with the planned expansion projected for the five year period 1959-64. The first year of the plan has not been met largely because of difficulties experienced in recruiting suitable staff. Table IV breaks down the Council staff by work category. For every scientist there are three complementary people. The engineering divisions require more technicians and a larger service staff than the pure science divisions. This accounts in some measure for the fact that the engineering divisions are the largest ones.

Table V shows the distribution of scientific research staff by field of discipline and level of academic attainment. 57% of the research staff hold the doctorate degree but this general average is much higher in the pure sciences (Biology 90%, Chemistry 85%, Mathematics and Physics 67%) where the doctorate degree is usually required as the minimum for professional status in the research field.

NATIONAL RESEARCH COUNCIL
STAFF STRENGTH
(EXCLUDING ATOMIC ENERGY PROJECT)



NATIONAL RESEARCH COUNCIL

Table IV

National Research Council Staff
1 January 1960

By Work Category	
Scientific	655
Technical	910
General Service	572
Maintenance	290
Total	2427

Table V

National Research Council Staff
Scientific Research Staff by University Course and Senior Degree
(Postdoctorate Fellows Included)

Course	Percentage			
	Bachelors	Masters	Doctors	Total
Biology, Biochemistry and Agriculture	0.2	0.8	8.8	9.8
Chemistry	2.3	2.1	24.2	28.6
Engineering	16.2	11.3	5.7	33.2
Mathematics, Physics and Radio Physics	3.9	4.6	17.3	25.8
Miscellaneous	1.6	0.3	0.7	2.6
Total	24.2	19.1	56.7	100.0

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LABORATORY OPERATIONS

LABORATORY OPERATIONS

Engineering Divisions

Building Research

Technical improvements in housing are the primary concern of the Division of Building Research. The research program therefore covers all aspects of housing design, building materials and components, and fundamental studies on soil, snow, and ice mechanics. Results of the research program are expressed in the National Building Code of Canada, an advisory document for the provinces and municipalities, now in force as the legal building code for over 40% of Canada's population. The Division also establishes the building regulations for all houses built with National Housing Act assistance. Problems of building on permafrost in the far north provide a continuing challenge, and the Division assisted recently in the construction of the Kelsey Rapids hydroelectric plant in northern Manitoba. Special studies of techniques and materials facilitating winter construction have also been made. Well over one hundred technical enquiries from architects, engineers, contractors and manufacturers are dealt with each month.

Mechanical Engineering

This Division works mainly in mechanics, hydrodynamics (hydraulic engineering and naval architecture) and thermodynamics. There is a continuing emphasis on improving Canadian transport equipment and facilities. With work for the St. Lawrence Seaway largely completed, harbour improvement studies for several ports (notably Saint John and Port Cartier) have been undertaken. Laboratory studies and full-scale sea trials are carried out for various vessel types and their components, and the possibilities of improving winter navigation are being investigated. Rail transport studies include diesel and gas turbine locomotives, substitute diesel fuels, and improvements in rolling stock. The development of aircraft for short or vertical take-off and landing - of great military and commercial advantage, particularly in undeveloped areas - is being studied in several laboratories of both the Division of Mechanical Engineering and the National Aeronautical Establishment. The possible use of ozone as the oxidant in rocket propellant combina-

NATIONAL RESEARCH COUNCIL

tions is also being investigated. Extensive testing and specification work is undertaken for a variety of industries and for government departments. A new 100,000 pound range calibration machine, intended as a national standard of force, has been installed.

National Aeronautical Establishment

The National Aeronautical Establishment, comprising the aeronautical, flight and structural activities of the Division of Mechanical Engineering, was established as a separate NRC Division effective January 1st, 1959. The research program concerns problems of high and low speed aerodynamics. Several projects involve fatigue and fail-safe investigation of aircraft components and mechanical systems, and a study of non-metallic structural materials resistant to very high temperatures has begun. Much of the work is now being devoted to civil aviation problems such as vertical take-off and landing, acoustic noise, runway roughness, air traffic control and airport lighting. Important reductions in size and weight have been made to a position-indicator for locating crashed aircraft developed with the Radio and Electrical Engineering Division. A new tri-sonic wind tunnel for investigating radically new forms of aircraft in a speed range up to Mach 4.5 is now under construction. The tunnel is an extremely advanced piece of equipment and compares favourably with similar tunnels anywhere in the world.

Radio and Electrical Engineering

Roughly half of the Division's work consists of defence projects involving the development, production and evaluation of new equipment. A polyurethane foam radome providing weatherproof covering for missile guiding and tracking radars, and believed to be the first of its kind in the western world, is an unclassified example. The rest of the research program involves fundamental problems in electronics and electrical engineering, with emphasis on applications of interest to Canadian industry. The application of electronics to navigational aids, permitting unattended operation of buoys, shorelights and fog alarms, has received considerable attention. The result is greatly simplified apparatus, and greatly reduced operating costs, for equipment formerly difficult and costly to service. A project directed at automatic operation of the beacon light at Sable Island West Lighthouse is underway. A pressure gauge capable of measuring the extremely low atmospheric pressures at satellite altitudes has been developed, and will be installed in a U.S. satellite scheduled for launching later this year to measure the composition of the upper atmosphere. Extensive aurora and meteor programs are also being carried out. In the field of medical electronics the following devices have been put into operation: remote monitors of blood-pressure and heart rate during operations; a venous pressure monitor and pumping rate control for the venous bypass pump used in heart-lung bypass procedures; and an infrared scanner, producing a film record of body temperature distribution in about three minutes, for use in the thermal investigation of breast cancer.

Scientific Divisions

Applied Biology

This Division's program covers practical problems related to the national economy, and fundamental investigations in plant and animal physiology, microbiology, biochemistry and biophysics. Problems of preparing, preserving and storing food constitute a large part of the work. Specific examples include the changes effected in foods during freezing and frozen storage, the cooling and insulating of railway refrigerator cars, controlled atmosphere storage of fruit, the processing and storage of milk, and the tenderness of meat. A statistical study of varying protein content in wheat and wheat exports has been undertaken, and an attempt is being made to discover the influence of various weather factors on the protein content. Although the physical sciences now receive considerable industrial support, fundamental research in

NATIONAL RESEARCH COUNCIL

the biosciences - necessary for further progress in both pure and applied fields - is still largely confined to university and publicly-supported laboratories. The Division is investigating the physiological and biochemical changes in mammals, birds and man in adapting to cold, and early in 1960 will take part in an international study on cold adaptation in Eskimos at Pangnirtung, Baffin Island. Other fundamental work includes the structure and function of plant cells, the chemistry of proteins and lipoproteins, the composition and structure of carbohydrates and fats, and studies of the microorganisms involved in the preparation, preservation and spoilage of food.

Applied Chemistry

The Division of Applied Chemistry works to provide new scientific information needed in the development of Canada's natural resources and chemical industries. The eleven sections of the Division are: analytical chemistry; applied catalysis; applied physical chemistry; chemical engineering; colloid chemistry; corrosion; high polymer chemistry; metallurgical chemistry; physical organic chemistry; rubber, and textiles. Much of the work falls under the headings of petroleum or corrosion chemistry, in that several sections work on topics related to these fields.

Although formerly much of the work involved solving immediate specific problems, the trend in recent years has been toward more general, long-term studies. This avoids conflict with industrial laboratories and consultants and often produces practical, as well as fundamental, results. For instance, studies in applied catalysis (the study of agents altering the speed of chemical reactions) also provided the explanation for certain types of smog formation. Another long-term investigation on the contacting of fluids and solids - an operation vital to many chemical engineering procedures - has resulted in a successful commercial operation for drying grain. The same method can easily be extended to chemical reactions and to removing liquids from other materials. A current project of both military and industrial significance uses lignin (a by-product of the pulp industry) instead of carbon black in reinforcing rubber.

LABORATORY OPERATIONS

Applied Physics

The work in Applied Physics is divided between research projects likely to be of practical value, and development of the fundamental standards on which measurements generally are based. All the fundamental physical standards for Canada are housed and serviced in this Division, which now has primary standards equal to any in the world in the fields of mass, length, time, electricity, temperature, and X- and nuclear radiations. Industrial problems receive considerable attention, particularly calibration work and industrial noise abatement. A new instrument for making maps from aerial photographs has been produced. Smaller than previous models, and involving fewer mechanical components, the machine permits correction by electronic computation of all known errors in the mapping process and indicates eventual automatic map-making. A caesium clock has been put into operation, which substitutes the natural and unchanging frequency of caesium atoms for conventional methods of time-keeping and frequency measurement. The apparatus offers a possible future substitute for the present astronomical basis for time, and is of great importance in scientific experiments where very short time intervals must be measured extremely precisely. The possible use of plasma motors to propel rockets in outer space is being investigated. The radiations group has made a study of the gonadal dose received by adults in diagnostic radiography, and has entered the field of radio chemistry to be able to measure radio isotopes more effectively.

Atlantic Regional Laboratory

Practical and fundamental investigations related to the resources and industries of the Atlantic Provinces are carried out in the Atlantic Regional Laboratory. An efficient method of drying plant materials has been developed over a period of several years for use with economically important plants such as eel grass, Irish moss, rock-weed and kelp. Increasing industrial demand for these seaweeds is indicated, and the equipment offsets drying difficulties brought about by the short, moist summers of the region. The problem of slime in the "white water" of Canadian pulp mills has received considerable attention. Several species of fungi in

NATIONAL RESEARCH COUNCIL

the slime, conditions affecting the growth, and the efficacy of various fungicides, have been established. Apparently the "white water" contains a substance which stimulates the growth of the organisms, and a project is now underway to isolate it and determine its structure. Basic chemistry in the fabrication of steel, which has received little attention from the industry in Canada, is another Divisional topic. This is a long-term project, involving years of investigation of the chemical reactions taking place at high temperatures in blast and open hearth furnaces, and which affect the properties and processing of the final products. The use in Europe of dried seaweed as animal feed has led to a comparison of the biological value of algal proteins. A chemical examination is being made of an extract of a red alga plentiful in some Atlantic areas and which the United States now imports from Denmark for commercial use.

Prairie Regional Laboratory

The Prairie Regional Laboratory studies chemical, biological and engineering processes for turning agricultural crops into industrial raw materials or commercial products. Most effective use of crops and microbes can only be achieved through knowledge of their components and the physiological processes by which compounds are produced. The Laboratory therefore works to arrive at a greater understanding of the plants and microorganisms of the Prairie region. Crops and industries best suited to the irrigation acreage to be opened up by the South Saskatchewan River Project are being reviewed. For some time the Laboratory has studied major plant constituents such as carbohydrates, protein, starch, lignin and fibres. Attention is now being given to the minor components - such as phenols, flavonoids and terpenes, which are known to have fungicidal and germicidal properties - both individually and as they affect the processing and behaviour of the major constituents. A plant extractives laboratory has been set up to systematically study extractives from local plants and shrubs. The chemical structure of glyceride oils has been examined intensively in connection with the development of oil seed crops as alternatives to cereal crops. A new theory of glyceride structure has been evolved, and the study is now dealing with the effects of glyceride structure on the quality of margarines and shortenings. The effects of dietary fats on the glyceride composition and structure of body fats in test animals is also being investigated. A mechanical foam breaker has been developed for the fermentation industry, and efforts have been made to increase the strength of insulating boards without increasing their density.

Pure Chemistry

The Division of Pure Chemistry is concerned with fundamental investigations in physical and organic chemistry. There are thirteen sections in the Division, twelve of which study long-term problems, while the remaining one prepares substances needed by the other sections. The work in organic chemistry includes investigation of the structure of alkaloids, studies of the infrared spectra of steroids, the synthesis of porphyrins and of compounds labelled with isotopes. Other sections deal with chemical kinetics and photochemistry, the study of the ionization potentials of free radicals by mass spectrometry, Raman and infrared vibrational spectroscopy, and the application of high resolution proton magnetic resonance techniques to the study of hydrogen bonding and other molecular interactions. Still others study certain aspects of surface chemistry such as the thermal properties of simple solids and imperfections in the bulk and the surface of alkali halide crystals, the heats of micellization by microcalorimetry, and the thermodynamics and stress-strain relationships associated with the adsorption of fluids by active carbons. There is also a small group interested in the chemistry of fats and oils, and one engaged in fibre research.

Pure Physics

In the Division of Pure Physics, investigations are under way on cosmic rays, low temperature and solid state physics, spectroscopy, theoretical physics, and X-ray diffraction. The work is on long-range, fundamental problems which do not have immediate application but which advance knowledge generally and provide the basis for further progress in the applied fields. The development of Canada's space research program has made it possible to carry out cosmic ray measurements using rockets flown to high altitudes. Great changes in cosmic ray intensity are caused by a flux of particles and moving magnetic fields coming from the sun, and high altitude and sea-level measurements help in studying these changes. The low temperature and solid state group is concerned with the electrical, thermal and mechanical properties of metals and semi-conductors. The now-familiar transistor is a semi-conducting device, and such devices are playing an increasingly important role in industry. The spectroscopy group studies the spectra of atoms and simple molecules with a view to determining their structure. Theoretical problems in atomic, molecular and nuclear physics are investigated by the theoretical physics group. In the X-ray diffraction laboratory, fundamental work in molecular and crystal structure, and identification problems for government laboratories, are undertaken. X-ray diffraction methods are very valuable for identification purposes because they are non-destructive and only require very small amounts of material. Two of the major projects concern narcotics and vanadium minerals.

Medical Research

The Division of Medical Research has no laboratories of its own - it makes grants and awards fellowships for extramural research in Canadian universities and their affiliated institutions. Basic medical investigations and clinical studies are supported. Sixteen Medical Research Associates were supported on a full-time, continuing basis in 1959-60. These are competent medical scientists nominated by universities which provide them with faculty appointments and research facilities. Forty-five Graduate Medical Research Fellowships, designed to enable medical graduates to obtain further training in fundamental research, were also awarded, and a new category - that of senior Postdoctoral Medical Research Assistants - was instituted. Divisional funds for 1959-60 were allocated as follows: annual grants in aid of research, \$627,485 (32% of the budget); grants for terms of three years or longer, \$847,035 (43%); non-recurring equipment grants, \$222,968 (11%); Medical Research Associateships \$134,715 (7%); and Graduate Medical Research Fellowships, \$147,100 (7%).

LABORATORY OPERATIONS

Services

The Division of Administration aims to provide the research organization with efficient services to relieve the scientist as much as possible of time-consuming non-scientific work. Centralizing administrative activities reduces the cost of administration and increases efficiency. The duties are distributed among the following five branches:

Administration

Administrative Services where all the normal administrative duties, such as purchasing, personnel, and general services for accounting, registry, transport, duplication, stenographic assistance, etc., are handled.

Legal and Patents Branch responsible for the processing of patents and handling of all legal matters affecting the Council's operations. The development and promotion of patents is handled by Canadian Patents and Development Limited, a crown company subsidiary to the N.R.C.

Plant Engineering Services to maintain general laboratory utility services of all kinds, and to plan and supervise alterations and minor construction jobs.

Awards and Grants

The Awards and Grants Office to look after all matters connected with the foundation side of the Council's program, including scholarships, postgraduate fellowships, grants-in-aid to universities, grants to associate committees, and the administration of the scientific publications office.

Information

The Information Branch responsible for the library, the liaison offices, public relations office, technical information service, economic studies, and international scientific relations.

EXTERNAL ACTIVITIES

NATIONAL RESEARCH COUNCIL

Awards and Grants

Immediately following its establishment in 1917, the National Research Council made a survey of research personnel in Canada; the results clearly indicated that the number of trained research men competent to undertake independent investigations was woefully inadequate. One of the main duties of the newly-formed Council, then, was to find some means of adding to the number of trained researchers.

To this end, scholarships for postgraduate research work in science were established by the Council in 1917; these have been awarded annually on a competitive basis to outstanding graduates who have given evidence of developing into investigators capable of conducting independent research in their chosen fields of science. The Council's scholarship program has been expanded greatly in the past few years to meet the increased need for scientists and engineers throughout the country.

Furthermore, to encourage the development of research centres in Canada, the National Research Council undertook to support worthwhile researches being directed by competent senior investigators in the universities of Canada. The recent demands on this program also have been very heavy due to the great expansion taking place in Canadian universities.

The Council's original aims are being achieved, as can readily be seen from a glance at the names of early scholarship holders and research assistants employed under grants. Numbered among them are directors of provincial research organizations, university presidents, heads of science departments in many Canadian universities, and directors of research in federal government departments, as well as several of the directors of the NRC laboratories and the President of the Council itself.

EXTERNAL ACTIVITIES

Associate Committees

Early in its history the National Research Council evolved a method of carrying on cooperative research on subjects of general and regional interest. Associate Committees have proved useful and effective throughout the years; they have provided a mechanism whereby hundreds of specialists have brought their experience and knowledge to bear on the solution of problems put before them.

The Council takes the initiative in bringing together those best equipped to deal with scientific and technical aspects of current problems, combining in Committees the wide practical experience of industrialists with the special technical knowledge of scientific workers.

A Committee may study a problem in conference, assess the current knowledge relating to it and recommend a course of action to be followed. It may have funds at its disposal for the cost of special research projects or its function may be a coordinating one. When the task assigned to it is completed, a Committee is disbanded, and when new problems arise new Committees are formed.

At the present time there are 39 Associate Committees, with varying numbers of subcommittees, covering the following subjects:

Aerodynamics
Animal Nutrition
Aquatic Biology
Automatic Controls
Aviation Museum
Building Code, National
Building Research
Control of Infections
Corrosion Research & Prevention
Culture Collections of Micro-organisms
Dental Research
Electrical Insulation
Engines Research
Fats and Oils
Fire Codes, National
Food Preservation
Forest Fire Protection
Geodesy & Geophysics
Grain Research
High Polymer Research
Mathematics, Pure
Medical Research
Oceanography
Parasitology
Photographic
Plant Breeding
Plant Diseases
Prairie Regional
Psychology, Applied
Publications & Abstracting Service
Radio Science
Railway Problems
St. John N.B.Harbour Model Studies
St. Lawrence River Model Studies
Scientific Information
Soil & Snow Mechanics
Space Research
Waves & Littoral Transport
Wildlife Research

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NATIONAL RESEARCH COUNCIL

Grants-in-Aid of Research

The National Research Council has provided over 36 million dollars in grants for research in Canadian universities, hospitals and other institutions since 1917. These grants enable senior members of university faculties and of the staffs of other institutions to engage in approved research investigations of their own choosing, or to cooperate in some phase of a planned program that is sponsored by the Council through one of its Associate Committees. The funds made available may not be used to remunerate the grantee but are applied to the purchase of special equipment and supplies necessary to the prosecution of the investigation and to the employment of students or other assistants. These grants provide funds for annual operating expenses including salaries, supplies and some equipment, but as many of the modern scientific tools for research are very expensive, separate grants are made to provide funds for purchasing major pieces of equipment, or to provide an installation that can be used by investigators in a number of university departments.

Prior to 1946, all grants were held by individuals at Canadian universities, but since that time grants have also been made to investigators in other institutions. In 1946, too, the scope of the Council's interests was broadened by the establishment of a Division of Medical Research and an Advisory Committee on Medical Research; since the Council maintains no medical research laboratories of its own, all funds allocated to this division for purposes of research are in the form of grants-in-aid of research carried on extramurally in hospitals and other institutions.

In addition to its own grant program, the Council has, since 1949, been responsible for the administration of the funds provided by the Atomic Energy Control Board for grants which it authorizes.

Other activities closely related to the research grant program and receiving financial support from the National Research Council include work carried on under research agreements, affiliations with international scientific organizations and participation in their meetings, cooperation with Canadian societies and organizations, i.e. Royal Society of Canada, Canadian Mathematical Congress, Canadian Standards Association, National Conference of Canadian Universities, etc. Approximately $175,000 was contributed toward the cost of these activities during 1959-60.

EXTERNAL ACTIVITIES

Table VI

Expenditures on Grants-in-Aid of Research 1959-60

Grants-in-Aid of University Research		
Science & Engineering	$4,818,000	
Atomic Energy*	650,000	
Medical	1,735,000	
		$7,203,000
Grants to Provincial Research Councils		70,000
Associate Committees' Administration		110,000
International Affiliations		12,500
Special Activities		147,500
Grant to Royal Society of Canada		17,000
Total		$7,560,000

*Funds provided by Atomic Energy Control Board.

NATIONAL RESEARCH COUNCIL

Scholarships

When the Council's scholarship program was instituted in 1917, 5 fellowships valued at $1000 each and 20 studentships valued at $600 each were offered. The number of graduate students in science in Canadian universities at that time, however, was so limited by the requirements of military service that only three fellowships and four studentships were awarded.

Following World War I, the number of scholarships awarded, as well as their value, increased slowly but steadily, until in 1931-32 5 fellowships, 22 studentships and 25 bursaries, valued at $1000, $750 and $600 respectively, were awarded. In 1932, the National Research Council's laboratories were formally opened and the increased obligations in connection with their operation, combined with a substantial reduction in the Parliamentary appropriation, made it necessary to curtail the scholarship program to a considerable extent. However, this setback was only temporary; with the outbreak of World War II and the great demand for trained research scientists, the number of scholarships awarded increased steadily until in 1945 it had reached the point which might have been attained had the temporary curtailment not been necessary. Following the war, expansion of the program was extremely rapid due to the large number of qualified university graduates anxious to continue their scientific training, and to the inauguration of medical and dental fellowships which were offered for the first time in 1946. Between 1917 and 1959 the National Research Council has provided about 5.3 million dollars for 4061 scholarships and fellowships which were held by 2472 individuals. During the present year, 149 studentships and 111 bursaries are being held by graduate students in Canadian universities, and 36 students are studying for advanced degrees at universities in the United Kingdom, United States, and Western Europe. The last group of students hold special scholarships awarded by the Council.

EXTERNAL ACTIVITIES

Table VII

Scholarships and Fellowships Held 1957-59*

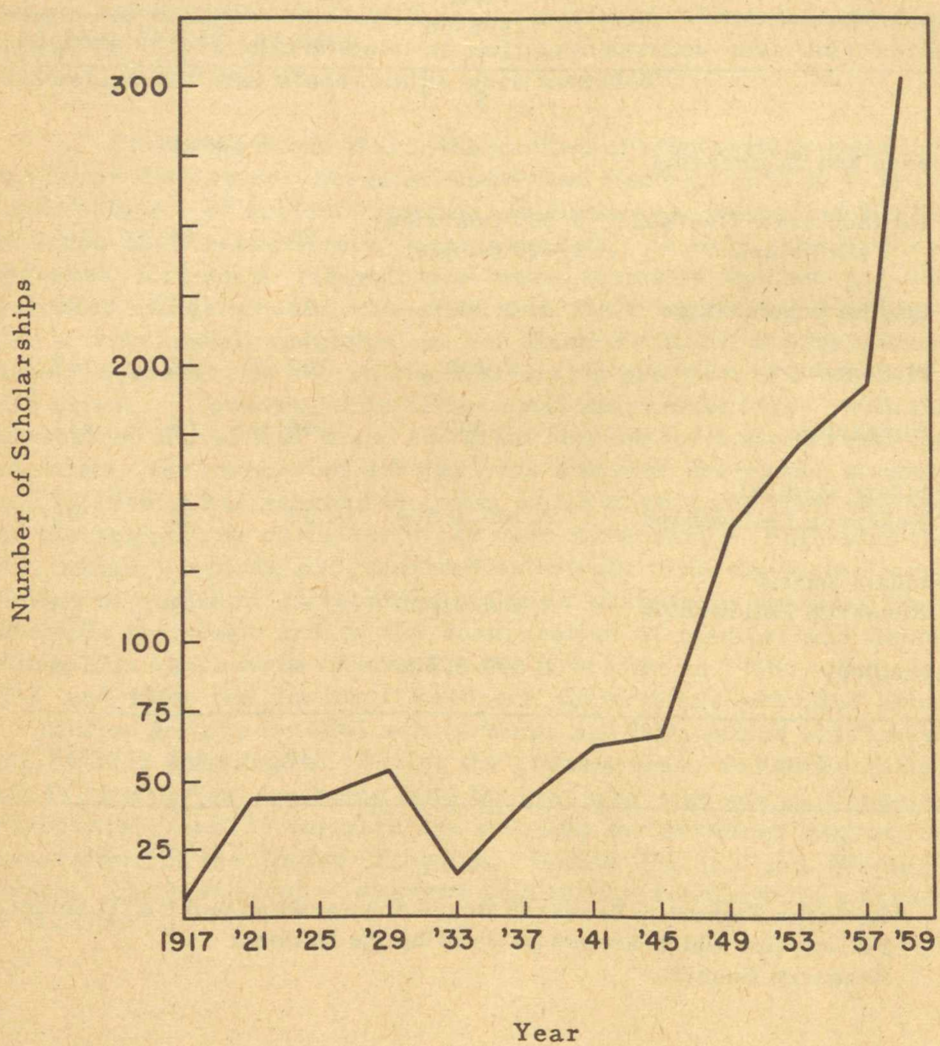
Type of Award	Value 1959-60	Number Held		
		1957-58	1958-59	1959-60
	$			
Science and Engineering				
Postdoctorate Overseas Fellowships	3,500 (married) 2,700 (single)	21	18	12
Special Scholarships	2,200	36	42	36
Studentships	2,200	105	112	149
Bursaries	1,800	46	68	111
Graduate Medical Research Fellowships	2,300-4,500	18	30	45
Graduate Dental Research Fellowships	2,500-5,000	-	3	4
Psychology	1,800-3,500	4	8	6
Total		230	281	363

*Excludes Fisheries Research Board Scholarships and NATO Science Fellowships which are not paid for by the National Research Council.

NATIONAL RESEARCH COUNCIL

Figure 3

Scholarships Awarded, 1917-59



EXTERNAL ACTIVITIES

Postdoctorate Fellowships

While the National Research Council has emphasized the need for supporting students and research in Canadian universities, it has not been unaware that opportunities and facilities for training in all branches of science are not equally advanced in these institutions. It has also recognized the value accruing to a student from association with leading scientists in other countries. Before World War II, a few special scholarships were granted for post-graduate study outside of Canada. After the war, this program was expanded and since 1948 a limited number of Overseas Fellowships have been awarded annually to Canadian students.

To complement this program, the practice of awarding postdoctorate fellowships tenable in the Council's own laboratories, instituted before the war on a very limited basis, was resumed on a much larger scale and with a much broader concept of purpose. These fellowships are awarded in open competition to Canadians and nationals of other countries. This phase of the postdoctorate fellowship program has been extended to the science departments of Canadian universities and to other Federal Government laboratories. The benefits accruing from such a program are many; not only do young scientists from other countries have an opportunity of working with internationally recognized senior Canadian scientists but they bring with them a diversity of training, experience and ideas which have a highly stimulating effect on the research effort within the laboratory groups with which they are associated.

Overseas Fellows receive a stipend of $2700 per annum (or $3500 if they are married) while Fellows at the Council's and Government laboratories and in the universities receive $3700 per annum (or $4500 if they are married). Travel grants to enable the Fellows to reach the laboratory in which the award is to be held are made in all cases.

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NATIONAL RESEARCH COUNCIL

Table VIII

Postdoctorate Overseas Fellowships and NATO Science Fellowships*

Year	Applications Received	Awards Made	Awards Accepted
1948-49	8	3	1
1949-50	10	6	4
1950-51	22	7	7
1951-52	29	7	6
1952-53	19	5	5
1953-54	39	14	13
1954-55	35	17	16
1955-56	50	22	21
1956-57	45	21	17
1957-58	53	21	21
1958-59	53	20	18
1959-60	46	25	22

*NATO awarded for first time in 1959-60

Table IX

Postdoctorate Fellowships
Tenable in the Laboratories of the
National Research Council
Federal Government Departments and Agencies
Canadian Universities

Total Number of Awards 1948-60		1444
Less Number Declined		383
Total Number of Awards Held 1948-60		1061
Less Number Terminated		828
Awards Currently Held		
National Research Council	138	
Department of Agriculture	16	
Department of Mines & Technical Surveys	9	
Department of National Health & Welfare	3	
Atomic Energy of Canada Limited	9	
Grain Research Laboratory	1	
Fisheries Research Board	1	
Universities	53	
To be taken up (NRC - 1 and Universities - 2)	3	
		233

EXTERNAL ACTIVITIES

Assistance to Scientific Publications

To provide a medium of publication, in Canada, for the results of research in certain fields of science, the National Research Council issues six scientific periodicals. Four of these were established (originally as a single journal) in 1929, another was started in 1944, and one in 1954. A seventh journal (The Canadian Journal of Technology) was published from 1944 to early 1957. The table below shows the growth of these publications during the period 1945-59.

Table X

Research Journals
Average Total Number of Pages Published 1945-59

Canadian Journal	Annual Average Total Number of Pages				
	1945-47	1948-50	1951-53	1954-56	1957-59
Physics	200	446	840	1066	1557
Chemistry	396	875	1153	1615	1810
Technology	426	532	387	381	129*
Botany	276	589	749	854	1093
Zoology	194	344	471	535	976
Biochemistry & Physiology	218	354	461	1013	1375
Microbiology	--	--	--	519	782
Total	1710	3140	4061	5983	7722

In addition to the journals published under its auspices the Council makes grants to assist reputable Canadian publications in such other scientific fields as mathematics and psychology.

*Discontinued after two issues in 1957.

NATIONAL RESEARCH COUNCIL

Interdepartmental Service

Early in World War II the Council was designated as the research laboratories for the Army, Navy and Air Force. War work for all the services expanded rapidly in laboratories located across Canada. After the end of hostilities these laboratories were set up under a new organization, the Defence Research Board, in the Department of National Defence. At a later date the Council's Atomic Energy Project became Atomic Energy of Canada Limited. However to avoid duplication of expensive facilities it still remains necessary for some defence work to be done in the Council's laboratories. This is particularly true for radio, radar and aeronautical investigations. Although a large part of our interdepartmental service is related to national defence our facilities are such that it is often necessary for the Council to undertake such large scale investigations as the Design and Construction of a Model of the St. Lawrence Seaway for the Department of Transport and numerous smaller investigations for other departments.

Patents

The Patent Section assesses the patentability of developments made in the laboratories, universities, or other Government departments or agencies. Inventors report through their department head to the Patent Section on anything that appears to be new and useful as required by the Public Servants Inventions Act.

This Section cooperates with Canadian Patents and Development Limited, a Crown Corporation. The Company arranges to obtain patents on inventions originating in the National Research Council, Government departments, and other agencies and also handles the development and licensing of these patents. After awards are made to the inventors in accordance with the Public Servants Inventions Regulations, profits are used for further research and development.

EXTERNAL ACTIVITIES

Scientific Liaison Offices

To facilitate scientific exchanges with other countries, the Council maintains Liaison Offices in Ottawa, London and Washington. In London and Washington the Liaison Officers are the Scientific Attaches at the Office of the High Commissioner and the Canadian Embassy respectively. Originally established as information centres, the Liaison Offices have recently played increasingly important roles in international scientific developments.

Technical Information Service

Technical Information Service of the National Research Council was established in 1945 to encourage the widest possible utilization of available scientific and technological information by Canadian industry. In coordination with the provincial research councils, Technical Information Service maintains a staff of trained scientists and engineers who visit industrial establishments to learn of their difficulties and technical problems. The central office maintained by the Council in Ottawa uses the resources of the Council and other Government departments to supply answers to the problems submitted to them. Since its inception in 1945 Technical Information Service has answered over 40, 000 enquiries.

NATIONAL RESEARCH COUNCIL

For Further Information

The National Research Council Review, 1959. N.R.C. No. 5251.

The Forty-Second Annual Report of the National Research Council, 1958-59. N.R.C. No. 5250.

National Research Council List of Publications. N.R.C. No. 3000.

Report on University Support.

Announcements and regulations for:

- Grants-in-Aid of Research
- Scholarships and Fellowships
  - Science, Engineering,
  - Medical and Dental Research
- Postdoctorate Fellowships
- NATO Science Fellowships
- Fisheries Research Board Scholarships
- Shell Oil Scholarships

HOUSE OF COMMONS

Third Session—Twenty-fourth Parliament

1960

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: J. W. MURPHY, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 2

NATIONAL RESEARCH COUNCIL

THURSDAY, JUNE 9, 1960

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

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1960

23266-0—1

SPECIAL COMMITTEE ON RESEARCH

Chairman: J. W. Murphy, Esq.

and Messrs.

Aiken	Forgie	Nielsen
Batten	Fortin	Payne
Best	Godin	Peters
Bourget	McLellan	Smith (*Winnipeg North*)
Brunsden	McQuillan	Stewart
Cadieu	McIlraith	
Dumas	Morissette	

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

ORDER OF REFERENCE

WEDNESDAY, June 8, 1960.

Ordered,—That the names of Messrs. Bruchési and Grafftey be substituted for those of Messrs. Fortin and Morissette respectively on the Special Committee on Research.

Attest.

LÉON-J. RAYMOND,
Clerk of the House.

23266-0—1½

MINUTES OF PROCEEDINGS

THURSDAY, June 9, 1960.
(3)

The Special Committee on Research met at 9.40 a.m. this day. The Chairman, Mr. J. W. Murphy, presided.

Members present: Messrs. Aiken, Best, Bruchési, Brunsden, Dumas, Grafftey, McIlraith, Murphy, Nielsen, Payne and Peters—11.

In attendance: From the National Research Council of Canada: Dr. E. W. R. Steacie, President; Dr. F. T. Rosser, Cice-President (Administration); Mr. F. L. W. McKim, Administrative Services; and Dr. J. B. Marshall, Awards and Grants.

Dr. Steacie continued his review of the booklet entitled "Organization and Activities", and was questioned by Members of the Committee.

Among the topics referred to were: Grants-in-aid of Research; the advantages and disadvantages of an endowment system of financing research; the encouragement of students to enter the sciences; and technological developments in the U.S.S.R.

Membership Lists of the Canadian Government Specifications Board and of other National Research Council Associate Committees, were tabled with the Committee.

At 11.00 a.m. the Committee adjourned to the call of the Chair.

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

EVIDENCE

THURSDAY, June 9, 1960.
9.30 a.m.

The CHAIRMAN: Gentlemen, I am very glad to see a quorum so early in the morning. Also I am sorry about the other morning. Some members unavoidably were detained by reason of rather poor plane service and in addition there were several other committees meeting. The members of our party have been advised that if they wish to remain on this committee they must attend. This is a very important committee. The new members will be more impressed perhaps after another meeting or two. Each meeting will be more interesting than the previous one.

This morning again we have Dr. Steacie with us together with his officials. He will continue this morning with his comments and then the meeting will be open for ideas from the members of the committee.

Dr. E. W. R. STEACIE (*President, National Research Council*): At the last meeting I was going through this booklet. I had reached page 33. I had mentioned that in order to keep in touch with provincial governments, universities and industry we had established a committee structure. At the last meeting I tabled the list of the associate committees and their membership. There is a list of these committees on page 33. All told they involve 759 people.

There are certain other committees. The international organization of science is mainly composed of the so called international unions. We are responsible for Canada's membership in most, but not all, of the international unions. There are a few others which specifically are related to the activities of a government department which is the adhering body. We have a number of national committees concerned with these unions. I might perhaps put on the record a list of these. They are as follows:

Canadian national committee on biochemistry;
Canadian national committee on biological science;
Canadian national committee on crystallography;
National committee on international commission on illumination;
National committee for the international union of history and philosophy of science;
Canadian national committee on nutritional sciences;
National committee on pure and applied chemistry;
Canadian national committee of international union of pure and applied physics;
National committee on physiological sciences;
Canadian national committee of U.R.S.I.—associate committee on radio science;
National committee on institute of refrigeration.

In respect of the associate committees, may I do as I did previously and just table it in place of putting it on the record. These involve 89 people altogether. There are duplicates; there will be some persons on more than one committee. The total membership is 89.

There are two other things which involve a very large committee structure. One of these is the associate committee on the national building code. This building code is put out as an advisory document. Any municipality in

Canada which wishes may adopt this as its building code with or without amendments. In fact at the present time a large proportion of the municipalities in Canada have adopted this. It has no legal significance. The municipalities are the responsible bodies. This is quite an undertaking. It means dealing with the fire prevention organizations, fire chiefs and people of that sort, those responsible for electrical or other hazards, dealing with the construction industry, the construction materials industry, the association of mayors of municipalities, building inspectors and so on. What has been done is that a network of committees has been set up. For example, there is a committee on reinforced concrete consisting of people from universities, municipalities, cement companies, the construction industry, ourselves and so on. I have a copy here. May I table this. It will in that way be available to any members who wish to see it. We could get extra copies. This consists of 258 people on the various committees.

The CHAIRMAN: Is it agreed that this be tabled?

Agreed.

The CHAIRMAN: Would you wish to have copies for all the members?

Mr. AIKEN: I think if it is tabled it would be available to the members.

The CHAIRMAN: In respect of the reports of our proceedings, I am hoping we might be able to have these a little earlier than at present.

Mr. BEST: I am told that our first report came out yesterday. That is eight days after our first meeting. I wonder if the clerk possibly could see if the printing might be speeded up.

The CHAIRMAN: Mr. O'Connor, would you see what can be done. We are going to have meetings twice a week and I think it is important for the members that we have the reports before us at each meeting.

Dr. STEACIE: There is another large one; it is the Canadian government specifications board. The idea, of course, is to try to get uniformity in government purchasing specifications. Really it is a function of treasury, but it has been delegated to us. This involves drawing up specifications on a very wide variety of things. I have here a membership list. This involves 569 people from government and 1,580 from outside. The result of this is that specifications are drawn up which are first of all sent to government departments and also are sent to industry. I think this has been a useful function. I would like to table this document.

Mr. BRUNSDEN: What are the main fields.

Dr. STEACIE: Everything under the sun. Perhaps the most trivial is a subcommittee on pencil sharpeners. Then there are things like textile materials for the armed forces, penitentiaries and so on; in this respect the government is a very large purchaser. It also includes things like paper, waxes and polishes. There is a committee on the standardization of envelopes, which I think has reduced the number of sizes of envelopes used in the government from 150 to 20 or something in that order. I am guessing. In the main these are more solid items. The main items are things such as paints, pigments and related commodities. It includes leather, paper products, fire hose, chemicals and so on. This of course primarily is designed for bulk purchasing. In other words all government organizations will have a great many specific requirements for small quantities of things, in which case they would not want to use these specifications.

Mr. BRUNSDEN: Is it not a little hard to relate this to research.

Dr. STEACIE: What happened is that this was given to us as a function when it was first formed, mainly because it was difficult to find any place else to put it. There is an active discussion going on at the moment which I think will result in this ceasing to be a Research Council function within the next year or two.

Mr. BRUNSDEN: That will not make you unhappy.

Dr. STEACIE: Not a bit. Actually, I think it is a very useful job. Somebody has to do it. From this point of view, for a number of years we merely have been suggesting that we thought it was somebody else's function. However, in no way did we have any desire to wreck the scheme by trying to walk out of it. Actually, it is in our act that we are responsible for specifications, but the act is old; it has evolved over the years and there are a great many things in the act which in fact we do not do. So I would welcome the transfer of this when the time comes. We have hesitated to make life too difficult for those involved because we felt it was a useful function. When this happens it will involve the transfer of about 20 people from our organization to whatever other organization might be set up.

May I table this document? It gives a list of those available.

The CHAIRMAN: Is this agreed, gentlemen?

Agreed.

The CHAIRMAN: Have you enough copies, doctor, that the members could have this morning?

Dr. STEACIE: I have not copies available this morning, but I could get them. Would you like them available for the whole committee?

The CHAIRMAN: It will be included in the next minutes.

Dr. STEACIE: I am only tabling this at this time, but if the members of this committee would like copies they could be made available.

The CHAIRMAN: I think we should all have a copy. Thank you.

Mr. DUMAS: I think we should have copies if at all possible.

The CHAIRMAN: Yes, I think this is very important.

Dr. STEACIE: We will have copies available at the next meeting.

The CHAIRMAN: All right. Continue now doctor.

Dr. STEACIE: There are two other groups of committees. We have several small screening committees to deal with grants and scholarships. This involves 30 people. Our council itself involves 21 people. If you add all these up you will see that this structure involves 3,306 members. Fortunately most of these committees do not meet often, but I think that it has been a useful network of committees.

Mr. AIKEN: Mr. Chairman, I would like to ask Dr. Steacie if most of these committees are voluntary or whether some of them have paid attendants.

Dr. STEACIE: None of them is paid. The general principle has been that our own council, for example, apart from myself and the vice-presidents who are government employees, serve without compensation. They receive, of course, their travelling expenses and living expenses while attending meetings.

Mr. AIKEN: Are those expenses paid by the council or are they paid by the organization to which the attending member belongs?

Dr. STEACIE: Their travelling expenses are paid by the council.

Mr. AIKEN: Yes.

Dr. STEACIE: They receive no compensation. They receive solely their expenses while travelling. In cases like the Canadian government specifications board and the national building code, and associate committees, it is felt that these are coöperative things and benefit the organization which the individuals come from as well as the government, and science as a whole, so that our general policy has been that when these people are members of our committees, if they are employees of a federal government department, that department pays their travelling expenses. If they are employees of a provincial government we expect the provincial government to pay this expense, and we do not pay it. If they are employees of an industry, then we do not pay the expenses.

Mr. DUMAS: What is your policy in regard to members from universities?

Dr. STEACIE: In regard to members from universities we do pay the expenses. This would apply also to the occasional case of a former employee of an industry who is now retired, or something of the sort. However, if he is actually working for an industry or a government we do not pay his expenses. If the member is working for a university, then we do.

The CHAIRMAN: Doctor, would you amplify for the members of the committee a point you made this morning which I thought was very important? You said there were 30 some odd members in regard to universities considering grants, degrees and bursaries.

Dr. STEACIE: Yes. We would like to come later to a discussion in detail of the university support, and table reports in this regard. There are approximately 30 people involved in small screening committees who make recommendations in each scientific field in respect of scholarship selections and to grants for research.

The CHAIRMAN: Are there 30 members from each province?

Dr. STEACIE: No, 30 persons altogether.

The CHAIRMAN: I mean from each province?

Dr. STEACIE: They will be spread across the country.

The CHAIRMAN: Yes.

Dr. STEACIE: We would like to feel that, in considering our university support, we do our best to be objective and our best to ignore the province from which the man comes, or the university from which he comes.

The CHAIRMAN: In other words, when an applicant makes an appeal to your council for assistance he is regarded as a number, is that the idea? He is considered on the basis of his merit only?

Dr. STEACIE: Yes. I would not say he was regarded as a number. There are two types of people. One type is the student applying for a scholarship. In this case we consider his academic record but we also try to consider him as a person. We know his history and we know whether he has published papers and what work he has done. We would also receive recommendations from the members of the university staff.

In the case of a grantee, the university professor applying for a grant, our main idea is to try to avoid treating him as a number, but make use of the fact that you have a group of people who know the work he is doing in detail, and try to assess not only the problem but the man and support him on the basis of his scientific merit and reputation.

The CHAIRMAN: I am glad that you have made that statement doctor.

The point I would like to raise next has regard to professor scholarships. You are involved in that respect, are you not?

Dr. STEACIE: I am not sure what you mean by "professor scholarships".

The CHAIRMAN: In the case of a professor in a university who needs higher schooling, do you consider him?

Dr. STEACIE: We would normally consider first those people who are not on university staffs but who are in graduate schools. Secondly we would consider grants to professors in universities for the carrying on of research in their own university, but not for the sake of their own education. Once in a while if a professor is going on Sabbatical leave we might consider, for example, assisting him in travelling, or something of that sort; but in general these grants are made for the use of the university professor in the way of providing research facilities, including the hiring of assistants. But they are not personal payments to the university professor at all.

Mr. BRUNSDEN: I take it you are more interested in recruitment than the advancement of an individual.

Dr. STEACIE: We are very interested in the advancement of the individual, but we generally feel that it is not our function to pay the salaries of university staffs. I think if we started doing that we would definitely be tampering with the freedom of universities.

The CHAIRMAN: Doctor, could you tell the committee, with respect to professors of university scholarships, is that one of your projects?

Dr. STEACIE: I do not like to use the words "professor scholarships" because I am not clear what this means. We grant no scholarships to professors.

The CHAIRMAN: Do you grant scholarships to teachers or lecturers?

Dr. STEACIE: We never grant a scholarship to a teacher or a lecturer. We grant scholarships to students who are taking higher degrees.

The CHAIRMAN: You do not grant scholarships to instructors?

Dr. STEACIE: No. In the rare case, if a young instructor applied for an overseas fellowship we would sometimes consider it; but in general we make grants to university professors for the sake of enabling them to carry on research. We expect them to be already educated before they join a university staff. Up to the time that an individual is educated we would support him as a graduate student.

The CHAIRMAN: Just so that we will have this clear, is it part of the program of your organization to have a scientific team on every campus?

Dr. STEACIE: We are concerned with the development of university research in this way; our function is to do anything we can to improve Canadian science. From this point of view we have taken the general attitude—and there may be occasional exceptions—that our purpose is to make grants in aid of research. In other words, we expect that a man in a university will be paid by the university. We expect that if he is to do any research the university will have to make sure that his teaching load is not such that he does not have time for research, and that the university will provide the basic facilities. We will then make a grant to aid him in his work.

As a consequence of that, what we are trying to do is encourage anyone we see showing signs of doing anything. We hope that ultimately this will lead to activity in all scientific departments in all universities; and in fact it is doing this. The initiative has to come from the university, in the sense that they have to hire the man first.

The CHAIRMAN: I hope the committee members will go into this subject in some detail during their general questions because I would like to see a scientific team on every university campus. However, we will go into that later.

Dr. STEACIE: We would certainly like to see that too, and I think we are producing this. We have, however, felt that it is not our function to hire university staffs. We feel that we have to avoid tampering with the freedom of universities. The moment a university gets a man who wants to do research, and if he is competent, we will do everything we can to provide him with the facilities, with the assistants and with the equipment to do his research. I think we have succeeded over the years in playing a large part in the development of research groups in practically every subject in all the major universities.

Mr. BRUNSDEN: Do you have any control over the type of research, or the particular research problem, sir?

Dr. STEACIE: We try to avoid exercising any control whatsoever.

Mr. BRUNSDEN: In other words you have no "yes or no", but take science as a broad field, so that if someone wants to do research in regard to the Athabaska oil sands in Alberta, you go along with it?

Dr. STEACIE: We would be concerned with the man's record.

Mr. BRUNSDEN: You would go along with it regardless of the research problem?

Dr. STEACIE: If he is a competent man to do the work, regardless of the problem, we would consider it. The only way in which a problem itself would become a major consideration would be if we were in doubt about the man himself, and if the problem were so ridiculous it might confirm our view that he was not a good man.

If, however, he had a reputation of being a good man we would, in view of his scientific reputation, encourage him to carry on.

Mr. BRUNSDEN: In other words you emphasize the man all the way through?

Dr. STEACIE: We emphasize the man all the way through. The moment we start to place emphasis on the project we would be effectively controlling the direction of university research itself. We are trying to avoid exercising this control in every possible way.

The CHAIRMAN: Is it your idea, Dr. Steacie, that universities should be concerned with pure research?

Dr. STEACIE: That is true, within limitations. I feel that the main function of the university should be pure research. In considering an engineering faculty it is obvious that the research must be applied to some degree. Here again you can do research in engineering that is of a basic kind rather than research that is of a very narrow ad hoc practical type; but in general we try to develop research in all fields, including applied fields. What we are trying to avoid is steering universities in the applied direction because we do not feel they should be steered in that dierction. We feel, if anything, that a university should be steered in the opposite direction to the applied research. Applied research, by and large, is something that should be done in government organizations and in industry.

Mr. DUMAS: Dr. Steacie, how many Canadian universities are receiving grants in aid of research?

Dr. STEACIE: Twenty-two, I think.

Mr. DUMAS: Does that include all Canadian universities?

Dr. STEACIE: With regard to the number of Canadian universities, this is a difficult figure to arrive at. You have a mixture of things to consider. For example in the university of Toronto you have universities like Victoria university which in fact is a constituent part of the university of Toronto. Do you call it a separate one or not? If you go across the country you will find in Alberta that you have two campuses but one university. This is true in all the western provinces; you have only the one university. In Ontario you have a number, and these include the older universities. This also includes some universities that are just starting. For example in Ontario you have Waterloo university and Carleton university. They are very recent. You also have some that are so recent that nothing has happened as yet. Sudbury is a good example of that.

The CHAIRMAN: Which university did you mention?

Dr. STEACIE: Sudbury.

Mr. AIKEN: Would you include Laurentian?

Dr. STEACIE: And Laurentian, yes. We have already given grants to Carleton and we gave grants to Waterloo. I am perfectly certain that we will be giving grants to Laurentian as well.

Mr. BEST: I believe Mr. Aiken is on the board of regents for Laurentian. He is primarily interested in that university.

Dr. STEACIE: You may certainly pass this information on with pleasure.

Another good example of this is Assumption, where essentially research was not done. Then there was the reorganization, and since then we have been giving grants.

The CHAIRMAN: Did they become an affiliate of Western?

Dr. STEACIE: Assumption is now a separate university, with Essex college an integral part of the university.

The CHAIRMAN: They were formerly part of Western?

Dr. STEACIE: It was formerly Western.

There are small universities that are essentially what could be called liberal arts colleges that do not do any graduate work and have no interest in research. These are very few in number, and very small. All the universities that are trying to do anything in the way of research we support.

Mr. DUMAS: Would you say something in regard to the universities in Quebec in this respect?

Dr. STEACIE: In so far as the universities in Quebec are concerned I would say that the development in research in the university of Laval and in the university of Montreal has been quite spectacular over the last 30 years, but in particular since the last war, so that we are now giving quite large support to McGill, Montreal, and Laval, which are three of the major institutions doing research.

Mr. DUMAS: Could you say something in regard to the Sherbrooke university?

Dr. STEACIE: At the present time there is a small grant to the Sherbrooke university. There has been a grant to one man. I had a talk to the rector just after the university was formed and I am sure that once they get going, we will be making grants to Sherbrooke. At the present time we are waiting for applications.

Mr. DUMAS: Are you supporting Bishop's university?

Dr. STEACIE: Bishop's university does not do very much research, but at times some research is carried out. We have supported particularly professor McCubbin of Bishop's, whenever he has applied for support.

The only university in Canada that we specifically do not support is the Royal Military college. The reason for that is that the Royal Military college, although it is now a university, is financed by the federal government. We feel therefore that it would be foolish for one federal organization to support another federal organization.

The CHAIRMAN: Dr. Steacie, I think the committee would be interested, since Mr. Dumas has raised this interesting question with respect to the Quebec universities, in what your organization is doing with respect to the humanities and the classic education in which they persevere more than we do in the other provinces.

Dr. STEACIE: We are doing nothing, sir. According to our terms of reference we have no responsibility for education, as such. We have responsibility for research in science, and the definition of "science", from this point of view, is natural sciences—in other words, what is usually called science, engineering and medicine, but not the social sciences or humanities. We, therefore, do not support these fields; nor do we support undergraduates: that is, all scholarships we give are for students proceeding to research degrees; and education is not our province.

In effect, the Canada Council was set up with rather similar terms of reference to ours, to take care of these fields.

In Quebec what happened over the last thirty or forty years is that there was a time when there was not a great deal of attention devoted to the sciences in the French-speaking universities in Quebec; so that in the twenties, for example, most of the research that was being done in Quebec was being done at McGill. This was because the French universities were primarily interested in the humanities and social sciences.

In the last thirty or forty years there has been a very big development of sciences in the French universities, and I think myself and feel sure the rectors of these universities would agree with me that the National Research Council has had a lot to do with this development of science in the French universities. There has been very considerable support, particularly to Laval and Montreal.

The CHAIRMAN: Your records will show the amounts that have been granted?

Dr. STEACIE: Yes, these could be produced. We publish a report on grants. Anybody who wants to take a calculating machine and sit down and take the time, can break these down into universities. We always avoid publishing in a form which gives a breakdown by province or by university, because what we are attempting to do is to ignore the province and the university, and to decide on the man, the activity and the quality of the work. I cannot tell you off hand the support over the years, but we could find it out. At the present time I think the position is this, that we always over-support the university that is on the way up. In other words, if you take a new university, formed in the last year or two, and compare this, say, with Toronto, we might make a grant to a member of the staff of a new university, whose reputation was not outstanding whereas we would probably turn him down if he was on the staff at Toronto; the reason for this being that if he is a border line case we will lean over in his favour in a new institution, but be more critical for one in an older institution. We expect, as the new universities develop, that they will come to the stage where it is support that we give them rather than encouragement.

We are trying to do two things at once: we are trying to support the established research worker, and to encourage the man who is just starting. We have one principle on this: we always regard a newly-appointed member of a university staff as a first-rate man until we learn it is true or otherwise; we would always support a new man, to give him a try.

The CHAIRMAN: That is what I raised a minute ago, when I asked you if it was part of your policy to have a team on every university campus.

Dr. STEACIE: Very much so. We are trying to develop this work. I think, in the preliminary stages of a new university, this is particularly important because very often the newly formed university is slanted entirely in the teaching direction and is having a hard time with its budget, is short of facilities and is, therefore, apt not to support research in the institution. Therefore, in the preliminary stages it might be that all the support they get comes from us. As they develop they will put more effort into it themselves.

The CHAIRMAN: Have you had any difficulty obtaining funds for this purpose? I want you to be very frank about this.

Dr. STEACIE: I would say our position is the normal one of any organization or person dealing with a budget. We can ask for what we feel is necessary. The government has then to decide amongst all its request how much goes where. We have been steadily pushing the amount of money that is spent on this, and I think we have been quite successful. If you consider the figures over the years, our universities support—was $13,000 in 1917-18, and it is $9,200,000 today. What happened was—

The CHAIRMAN: What was it five years ago?

Dr. STEACIE: —there was a slow, steady rise, and then it has accelerated. If we go back a few years, in 1954-55 it was $2.2 million; in 1955-56, $2.6 million; in 1956-57, $3.7 million; in 1957-58, $3.6 million; in 1958-59, $6.1 million; in1959-60, $8.4 million; and the estimates are $9.2 million for the coming year. There is a possibility of a little additional spending out of income, so that we would probably spend $9.4 million in the coming year.

Mr. GRAFFTEY: As most of us here know, Dr. Wilder Penfield in the M.N.I. at Montreal is quite an advocate of an endowment system. He has said quite a lot about endowments for research in his writings and speeches. To your knowledge, are there many countries in the western world, for example, which have fixed endowment systems, as government policy, aiding that type of research?

Dr. STEACIE: I do not know of any. The difficulty is this: one of the problems of university finance, of course, has been inflation, so that universities dependent on endowments have found their endowment income becomes less and less important. In our own case one can look at it in two ways. First of all, I know Dr. Penfield's views very well, and he is, incidentally, a former member of our council. There is no question that in principle endowment gives freedom. I think Dr. Penfield would agree—and I think it is fair to say this—that there is no other source of university support anywhere in the world that involves less tampering with the freedom of universities than our own. This has been our one object. We do not concentrate on projects: we do not try to persuade universities to work in a given field. Grants are outright. Equipment purchased under grants is the property of the university. There are no strings on these grants at all. The result of all this is, I think, that the man who gets a grant is not in any danger.

Now, it is true that one has this to think of: A man is being supported at a rate of say $10,000 a year in a university. If that $10,000 came from endowments he might be quite sure of support for the next twenty years. If it comes from estimates it is from year to year. On the other hand, even if he had an endowment he could be pretty sure that in 20 year's time the money would not be worth what it is today, so that he would be running down if he had an endowment. Again, there has never been a case in our estimates of what one might call an irresponsible cutting by the government. I think we have made it clear that if a government of the day raises our estimates for university support for the next year, that is for ever. If you like, they are free to raise it, but they are not free to cut it. The damage they would do by an erratic rise and fall would be almost impossible to contemplate. Consequently, I think we have established a pattern where the university man who is being supported is in no danger.

If you come to endowments, the problem is this: We are getting close to $10 million a year. If you take money at 5 per cent, it would cost $200 million to endow us for this program. If the government offered this to me tomorrow I would refuse it, because I feel strongly that our support in five years from now has to be $20 million and not $10 million. If we were fixed to an endowment of $200 million, I think we would be stuck. In other words, the rate of rise of universities in this country, the rate of development of science in this country, is so fast that I can think of nothing more dangerous than getting stuck with an endowment. I feel it is absolutely essential that five years from today this figure of $10 million be $20 million.

Mr. GRAFFTEY: From what you say, sir, for lack of better expression on my part, the advocates of an endowment plan today use this freedom-from-control argument. Is this one of the main arguments they use, that an endowment plan would involve freedom from control?

Dr. STEACIE: Yes, and I think, with great justice. In other words, if you are in a position where you are not dependent on any outside source for your support, you are in a position of greater freedom.

Our job, as we see it, is to try to ensure the maximum freedom that we can possibly ensure. But from the practical standpoint we do not believe that endowment is feasible: we do not believe that any government of the day is likely to put up enough money to give such an endowment today. We also feel that if they did, the freezing of the level at that point would be disastrous. At a time when you are rising as fast as this, what you need is a very rapid rate of increase, which you do not get with an endowment.

My feeling is, the ideal position would be to see every university endowed to the stage where they do not have to ask any government, any industry or any individual for anything—

The CHAIRMAN: Have you got a formula?

Dr. STEACIE: —but I think it is just a total impossibility from all points of view. The figures are fantastic.

The CHAIRMAN: Doctor, you made an interesting comment concerning the future commitments, shall I say, of governments, and we will go into the figures as to this rise. I feel the committee members here would be interested in knowing your views on whether there is any program, any long-range program, for the education of the youth of our country. We know what has happened in Russia. Our youngsters who are started into elementary schools today, what are they going to go through, and is there any reason, and if so, how many reasons why they should be persuaded to take up certain fields which are very familiar to you?

Dr. STEACIE: Well, this is a large question. I would like to make certain things clear. The first is that because of my period as a member of a university staff, and my associations with the universities since, I may or may not have the right to qualify as an expert in university education, from the higher education standpoint. I think I might qualify as an expert on higher degrees and post-graduate instruction: I have no qualifications whatever as an expert on school education. Consequently, I think I should not comment on this, because I do not think this committee is a body that should get inexpert opinion.

On the general question I think one can make some predictions, which boil down to this: Are there going to be problems because of the increasing importance of science? Is this going to present educational problems, both at school and at university level? And there is this problem you have raised, Mr. Chairman, that of steering students.

The CHAIRMAN: That is right.

Dr. STEACIE: My feeling is that there is a very active discussion on school education going on, and I think there are changes coming about. Anyone who is interested in science is certainly interested in the quality of science education in schools. As I say, I think this is something I am not an expert on, but there is a lot of effort being put into it.

In dealing with Russia, I think we should be very careful what conclusions we draw. There are several fallacious ones. The first thing is that in taking statistics of the number of scientists produced in Russia it is generally overlooked that Russia's definition of "sciences" includes the whole of university education. The academy of sciences of the U.S.S.R. has a section on history, on social and literary sciences. In Russia, any man who graduates with a degree in history, economics, literature or the classics is a scientist by definition. When you see the figures, he is included.

The second thing is that in Russia the influence has been in the direction of producing a far larger percentage of people we would call scientists than people we would call humanists or social scientists. When you start to run your whole economy you have to find some educated people somewhere. The consequence is you will find that while with us the executive officers of larger organizations may be lawyers, may be economists, and they may be other things, in Russia they will almost always be engineers and scientists, because almost the whole university production is this.

We want to compare, first, not the production of scientists in the two countries, but the production of educated people in the two countries; and, second, to consider whether in Canada we are producing enough scientists and engineers proportionately. If you compare the total production of educated people, then I do not think that we need panic at the Russian position. What I do think we need to consider very seriously is the fact we are not supporting education, financially, the way they are in the U.S.S.R., and perhaps we should be doing more about it.

This, I think, is a basic educational question upon which, as I say, I am not an expert. In science, Canada is going to need more scientists and more engineers. The universities are expanding, and these people are going to be forthcoming. Certainly, we are the last country in the world that should be worried at the moment about steering more and more students into science and away from other things, because, in fact, at the moment we are operating on a surplus—there are Canadians going to the United States. This surplus is much less than it used to be and, consequently, I think the future picture is quite bright. Also the future means that we are going to need an increasing number of people in science. But I would like to feel we would take this quietly, that we would go at it in the normal way, which is that if an economy benefits, say, by students pursuing a career in science, then more students will go into science because it is an attractive career; and I think this is happening. But I personally do not believe in panicking at this stage, and in rushing out and trying to persuade students not to go in for art, literature or music, social sciences or law, and thereby producing discontented engineers. But I would like to see provision made so that the good students are certain of an education.

I think our main problem is not steering; I think it is to make sure that we do not do any worse by the bright young men in Canada than they do for them in the U.S.S.R.

Mr. NIELSEN: Would you say that the achievements of the Russian scientists in more recent years have been due then to the better calibre of their scientists they produce over there rather than to a greater number of scientists?

Dr. STEACIE: No, I would not put it that way. What has happened in the U.S.S.R. is that there has always been a scientific tradition in Russia, at least ever since the time of Peter the Great. But the total amount of science done in Russia was not great before the revolution. In fact the total amount of science done in any country was not very great 40 years ago. But at the revolution they made a great effort to have more education in order to raise the level of science, and a 40 year program was brought in.

The result is that today the three main scientific countries in the world are the U.S.S.R., the United Kingdom, and the United States. The Soviet Union has therefore got into the big league in science, and it is now one of the major scientific powers.

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Any attempt to say that Soviet science is better than American science, or that American science is better than Soviet science is, I think, meaningless. If you consider very narrow fields of research, that is not subjects but fragments of subjects, then you will find that there will be certain fields in which the Russian work is superior to the work done in the United States, and where the American work is superior to the work done in Russia; praising Russian science does not mean in any sense that they are essentially better than the United States.

The CHAIRMAN: I think the committee would be interested in your elaboration of this point in view of the fact that Russia raised the first sputnik—was it not in 1957?

Dr. STEACIE: This was not a scientific achievement in any sense; this was a technological achievement.

Mr. NIELSEN: And what is the difference.

Dr. STEACIE: The difference is that the basic science behind it is probably running at about the same level in both countries; but the Russians have concentrated on technological production.

I am not an expert in these things and I do not want to get into a position of criticizing military programs but I think you could say that they have been very successful in their program. But that does not mean that their basic science is superior. What it means is that if the United States wanted to put up more satellites and to produce less automobiles, they could certainly do it. In other words, it is a question of consumer goods versus spending on fields which involve prestige.

So, as a technological achievement, it is a very great one. No one could deny it. But that does not mean to say that taking Russian science as a whole it is superior to anybody else's science.

Mr. BEST: Surely one of the major differences here is the actual freedom between Russia and the western countries, and our own. One of the great difficulties of a democracy is the freedom of choice in so many different directions; and when a small group in Russia would have the power of direction of research or exploitation of technological paths, perhaps it is not due to a fundamental increase or improvement, or a higher quality, but the ability to direct in certain narrow fields. Would you agree?

Dr. STEACIE: I would agree entirely.

Mr. BEST: This would seem to me to be the problem which comes to hand when you speak about what we could do with more education in Canada. We have freedom in this country, and we have freedom of approach, yet we have this disagreement on the part of our federal government as to who should speak in the way of educational approaches; even with our federal government and provincial governments; yet this is something which is not present to such an extent in Russia.

Dr. STEACIE: Yes.

Mr. BEST: This is one area of these paths of approach: I do not know too much about these fields, but it seems to me that in medicine and in botany, in the past Russia had great schools in those fields.

I may be wrong but there seems to be a much greater approach in recent decades in technology and the physical science fields, perhaps to the detriment of medicine, agriculture, and botany.

Dr. STEACIE: I think this is noticeable. One is impressed in the Soviet Union by this, and it is noticeable that in a discussion of the five year plan, the Soviet authorities are aware of this themselves, as is shown from the fact that while in the past they have stressed physics more strongly than chemistry, and they have stressed chemistry more strongly than biology, there is now an attempt to restore the balance, to a degree. But what I was trying to get at was merely this: that before sputnik went up, the general public on this continent particularly seemed to take the attitude that the Russians could not do anything in science.

But anybody engaged in scientific work knew that there was a great deal of first class work in science being done in Russia. And the moment that sputnik went up, the public changed their attitude overnight. What you must realize is that Russia is now one of the great scientific countries in the world; and that like any other great scientific country there will be fields in which she is stronger, as well as fields in which she is weaker. They are capable of filling in those gaps, but that is quite different from saying that the Russians are ahead of us.

Mr. BEST: We seem more or less to have slowed up at page 33. I wonder if Dr. Steacie might continue today and get over the whole of this booklet, when we might proceed with this discussion a little further.

The CHAIRMAN: Have you any more questions?

Mr. BEST: I have two or three comments to make on some other things.

The CHAIRMAN: It is quite all right, please proceed.

Mr. BEST: You mentioned the endowment problem; your feeling was that endowments from the general university point of view, should be private endowments, and that you were troubled a bit in the case of government policy. Naturally it would play a part along with private endowments at the university level. And the chairman mentioned research teams, and the need or necessity for at least one research team on every campus.

The CHAIRMAN: That is right.

Mr. BEST: This would be a problem presumably only in the very small universities, or in the very new ones, in Canada. Is that right?

Dr. STEACIE: Yes, I think you will of course inevitably have great universities in all countries which occasionally have poor departments; but things change. However, by and large we are now reaching the stage where the major universities in Canada have made respectable efforts in all the major subjects.

Mr. BEST: I was not concerned with that, but with the fact, as I believe the chairman was emphasizing, that there be research teams covering the whole of natural science.

Dr. STEACIE: We would be very unhappy if there were not groups in all the subjects, and we would also be very unhappy if all the scientists doing research in a university were organized into one team. I can think of nothing that would produce less good work.

But if you take in all the major universities, you will find in the fields of medicine, science and engineering that a respectable effort is being made, but that engineering comes last in this group. However infiltration of research into engineering is developing, and I think quite well, but it is still behind the rest.

Mr. BEST: Do you not think, apart from the fact that there are many research teams in natural science and taking the whole picture on each major campus, that there is a real problem in Canada in organizing specialized research teams?

I am thinking more of British work or thought in this matter. Let us say you have a team on insect physiology such as at Cambridge. You may search all over the country for one place; and admittedly you do not want to initiate this as a matter of policy. Perhaps it should come from the university; but you try to find some place in the country, in Canada, some campus where a small group could work on a field, and when it would be virtually impossible for such a group to be duplicated at any other campus across the country because of the specialized and perhaps the advanced nature of that research.

I am thinking of something which might be in the field of bio-chemistry, genetics, or physiology, and some of those borderline science areas in which it would be virtually impossible to have one man on each campus specializing in these various fields, but where it might be possible to have, one, two or three staff members—and I suppose a number of graduate students at one campus in the country.

Dr. STEACIE: I think this is developing. We of course are in the early stages relative to Britain and a lot of places where research is quite new. It is only a matter of the last ten to 15 years. There are quite a number of places where this is developing. In some places it has been the result of the physical apparatus, such things as nuclear machines of one sort or another; and in other cases, groups have come together; and you have major groups in this way.

The medical problem comes down to a question of the medical research council units which have been located at certain universities in Britain. This has its advantages as well as its drawbacks. There are feelings in Britain in certain cases that this positioning of employees of different organizations on the same university campus with the same group does not work out very well.

We have tended to go in a different direction. It is rather to put up the size of the grant and to make the grant quite often in a block form with the hope that as sufficient money becomes available, you can make it large enough to enable the creation of this group.

For example, Dr. Penfield's grant was mentioned: our grant to the M.N.I. This is not in the form of a grant to a man for this, that, or the other thing, but rather it is a block grant which can be used by the institute for their general objectives, and in fact it is largely used for the assembling of borderline teams.

I think we started in a position where there was not much research going on, and that we have got to the stage where there is more development. I think as these specialized groups begin to appear we will certainly support them, but I am not saying that we do not have some influence on their formation.

Mr. BEST: I think this is an area into which we might go in greater detail in future, because I know in connection with the biological sciences that the universities desire perhaps to have some direction given to them in this field.

I have a copy of a letter to Mr. Churchill from a graduate student who was going to the United States. He was interested in some field having to do with fish, and there was no school in Canada which could satisfy his particular need. This is just one example which I am sure can be duplicated. There might be thousands of incipients, young people wishing to work in specialized fields, perhaps in the borderline field or area.

Dr. STEACIE: I think it is developing, but I think on the other hand there will always be difficulty, just as in a country which is much larger than we are —such as the United States—there will be a larger number of groups, and therefore if you make your field narrow, you will have more chance of finding it in the United States than in Canada.

This was certainly the case before the war in Germany where essentially the German universities were the focus of the whole of central Europe. You could do good work in Hungary and in Czechoslovakia, but if you wished to specialize in a given field, there was a considerable chance that you would have to move to Germany in order to do it. And we are in a similar position, but it is one that our council will certainly consider.

The CHAIRMAN: I think you have raised an important subject, Mr. Best, and I think it is good for a session.

Mr. BRUNSDEN: May I ask if out of your experience you have received any expresisons of dissatisfaction on the part of the universities with respect to their share, or with respect to what they think is their share?

Dr. STEACIE: You mean as between one university and another?

Mr. BRUNSDEN: Yes.

Dr. STEACIE: I think the answer to that, simply enough, is no. We have I think saved ourselves a great deal of trouble by the fact that the program is firmly in the hands of the council, and the council is largely composed of university people; effectively, therefore, it is university people who are making the decisions, so you cannot be accused of dominating the universities.

What of course happens—and I think it is obvious that it must—is that the opinion of one council on the relative merits, let us say, of two physicists, one in each of two different universities, may be different from the views of the universities themselves. Consequently at any time there will certainly be universities who feel that we did not do as well by Professor X as we did by Professor Y, or that we did not do as well by Professor so and so as we ought to.

But when you take the whole picture, I think the universities themselves feel that they are getting fairly done by in this, and that the council is making an objective attempt to treat the individual university professors on their merits. I do not mean that you never get a case where, after a meeting of the council in March, one university does not feel that one department did not do as well as it might have.

But I think to a great degree the universities appreciate the fact that this is done by an outside body, and that it is more possible to be objective about the relative merits of any department in a university, by having an outside body look at the situation. So I have always felt that our greatest friends were the presidents of the universities.

Mr. PAYNE: What control do you exercise in order to see that there is not duplication within research from one university to another? Do you find that is a problem.

Dr. STEACIE: No. I think the fundamental thing there is that duplication is a word which is dear to the heart of treasury. When you apply it to research it is an advantage, not a disadvantage. In other words two persons looking at the same problem will never look at it from exactly the same point of view. No one doing research wants to find himself merely repeating what somebody else has finished. The scientific literature is organized so that he should not do this. What you are up against is making sure that you are not duplicating anything done in the rest of the world. The problem of making sure you are not duplicating what is done in Canada is a minor one. It is the world you have to consider. Our feeling is that this is something we should not interfere in.

The CHAIRMAN: On that point, do you get information bulletins on science and the achievements of the U.S.S.R.

Dr. STEACIE: Yes, a very large number. We get all the journals which appear in the U.S.S.R. This is a very large amount of material.

The CHAIRMAN: Are there any which you do not get from Russia?

Dr. STEACIE: Things concerned with defence, obviously.

The CHAIRMAN: Classified material.

Dr. STEACIE: Yes. I think the thing which should be emphasized is that any man who is doing research is incompetent if he is not aware of everything being done in his own field in the world. It is just straight incompetence on his part if he does not know this. It has to be assumed that the man will find out what is going on, and the whole of the scientific literature is organized in this way. The question of what people are doing and have not finished is a more personal problem. I think, however, you will find that any person who is established in his own field in science, and has a reputation, will be aware of what people in the rest of the world are thinking of doing. This will be handled by private correspondence.

Mr. PETERS: When Dr. Steacie mentioned how they go about scientific research in other fields, I am wondering whether or not ideologies have some effect on this, in that in America in the main we have scientists and engineers working in fields where we are producing something having a commercial value, rather than pure science. Germany, for instance, before the war had a great deal of pure scientists who were playing around with ideas and who came up with many developments which had no commercial application at all. I know in Canada everybody wants a good job and a job with good money; the only pure science is in the universities and foundations. Is it true that we are looking for something of value rather than science on an ideological basis?

Dr. STEACIE: In the United States there has been a worry and there has been a very definite effort to raise the percentage of pure science. In Canada actually the position is totally different. Relatively the industry in Canada does not do very much research. Consequently, the larger part of the research done in Canada is in pure science and not in applied science.

Mr. PETERS: What is the situation, for instance, in Russia or Germany?

Dr. STEACIE: The situation in Russia is not very different. The academy is very considerably slanted in the direction of pure science. There is a great deal being done in Russia also in applied science. I would say the position is not very different as between Russia and the United States in respect of the ratio between pure and applied science.

Mr. PETERS: Does Germany do more pure science still?

Dr. STEACIE: German science is recovering, but Germany no longer is in the dominant position in which it was before the first war. Germany was recovering between wars. They lost a very large percentage of their scientists because of their anti-Semitic activities. This wrecked a lot of schools in Germany. The last war did it again. I do not think German science is dominant in any sense today in the way in which it was 30 years ago.

The CHAIRMAN: Mr. Peters, you raised a question which I think perhaps we should have more information about.

Mr. PETERS: I think people all over the world are interested in whether we are not concentrating too much on commercial development. I think most of our scientific surprises came from somebody playing around and not knowing exactly what he wanted.

Dr. STEACIE: Actually the stronger group scientifically in Canada, outside the federal government, certainly is in pure science. For example, in our own lab, although our basic function is as an applied lab, we are doing something in the neighbourhood of 20 per cent of our effort in pure science. In general I think the Canadian worry is how to get more research into industry. I think we are on the other side of the fence.

The CHAIRMAN: I did not quite finish my statement. I think it is important to this committee. I hope the members will agree that we should have, if we can, the amount spent by industry in Canada on research, say ten or five years ago, and today, in order to see what is the trend. Do you agree with that?

Mr. BRUNSDEN: Is it possible to obtain that?

The CHAIRMAN: Yes. It would include bursaries, scholarships and so on.

Dr. STEACIE: There is a survey which was made by the Bureau of Statistics in cooperation with ourselves which would be two or three years out of date.

Mr. GRAFFTEY: Is industry in general using the tax concessions which they already have in research to the utmost, in your opinion? I do not know the details, but I believe there are certain tax benefits which industry can derive. In your opinion are they using these as much as they possibly could?

Dr. STEACIE: The main Canadian problem in industrial research is the size of the market. We have a small market relative to the United States and there are tariff problems. The whole chemical tariff, for example, is under overhaul at the moment.

Mr. GRAFFTEY: I believe there are many suggestions emanating from industry that further tax considerations could be employed.

Dr. STEACIE: I think this is getting a little beyond me.

The CHAIRMAN: Mr. Grafftey, I may say, as chairman of the committee, as some members know I have been exploring this thing for the last twelve years. Industry is not using its tax exemption and never has.

Mr. BEST: We have certain exemptions now.

The CHAIRMAN: This is all on record in my speeches.

Dr. STEACIE: The main problem is complex. There is the difficulty of the small market. The trend is in the direction of more spending. In 1958, the expenditure was about $150 million by industry on research.

Mr. PAYNE: Basically, this is applied research.

Dr. STEACIE: Yes, within industry itself.

The CHAIRMAN: Would it be agreeable generally if Dr. Steacie would try to get the amount spent by industry on research separately by scholarships, burseries, fellowships and all that sort of things? In this country it is mostly applied research. A good deal of it is being done in the United States.

Mr. PETERS: Was the exemption given to industry originally intended for pure science? I am thinking of things developed in Canada by companies like the Bell Telephone Company and so on.

The CHAIRMAN: Gentlemen, before we adjourn I would like to welcome to the committee two new members from the province of Quebec, Mr. Grafftey and Mr. Bruchesi. I am very glad you are here this morning. To the other members I can say that we will do some talking this afternoon about some of the other members who are not here. We are not going to go ahead with just a basic quorum. This committee is too important for that.

Mr. PETERS: I, for instance, had three committees this morning.

The CHAIRMAN: I am speaking about my own people.

Dr. Steacie will not be with us for one week. He is receiving an honorary degree from Oxford.

We are looking forward to having some trips out to the lab. Also before the session ends we will try to have a brief on the Chalk River development in order to orient the new members with more research. We cannot complete this research enquiry at this particular session.

Mr. PETERS: Perhaps we could have the atomic people bring their set-up to us. They have a very good one which I have seen at exhibitions.

The CHAIRMAN: Is it agreeable to everybody that we have our meetings on Tuesdays and Thursdays?

Mr. PAYNE: Before we adjourn I think some thought should be given to spreading our meetings beyond Tuesdays and Thursdays. There are many other committees and we find it is essential to attend many of them. As a western member I am going to say something which I hope will be taken kindly. In this committee, as in many others, there is a tendency to confine the work to two days of the week, largely because of those who live closer to Ottawa. I think it would lessen the load and make it easier for us to function if we considered, for instance, having a meeting on Friday morning rather than Thursday.

Mr. PETERS: Even Saturday would not be bad.

The CHAIRMAN: What about Wednesday?

Mr. BEST: Wednesday afternoon.

Mr. PETERS: I have to be in the house when anything is up in which we are interested.

The CHAIRMAN: We would excuse you.

Dr. STEACIE: Wednesday afternoon would be difficult for me, but I am sure someone else could go on on Wednesday if I should be away.

The CHAIRMAN: Our next meeting will be on Tuesday and probably again on Wednesday.

HOUSE OF COMMONS

Third Session—Twenty-fourth Parliament

1960

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: J. W. MURPHY, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 3

NATIONAL RESEARCH COUNCIL

TUESDAY, JUNE 14, 1960

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

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1960

23322-1—1

SPECIAL COMMITTEE ON RESEARCH

Chairman: J. W. Murphy, Esq.

and Messrs.

Aiken	Dumas	Nielsen
Batten	Forgie	Payne
Best	Godin	Peters
Bourget	Grafftey	Smith
Bruchési	McLellan	(*Winnipeg North*)
Brunsden	McQuillan	Stewart
Cadieu	McIlraith	

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

MINUTES OF PROCEEDINGS

TUESDAY, June 14, 1960.
(4)

The Special Committee on Research met at 9.40 a.m. this day. The Chairman, Mr. J. W. Murphy, presided.

Members present: Messrs. Aiken, Batten, Best, Brunsden, Cadieu, Godin, Grafftey, MacLellan and Murphy—9.

In attendance: From the National Research Council of Canada: Dr. E. W. R. Steacie, President; Dr. F. T. Rosser, Vice-President (*Administration*); Mr. F. L. W. McKim, Administrative Services; and Dr. J. B. Marshall, Awards and Grants.

The Chairman observed the presence of quorum and suggested that Dr. Steacie continue with his review of the booklet entitled "Organization and Activities".

Dr. Steacie, in his remarks and in answer to questions, dealt with the subjects of Grants-in-Aid of Research, Scholarships, and Postdoctorate Fellowships.

Copies of a booklet entitled "Industrial Research-Development Expenditures in Canada-1957" were distributed to members of the committee.

At 10.55 a.m. the Committee adjourned to the call of the Chair.

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

23322-1—1½

MINUTES OF PROCEEDINGS

TUESDAY, June 17, 1980.
(14)

The Standing Committee on [illegible] met at 4:10 p.m. this day. The Chairman, Mr. [illegible], presiding.

Members of the Committee present: [illegible]

Appearing: [illegible]

On [illegible] the Committee [illegible]

[illegible]

[illegible]

At [illegible] p.m. the Committee adjourned to the call of the Chair.

[illegible]
Clerk of the Committee.

EVIDENCE

TUESDAY, June 14, 1960.

The CHAIRMAN: Gentlemen, we have a quorum, so we will start.

Dr. Steacie, we left off at the last meeting at this first presentation of yours, organization and activities. Is there anything else anyone had to bring up before we continue with Dr. Steacie?

Concerning the meeting of June 20, that week is a bad one. Your Chairman may be away on business that was set up about six months ago in connection with the Canadian-American committee on pollution. I happen to be chairman of that. The vice-chairman made commitments some six months ago; and Dr. Steacie is also going to be away. What is your pleasure? We will carry on with something else, although the following week we might, maybe, arrange a trip to Chalk River; and there are other trips to be made out.

Dr. E. W. R. STEACIE (*President, National Research Council*): I will only be away on the Monday and Tuesday, and I will be here the rest of the week.

The CHAIRMAN: Have you any ideas, Mr. Batten?

Mr. AIKEN: This would be a Tuesday meeting?

The CHAIRMAN: That would be the Tuesday meeting.

Mr. BRUNSDEN: That is next week?

The CHAIRMAN: That is right. They are opening the observatory in Penticton, and that is the meeting you will be at, Doctor?

Dr. STEACIE: Yes, I have to speak at that.

The CHAIRMAN: Unfortunately, I cannot accept that invitation. We will let it ride and see what we can do.

Will you continue then, Doctor?

Dr. STEACIE: I think formerly in the booklet we had finished page 33, and then, before getting on to page 34, there was a rather general discussion about quite a variety of things. I do not know whether you want me to go into the grants at the moment. I think we mentioned them two or three times, and I expect you would want to call Dr. Marshall later, who will discuss the grants in detail. Do you want me to do anything about the grants now, or shall we pass them over, with the idea that Dr. Marshall will be coming?

The CHAIRMAN: Would he be here the next time?

Dr. STEACIE: He is here now.

The CHAIRMAN: I think maybe he should speak on the grants.

Mr. AIKEN: I think, probably, we should finish with the direct research.

Dr. STEACIE: If we go through them, I will just point out, on pages 34 and 35, that the grants are a considerable item. They are becoming a steadily increasing fraction of the budget, which I think is proper. They now run, in the current estimates, at $9,200,000. If you then add in some administrative costs and things of that sort this $7,500,000, as listed here for 1959-60, will become about $9,500,000 for 1960-61. I am sorry: that $9,500,000 will be grants plus scholarships. It will become about $8,500,000 for grants only, for 1960-61.

Page 36 deals with scholarships. Actually, from our point of view, we make no distinction in estimates between grants and scholarships. The reason for this is that we finance more graduate students under grants than we do under scholarships, and from our point of view the two things are interchangeable. They are both part of the same program of trying to build up Canadian graduate schools and to build up research-trained people in Canada.

Page 37 gives a list of scholarships held. You will notice that in 1957-58, 1958-59 and 1959-60 there is quite a steep rise; and there is an equally steep rise from 1959-60 to 1960-61. We cannot give the actual increase for 1960-61 because we always award scholarships which a number of people refuse, either because they change their mind or because they have other scholarships. Consequently, it will be another three months before we can give a definite figure of scholarships held for 1960-61; but it will be something of the order of at least eighty more than in 1959-60, and perhaps 100 more. As I say, we finance far more students under grants, so the total number of students being supported is certainly over 1,000. The values of the scholarships also are under review, and there will be some increase in some of them, but not others, in the coming year; that is, the 1961-62 fiscal year.

There is a graph on page 38 which merely indicates the rate of increase.

Then we come to page 39, postdoctorate fellowships. There are really three distinct types of postdoctorate fellowships. They all have the same value. The first, historically, started with a decision of the National Research Council that it was desirable to get younger men coming through the labs for brief periods from foreign countries. Accordingly, postdoctorate fellowships tenable in the labs were started. This was somewhat unusual, in that it was not customary to have this type of fellowships in anything other than academic institutions, but the thing worked very well. The number of applications was very large. The way the money is obtained for these fellowships is to charge them against salaries. In other words, effectively a division can decide that rather than hire a man it will appoint a postdoctorate fellow and use the money available in the salary vote for this purpose.

In our own labs these fellowships come out of our salary vote and are not part of the scholarships and grants allotment. It should be emphasized that in every case where we have a postdoctorate fellow we could have a permanent member of the staff, but we chose to have fellows instead. The estimates show these positions in the salary vote.

It was desirable to expand these into academic institutions, so we set up fellowships, under the same rules and regulations, tenable in academic institutions. They come out of the scholarships vote.

There are two types of postdoctorate fellowships in universities. One is where a university itself decides that out of a grant it will spend the money on the postdoctorate fellow. If they have a grant which is large enough to permit this, then it is entirely up to them whether they spend it on fellowship or graduate student assistance, or on equipment. The others are the formal fellowships, and these are done on a quota basis, depending on the amount of research in the institution.

A certain number of fellowships are alloted to the university, and it is up to executive head of the university to decide to which department these should go. The numbers start at eight with a larger university, and scale down to three for the smaller universities doing much research; and some of the very small universities, in which there is not a great deal of research, have no allotted fellowships, but they can be awarded as special cases arise.

Mr. BRUNSDEN: These postdoctorate fellowships, are they granted on an assigned basis? That is, are they granted for assigned work, or may the one enjoying the fellowship choose his own field?

Dr. STEACIE: In general, it is a mutual arrangement.

Mr. BRUNSDEN: Worked out by arrangement?

Dr. STEACIE: Yes, by mutual arrangement. In other words, to take a personal case, the fellowships in our own labs were started by myself when I was director of the chemistry division, and the original people were to work with me. We did a sort of trial run, to see if it worked. I had six working with me at the start. It is obvious that nobody would want to come to work with me unless he was interested in my field. When the man arrived I would then try to sell him the problem that I wanted done the most, but also would put up other alternatives. If he had the feeling that he would rather tackle something different, or had ideas of his own we would come to a compromise on what we would do. This is at the level of the postdoctorate fellowship. This is more or less the universal arrangement, that by a mutual process you will decide what you are going to do.

Mr. BATTEN: Why do you prefer the fellow to the permanent position?

Dr. STEACIE: For several reasons. One is that I think one of the worst features of a government laboratory is that it has a permanent staff, that all its staff is permanent, usually. In a university the age level remains constant, no matter what happens to the staff. The students come and go, and the staff can get older or not, but the average age is always low.

In industry there is a tendency for staff in the research lab to move into administrative posts in plant operation and, consequently, there is quite a turnover in the industrial research labs.

In the government the problem you have is this: Suppose you get a first-rate man who is 35. You will have to give him scientific assistants who work with him. If these scientific assistances are 25, this is a perfectly satisfactory situation. If they all get old together and you arrive at a situation where you have a man of 65 with three research assistants of 50, that is not a satisfactory one.

If the people are good, you run into Parkinson's law: you cannot hold a man who is any good in science without his having assistants. But if his assistants turn out to be good, you cannot hold them unless you make them free and give them assistants. If you are lucky and skilful in your choice of staff this will entail multiplying your staff by three every five years, which is something you do not want to do and would not get permission to do.

We felt we had to have a turnover. There are two ways of getting such a turnover. One way is to wait for people to leave. This is not the best way, and we felt there would be a great advantage in having people come in for a short period, and a deliberately fixed period, with a turnover.

In the applied divisions, where we have very specific jobs, we have to do, we work mostly with permanent staff.

In the pure science divisions and in the fundamental groups within applied divisions, we tend to work with skeleton permanent staff, plus postdoctorate fellows. In pure chemistry the permanent staff is about 16 or 15, and the number of fellows is about fifty or sixty. So that you are working with assistants who are mostly fellows. This makes an attractive arrangement for the staff and gives a good opportunity for assistants, provided your permanent staff is good. You will not get applications if it is not. It also gives you a turnover of people, and brings them from different places. This is a very healthy situation, and gives you a very cosmopolitan group. Our normal situation is that we would have people from between twenty and thirty different countries at any given time in the lab on fellowships.

Over the years—during the last ten or twelve years—I do not think I know of any country from which we have not had at least one fellow. We have one from the U.S.S.R. at the moment. We have had various other people from behind the iron curtain. We have people from Africa and Asia, the Commonwealth and all the European countries, the United States and, of course, Canada. The net result of this has been, first, I think, that internationally this has been a scheme that has got a great deal of recognition. We are, in fact, providing postdoctorate fellowships, on an international basis, on quite a large scale relative to our population.

Mr. BRUNSDEN: Is this a unique position, or has it been pursued by other countries?

Dr. STEACIE: This is a unique position, in a sense. It has been adopted in other government organizations, in other countries, some as deliberate copies of ours. I do not think it has been as successful in most other countries, and the reason it has not is that we have made a very definite effort to make sure that these postdoctorate fellows get a square deal. I think this is the absolutely essential feature. Unless the lab he is working in looks a little like Oxford or Cambridge and does not look too much like a government organization, he is not going to get a square deal. We think this is only satisfactory because we try to retain as great an academic air as possible in the labs. We will not allow fellows to be put on applied work of too *ad hoc* a nature, and we will not allow members of our own staff to work with them unless we are sure our own staff are of high enough quality. We have made a very definite effort to make sure the postdoctorate fellow gets his money's worth out of this thing. As long as we do this we get good men, and as long as we have that situation it is a profitable scheme for us.

The CHAIRMAN: Your staff is not under the civil service?

Dr. STEACIE: No.

Mr. MACLELLAN: What kind of work are they doing?

Dr. STEACIE: Mostly fundamental work. Originally this started in pure chemistry. Then it went into pure physics. Then it appeared to be obvious that in applied chemistry there were fields in which there were a lot of people from foreign countries who had an interest and we began to get requests from students abroad to work in applied chemistry as well as in pure chemistry. We decided that there was enough work of a long-term nature to make this worthwhile.

Since then it has expanded, and we are running fellowships now on a routine basis—that is, a continuing basis—in pure and applied chemistry, applied biology, applied physics, pure physics, and the prairie regional lab.

In the more thoroughly applied divisions—the engineering divisions, particularly—we feel that the fields of work that are suitable for fellowships are relatively limited, so that it has been done on a smaller scale. In radio and electrical engineering there are one or two groups which always have fellowships. Most of the others do not. We never put fellows on work that is done for the armed forces and has any security restrictions. I think that would be contrary to the meaning of the word fellowship.

In aeronautical engineering we do not normally provide fellowships, but occasionally you get a man who has a very specific reason for wanting to come to work with a man in that division.

Similarly, we do not have many fellowships in building research, but once in a while somebody turns up who is interested in some phase of concrete, or something of this sort, and he knows what he is coming to; and we feel there is no objection to the work being really thoroughly applied, provided the student knows what he is getting.

The CHAIRMAN: The students in these foreign countries, are they in the civil service of their prospective country when they come in?

Dr. STEACIE: They could be. From our point of view we do not care in the least what kind of organization the man is in at home. What we care about is his publications, his scientific training and his reputation. We will not accept recommendations from the government of the foreign country from which the student comes. An application has to be made by the man, personally; recommendations have to be from people he has worked with experimentally; and we will not pay any attention to sponsorship by a government.

The CHAIRMAN: What about an industrial sponsorship?

Dr. STEACIE: We will not pay any attention to that either. However, we will accept recommendations of men he has worked with in industry. In other words, we are not interested in giving a fellowship to the employee of an industrial concern or the national of a country, as such. We are interested in giving the fellowship to a man who has done some scientific work and looks as though he was well trained and is going some place. We do not care what country he comes from and with whom he has worked.

The CHAIRMAN: Do you follow up after he leaves?

Dr. STEACIE: Yes, to a degree.

The CHAIRMAN: Have you ever been disappointed?

Dr. STEACIE: Oh yes, of course; but on the whole we have done pretty well. I would say there are very few universities anywhere in the commonwealth now who do not have on their staff someone who was here on a fellowship at one time or another. There is really an extraordinarily wide spread in the number of people. If you start visiting European countries and Britain and the Commonwealth countries, it is surprising how frequently you will find someone who has been on our staff on a postdoctorate fellowship.

I spent a month in India a year-and-a-half ago, and every lab I entered in India had at least one postdoctorate fellow who had been here and had gone back.

Mr. BRUNSDEN: Purely from a selfish point of view, and considering the taxpayer, are you yourself fully satisfied this policy is well under way and is profitable to this country?

Dr. STEACIE: I think we have gained a great deal by it. It has produced a much more international flavour to the lab and brings in a steady succession of young men trained in different places and who have slightly different outlooks in experimental techniques.

Mr. BRUNSDEN: My point is, after they have been here we lose them, and they go back to their own country. Having that in mind, what do you think?

Dr. STEACIE: We are still gaining. You lose continuity in the work, but you gain in enthusiasm and diverse outlook. Actually, there is an optimum number of them that might stay in Canada. I would not like to see a situation where everybody who came on one of these postdoctorate fellowships from abroad stayed. If this happened we would soon lose the very enthusiastic recommendation from university professors abroad, because they would be losing their men. On the other hand, it is very nice for us if some of the better ones stay.

Two things have happened. One is that although the pure chemistry division operates on a skeleton staff, and mostly fellowships, applied chemistry operates mostly on permanent staff and has some fellowships, They have recruited a number of exceedingly good people from this scheme, both Canadians and others.

The CHAIRMAN: Is it the policy of some of the United States universities to give scholarships or fellowships to Canadians, in order to give them a broader teaching, and actually to encourage them to return to Canada? Am I right in that?

Dr. STEACIE: Well, I think the American universities, on the whole, are interested in the thing from the same points of view as we are. That is you have both a selfish and an unselfish motive. If you can get good research students this will raise the level of your graduate schools. At the same time, they have an obligation to these students, and they want to do the best they can for them. It seems to me that American universities with Canadian students have just the same attitude we have with the foreign students. McGill has a very high percentage of foreign students. It has always, in particular, a much higher percentage of West Indian students, but I think these have been good students; and this fact has enabled McGill to make a very definite contribution to the West Indies.

Mr. GODIN: With this temporary work system, do you find it possible for the department to continue in a certain line? Say a man comes in and makes a bargain, and wants to work on a specific problem, say, 70 per cent of the time, and you coax him into doing 30 per cent of what may be helpful, and he proceeds and then comes to the end of his term and leaves, have you a scheme whereby the department can continue in that field, or is there a loss in research there? Or is there a scheme you use to obtain a new fellow to continue the work?

Dr. STEACIE: I think the basic thing here is quite simple. If your staff are not very good and the student is more apt to have ideas than they are, you will find it would always be the student's problem that was being worked on. If you make sure you do not have them come except to a man who is really first rate in his field, 95 per cent of the time the student will be entirely agreeable to doing exactly what that first-rate man wants him to do. In other words, he has chosen to come because of his work and, therefore, obviously he is going to be susceptible to suggestions as to what is the best problem to work on.

Actually, over the years I have had as large a group of these as anyone else. As I say, they started with me. I probably have had—it is hard to say—forty to fifty work with me personally. This has never been a very difficult problem. When things are going well and are interesting you will always find someone who wants to take over and go on. When it came to starting something new, I generally had a list of problems and discussed these with the people as they came in, and I was perfectly happy whichever they chose. Mind you, we are not dealing here with specific problems for the development of Canadian industry. We would not put a fellow on a problem that was applied, where we had a duty to do a job. We are dealing with long-term work.

Mr. GODIN: My worry was perhaps the piecemeal operation of the department, in the sense that a good specialist works hard on one scheme, and then goes away.

Dr. STEACIE: I think the continuity is good.

Mr. GODIN: It is followed through somewhat?

Dr. STEACIE: I think the continuity is good. Actually, this is the same way university graduate schools work. A university professor does work exactly on this basis, by a succession of graduate students. There is no question in the world that university research basically is far more efficient than industrial research. I think this is the most outstanding feature of the whole thing. Because of enthusiasm and because of the system you get far more work done for far less money in a university than you will ever do in any other institution. What we are trying to do is to copy the university system as much as we can.

Mr. AIKEN: The full benefit of the work remains with the Council—the notes on experiments and results?

Dr. STEACIE: The publications and everything will be. This work these fellows are on is all long-term work. It is either pure science or long-term applied science, where publication would be the end result. The work will be published and the publications will be from the council. This work that is being done under this scheme has had a great deal to do with maintaining the scientific reputation of the council.

Mr. BRUNSDEN: Are you saying there is a very small percentage of fellows who complete a project in which they are engaged while with you?

Dr. STEACIE: They would usually complete it, but in this sense, that they would complete a chunk of it. Normally, one thing leads to another, and in a broad way the problem that an active scientific worker is on probably is never going to be finished; it will go on for his whole life—and in a way it will be the same problem for his whole life, but the slant will vary from time to time, and you are never sure in what direction you are going to be led.

What happens, actually, is, of course, that the problem goes ahead by a series of pieces of work, which are done by individuals, and it is the same, normal set-up as goes on at a university graduate school. But normally in two years, or one to two years, you can finish one phase of something and go on to the next one.

These fellowships are for one year, extendable for a second. You usually know from the start whether a student is going to stay one or two years. If he is only staying one, then in general a problem is chosen so that one year is satisfactory and he can accomplish something reasonable in the year.

Mr. AIKEN: Are there any questions on copyright which arise out of this work at all, as between the fellow and the council?

Dr. STEACIE: The same position would arise here as arises in the case of employees. That is, there is the question of patent rights. The only thing that one can do, of course, is to have an assignment of rights. In fact, the kind of work that is done is something that is extremely unlikely to lead to patents, because long-term work does not lead to patents. In general, the major scientific discoveries are not patentable. Trivial things do lead to patents, but the important things never do.

Mr. GODIN: What about the aviation field?

Dr. STEACIE: This is one in which we do not go in for fellowships. This is more towards development and less towards fundamental research.

Mr. BEST: Dr. Steacie, you publish a small booklet yearly, or twice a year, with photographs of your award winners coming from foreign countries?

Dr. STEACIE: Yes.

Mr. BEST: Are these specific, in a group, and specific foreign students studying in your council laboratories published in this booklet I am thinking of—specific students outside of Canada?

Dr. STEACIE: No, they include all. The number of Canadians on these postdoctorate fellowships is not great. The reason for this is that we send Canadians overseas on postdoctorate fellowships ourselves.

Mr. BEST: I want to check into the terminology we are using here. "Overseas fellows" is mentioned in the last paragraph?

Dr. STEACIE: Yes.

Mr. BEST: Are we meaning there, Canadians studying overseas?

Dr. STEACIE: Yes.

Mr. BEST: "Postdoctorate fellowships," as a phrase, means all the Canadians studying overseas?

Dr. STEACIE: No, those are postdoctorate fellows studying overseas; Canadians studying overseas.

Mr. BEST: Do you include these under the heading of "postdoctorate fellowships"?

Dr. STEACIE: No.

Mr. BEST: "Postdoctorate fellowships," then, are ones studying in your own laboratories here?

Dr. STEACIE: There are three classes, as I said before. They are in universities in Canada as well. This little booklet does not list them. This is an internal lab publication. There is the third group, where some of the other government agencies in Ottawa became interested in having these fellowships also. They asked us if we would handle the appointment and qualifications. At this point the treasury suggested that if we were going to do that it might be tidier if we had them in our vote. We therefore also award a small number to the mines branch, geological survey, dominion observatory, the Department of Agriculture, and so on.

Mr. BEST: When did you start this program of postdoctorate fellowships?

Dr. STEACIE: In 1947.

Mr. BEST: On page 40 you list the number of postdoctorate overseas fellowships, and we have some idea of the quantity of those; but have you some figures on the quantity of ones tenable in Canada since 1947? Could we have that on the record, perhaps?

Dr. STEACIE: Table 9 on page 40 gives this.

Mr. BEST: I see, pardon me.

Dr. STEACIE: This includes everything, the universities and federal government agencies. There were 1,444 awarded but 383 declined, and the actual number was 1,061 in twelve years. Of that number 233 were, at the time this booklet was printed, still working, and the remainder had terminated.

Mr. BEST: How many of those would be from other countries, what proportion? Have you the figures of those?

Dr. STEACIE: Of the 233?

Mr. BEST: Yes.

Dr. STEACIE: Oh, they would be 80 per cent foreign.

Mr. BEST: Do you feel this is really a major contribution on the part of Canada to international scholarship or an exchange of research?

Dr. STEACIE: I think it is a major thing. It has amused us at times that when various schemes have come out for commonwealth exchanges at the postdoctorate level the numbers have been so small compared to what we are doing already. It is in part a selfish scheme. I think this was done more to put Canadian science on the map than anything I know of, because we get the best people, and they come and then they go home. We have now got people on the staff of every major European university, in fact, almost every major university in the world, who have been here as fellows. From this point of view I think it has done a great deal of good. From the other point of view, we have had a very brilliant collection of youngsters in the labs. This has done us a great deal of good. Inevitably, the largest numbers of these are foreign, but by no means altogether. The reason for this is that an Englishman having taken his degree at Oxford is apt to feel that two years in Canada would be a very interesting experience. The man who took his degree in

Toronto would feel that two years in Oxford was a very interesting experience. So we provide our own students with the means of going the other way. In addition to that, the man who takes his degree, say, at Toronto and thinks of coming to Ottawa is apt to want a job rather than a fellowship, has decided that he wants to stay in Canada, and decides the N.R.C. is a nice place to work. The result is that the number of Canadians we award internal postdoctorate fellowships to is relatively small.

We have a big list of Canadians each year that the committee decides should be given postdoctorate fellowships. By the time we come down to the actual deadline some have withdrawn because they have other types of overseas scholarships. The largest group withdraw because we have given them overseas scholarships ourselves. Another group withdraw because we have given them jobs. Another group withdraw because Canadian universities have given them jobs; and we end up with a relatively small group. This is the reason for the figures slanting towards foreign fellows.

The CHAIRMAN: Would you tell the committee your policy established over the years, that of having this committee determine the scholarships? I do not mean, do you have anything embarrassing to say.

Dr. STEACIE: I am not quite sure what you mean—in our scholarships committee?

The CHAIRMAN: Yes.

Dr. STEACIE: You mean the method of choice and so forth?

The CHAIRMAN: That is right. We might get five from London and 25 from Saskatchewan?

Dr. STEACIE: Yes, quite. Here I think we have done our best to steer clear of what you might call charges of bureaucratic dealing. The choice of people for all scholarships and all grants is made by a committee of the members of the council, consisting of the university members. The result is we put this firmly in the universities' own hands. We very rarely have any trouble. There are considerable fluctuations. You will get years in which one university does very poorly, relative to another. You may get minor complaints, but these are not substantial, and I think everybody is happy with this situation. We do make mistakes, of course. I think that is inevitable; but I think we have been remarkably free from charges of unfairness in this sort of thing.

Also, I think one thing that is quite interesting—and I do not know whether I should say this or not—and to me has been the astonishing and virtually total lack of any attempt at political interference. This just does not happen: there just is no attempt to exert any pressure, politically, in any of these things.

Mr. BRUNSDEN: Perhaps now you have this committee that situation will change.

Dr. STEACIE: I doubt it; but it has been a very interesting thing. I get calls from members occasionally, wanting to know what the system is. They want to know how people should apply, want to know what is available, and that sort of thing; but freedom from any attempt to exert pressure, I think, is very notable.

The CHAIRMAN: Pressure would actually corrupt or spoil it, would it not?

Dr. STEACIE: I think it is extremely important there should not be any. Another thing I think is extremely important is that the awarding of grants to individuals should not be part of the estimates procedure. It is not. That is, there is no discussion as to who is going to get money in the estimates, when there is discussion on the estimates. I think it is absolutely essential that the council should be left free to make its own decisions and, in fact, the council is.

We are now having to decentralize and are bringing more university people in on panels, and things of this sort, because as the program grows life gets too short, and the meetings to choose scholarship winners, and so forth, begin to get a little difficult. We are reaching the stage of about 1,000 applicants for scholarships. The job of sorting these and making a decision as to who is awarded scholarships has become quite a big thing.

Mr. GRAFFTEY: What are the basic factors which determine a grant as opposed to a scholarship? What are the basic considerations which differentiate between a grant, as opposed to a scholarship?

Dr. STEACIE: Fundamentally, what we are trying to do is to foster Canadian science in the university, or Canadian science in general. You can do this in two ways, either by supporting a good scientist and giving him the money to buy equipment and to hire assistants; or you can support—and this is just as necessary—the best students in graduate work. We do it both ways. The scholarship winner is free to choose the man he goes to. The man with a grant can appoint an assistant and the student can shop around and find an appointment under a grant. So far as possible, we have tried to have a system in which we would hope the best students would be given the scholarships.

The CHAIRMAN: What happens when a bright young chap has the opportunity of choosing between several scholarships and grants? Is the decision up to him?

Dr. STEACIE: Yes. We over-award our scholarships in the knowledge that there are other scholarships available and that there will be a fair number of resignations. We over-award 15 per cent. In other words we award scholarships amounting to 15 per cent more than the budget, with the statistical knowledge that 15 per cent will refuse. They will refuse for various reasons—other means of university support, a change of mind, a decision to go abroad instead of staying in Canada, and quite a wide variety of things.

Mr. MACLELLAN: Do other countries play host to our students in something like the same ratio we are host to them?

Dr. STEACIE: Actually we merely have been reversing the trend. In the old days all Canadian students received their higher education abroad. There was a time when the only way to become a chemist or physicist was to go to Britain or Germany, particularly in the early years of this century; we were dependent on this. Actually, most graduate students who went to Britain in the period before the first war and largely before the second war were financed by the British. The Rhodes scholarships were supported by British money, for example. When you take the total, the number of Canadians who have been educated in Britain at British expense is very large.

Mr. MACLELLAN: Is it still going on to a certain extent?

Dr. STEACIE: Yes.

The CHAIRMAN: Is it not a fact that, in the years not too far back, if a bright young student wanted to advance his education by taking a Ph.D. degree he would have to go out of this country?

Dr. STEACIE: Yes. At the end of the first war I think two or three persons had obtained a doctor's degree in science in Canada. These were persons who had been on the university staff for probably twenty years and got the degree because of the work they did on the staff; they really were not graduate students. This thing really started at the end of the first war, but Ph.D.'s were still pretty rare. At the beginning of the second war, except in some rather rare and unusual circumstances only McGill and Toronto gave a doctor's degree in science. They now are given right across the country by virtually every university in Canada.

Mr. BRUNSDEN: Going back to the days you speak of when all of them obtained their doctor's degree outside of Canada, has there been any return to Canada of our own Canadian students?

Dr. STEACIE: I would say at the present time it boils down to two phases; if a Canadian student goes at the postdoctorate level, there is a very good chance he will come back to Canada no matter where he goes.

Mr. BRUNSDEN: Today?

Dr. STEACIE: Yes. If he goes at the lower level he will almost always come back from Britain or Europe and only sometimes from the United States. I think in the past it probably always has been similar. There are Canadians who have stayed on in British universities and who have entered British industry; but most of the Canadians who went to Britain in former years have returned to Canada. This is not true in respect of the United States.

The CHAIRMAN: I think Mr. Brunsden has hit on an interesting point. I am only trying to qualify a statement, but I would like your opinion on this, doctor. In respect of these university graduates who go to the United States, for instance, where a great deal of our research work is done, we do not exactly lose all the benefits of their having been educated in the United States, do we?

Dr. STEACIE: No. Actually, I think there are two things we must bear in mind. One is, suppose you have a very bright Canadian student who wants to work in a certain narrow specialized field. I think it is a very nice thing if he can go to the United States and work in this field if there is no way of doing so in Canada. He would be doing the work under conditions of life which are not too different from the conditions he is accustomed to. In other words we have a duty to the student in the early stages. We cannot expect to have here in Canada the specialized research they have in a large country.

Mr. BRUNSDEN: The other day we were considering the practicability of arresting this flow of brains out of Canada. I am trying to determine whether or not the policy you enunciated in the National Research Council is tending to move towards that end?

Dr. STEACIE: Yes, very definitely. The flow is slowing down. There are two separate things to consider—engineers and scientists. Most engineers do not do research. In engineering you have to consider whether the flow is in respect of research or other work. In science essentially it is research. The flow is slowing down. What we would like to see is not the flow stopped, but rather slowed down to the stage where the number of Canadians going across the border is about equal to the number of Americans coming across the other way. I think a healthy transition of this sort would be a good thing.

Mr. GRAFFTEY: Apart from the factors you outlined, would remuneration not be a great consideration also?

Dr. STEACIE: Yes; it is a great one. I think the problem is this. There was a time in the United States and in Canada when the salary scales were all in the same way. That is to say the highest was in industry, the second highest in government, and the lowest in the universities. This was true in the United States and Canada. The Canadian scale was below the American. The net result of all this was that Canadian industry had a hard job keeping people because they lost them to the United States industry. At other levels it got worse, because the universities were tending to lose them to government or industry in Canada and then they would be lost to all three in the United States. What happened over the years is that there has been a decided improvement in the position. At the present time the Canadian university salaries compare favourably with the United States university salaries. I do not mean this is universally so or that the situation is perfect; but it is not too bad. Canadian industry has been trying to keep pace with United States salaries. This has been very difficult because United States industrial salaries have been climbing at a fantastic rate in science. Most of this is due to the fact that they are working on defence contracts. It is government money anyway and the different firms are bidding against each other and the United States government will pay the bill in any case. These salaries are getting very high. The Canadian company is up against quite a serious situation. I think perhaps the Canadian subsidiary is up against almost the worst situation in trying to maintain its staff when its own people can move over to the parent company at much higher salaries.

The government position has varied. At one time our salaries in the National Research Council compared favourably with Canadian industrial salaries and they were both ahead of the universities. We were very worried about the university position. The present picture is that Canadian industrial salaries have skyrocketed, the university salaries have gone ahead reasonably well, and the government salaries have been left far behind so that the position has been becoming increasingly worse relative to the rest of the Canadian sector. At the end of last week increases in scientific salaries were announced. I think that is making a very fundamental change in the situation. In other words I think that the salary scales have now come back to a position where we are competitive with Canadian universities.

The CHAIRMAN: That is only in government departments. Did that apply to your department?

Dr. STEACIE: The corresponding thing for us will come along.

Mr. GRAFFTEY: Do you think these increases will stop any possible outflow to the United States?

Dr. STEACIE: No. What you are up against here is the very fundamental problem. The standard of living in the United States is higher than it is in Canada. Everything leads to this conclusion. The standard of living in Canada is very high, but it is not as high as it is in the United States.

I do not think you can take one segment of the Canadian economy and run it on a level with the United States. In other words I just think it is not possible to match the United States industrial salaries in the situation we are in.

I think everything has indicated that, provided the career opportunities are satisfactory, Canadians will stay at home even if there is a considerable salary differential.

In the universities recently there has been improvement in salaries and a great improvement in facilities. Universities are not now finding it difficult to persuade the better Canadians to take jobs.

Mr. BRUNSDEN: Is it not true that there is replacement material available elsewhere if they do not remain in Canada—speaking in terms of universities.

Dr. STEACIE: It is of course commonplace that in the universities or in industry in Canada we import from Europe and export to the United States in personnel.

The CHAIRMAN: Is this not absolutely necessary if you are going to have universities across Canada placed in a position where a student will go to that particular university to obtain an advanced degree?

Dr. STEACIE: Most of the leading persons in Canadian universities in science are Canadians. There have been, however, some very good persons brought in from outside.

The CHAIRMAN: I was referring to the increase in remuneration.

Dr. STEACIE: I think the increase in remuneration was absolutely essential.

The CHAIRMAN: If a man is going to study for a Ph.D. in some branch of science he would go to the best university.

Dr. STEACIE: Yes.

I think we will always be in the position where Canadian industry is bidding against American industry and this is inevitable. It is true at all levels. It does not matter whether the man is a bricklayer or a physicist; he can get higher wages if he goes to the United States.

Mr. MACLELLAN: Do you think this policy of sending Canadians overseas helps feed scientists to Canada from Europe in that our Canadians will bring people back with them? Do you find that is the case?

Dr. STEACIE: The actual flow from Britain to Canada has slowed down. I think this is because opportunities in Britain have improved and there is less tendency for the people to move out. There is still a number, but it is not as big as it was.

The CHAIRMAN: Would it be agreeable if we start now on page 141?

Mr. AIKEN: I would like to ask one further question. Have you any figures showing the number of Canadians who go overseas for postdoctorate scholarships and the number of overseas students who come to Canada?

Dr. STEACIE: This would be a little awkward. It would involve not only our fellowships and things of like nature, but would also involve a variety of other things. There are quite a number of university fellowships and various things of that sort. My feeling is that it would balance pretty well.

Mr. AIKEN: My point simply is whether or not Canada is holding its own and that people are coming here in the same quantity they are going from here to other countries.

Dr. STEACIE: Scientifically there is a net immigration. If you take all scientific people, more are entering from countries other than the United States than are leaving. However, some of these immigrants come from Europe to here and then go from here to the United States.

Mr. AIKEN: Our net importation, then, is increasing as an educational country.

Dr. STEACIE: I am sorry; I was thinking of the science establishment. Educationally, if you leave the United States out of the picture, there are far more foreign students coming to Canadian universities than there are Canadian students going to foreign countries—by far. This is leaving out the United States. Putting in the United States it might be a balance; I do not know exactly.

Mr. MACLELLAN: What is the reason for that? Is it that our reputation in science is picking up?

Dr. STEACIE: We always have had a lot of foreign students. McGill always has been the center of education for the West Indies. We have a great many Colombo Plan people and have all the Asian countries. There also are a great many African students, Nigerians and various others. There are a variety of students who come from the United States and various parts of Europe. In the graduate schools at the higher degree level. About one-third of the students are foreign and two-thirds Canadian. This is rather surprising: it actually means the percentage of foreign students in a number of Canadian universities, in the graduate schools, is higher than the percentage of foreign students in places like Oxford and Cambridge—which, I think, is the reverse of what most people would have thought. So, this is a major flow.

The CHAIRMAN: Have you any record of the number of foreign students from any European country, any country, coming into Canada to take a degree, and when they have got a degree they go to the United States?

Dr. STEACIE: That is difficult to determine. The statistics of foreign students are available from the National Conference of Canadian Universities and Colleges, and from the Bureau of Statistics. The emigration figures are difficult in this way, that we do not keep figures of the people who leave the country. Not being a police state, you are free to leave if you can get in where you want to go. The result of this is that we have figures broken down by category of job, to show who comes into Canada from Europe, say. We can tell how many engineers enter from Europe, and this sort of thing. The only figures we have as to who goes from here to the United States are American immigration figures, but they do not distinguish between a man who is a Canadian and a man who has temporarily resided in Canada. Consequently, the figures you get for the number of Canadians crossing the border include the people who originally came from Britain and stayed, say, two years and then moved on to the United States. We all know these figures, to a degree, from the various universties however. McGill and McMaster, and various other universities, have done an analysis of all graduate students taking the Ph. D. for the last 15 years—where are they now, and what are they doing?—and this kind of thing. From this one can draw some conclusions.

Mr. BEST: Following up some of these questions, I think Mr. McQuillan mentioned this two-way traffic and the comparable figures. On page 40, table VIII and IX—table VIII, I believe, adds up, in the right-hand column, to 151 awards accepted in that period of time. The overseas fellowships, plus the more recent NATO science fellowships have been much smaller in number than postdoctorate fellowships attainable at Canadian institutions. Is this done, or slanted on a policy basis, or would you say that partly the reason is many Canadian students study overseas?

Dr. STEACIE: This is the number of applications only. Policy-wise we have decided we would prefer to support the student at the doctorate level. In other words, in order to build up Canadian graduate schools we want slowly to cut down the number of students we finance to take a course overseas at the graduate level and support them more at the doctorate level.

Mr. BEST: It is a policy decision, to try and cut them down?

Dr. STEACIE: Yes, it is a policy decision to try to cut them down, because these people are not building up Canadian graduate schools. If we support men in Canadian universities we are educating the students and building up the graduate school, both. If we support men to go to Britain, we are educating the student, but we are not building up our graduate schools.

Mr. BEST: You get this at the postdoctorate level?

Dr. STEACIE: No, not at the postdoctorate level. These last two years we have been prepared to grant more postdoctorate fellowships than we have given. We want to keep the standards up, and do not want to send second-rate people over; and out of 46 applications we awarded 25. In other words, we will not award them all if the applicants are not good enough. I think also you have to remember you have in here competition from our own scholarships in educating people at the graduate level abroad. We are still supporting 50 or 60 people in England who are taking graduate degrees in England. There are also fellowships, both graduate and postdoctorate, supported by various industries—Imperial Oil, Shell Oil, and various other industries. The 1851 exhibition does it also, and a number of other organizations, so the total number of Canadians studying in Europe, either graduate or postdoctorate is much larger than the postdoctorate figure here.

Mr. BEST: This is interesting. Funds are provided by other countries for this?

Dr. STEACIE: Funds are provided by other countries for this, and by ourselves. But we would like to see the situation where a higher percentage of people went over on postdoctorate fellowships after getting their Ph.D. But the difficulty is that jobs are available, and the expansion of universities has been one of the main things. University posts do not come along too often, and anybody who can get a university job is very foolish to turn it down to take a postdoctorate fellowship, because two years later the position may be different.

Mr. BEST: Can you tell us about the NATO science fellowships, what fields they apply to?

Dr. STEACIE: The NATO science committee, on which I am the Canadian representative, was set up as part of the idea of NATO being more than a military alliance—in other words, as having economic and other significance. The Committee has gone into certain activities—grants and other things too—but one major feature is scholarships. What emerged on discussing the scholarship situation was that while we have this very large postdoctorate fellowship scheme, by which people could come to Canada, and while we also send people to Britain and Europe on scholarships, none of the other countries had such a two-way operation, and in most cases they were completely parochial, except for Britain and the U.S. In other words, various foreign governments would give fellowships to their own citizens to stay within their own country, but would not give any money for a foreigner in their own country, or for their own students to go abroad. The point was made that the thing European science needed very badly was more exchange of personnel. So that NATO fellowships were started. The awarding of these fellowships was not on the basis of need, but on that of a formula. I think this is inevitable in international organizations. The net result of this is that Canada is getting a considerable amount of money from NATO for scholarships. It is not as much money as we are putting up, but the net loss is not very great.

Mr. BEST: What are the areas of study?

Dr. STEACIE: Science in the broadest definition.

Mr. BEST: It is not slanted particularly in the defence or military way?

Dr. STEACIE: No, there is nothing whatever to do with defence.

Mr. BRUNSDEN: Mr. Chairman, the Prime Minister promised a very interesting announcement this morning, and it is now five-to-eleven. I wonder if we should not take a moment to plan the work of the committee for next week?

The CHAIRMAN: That is probably a good idea.

Mr. BEST: What about this Thursday?

The CHAIRMAN: I think we are all set for this week. Is that what you meant?

Mr. BRUNSDEN: Yes.

The CHAIRMAN: I have some interesting questions, and I want to go into professor scholarships. The questions we do not happen to ask Dr. Steacie we can ask Dr. Marshall, so we are not stuck.

Mr. BEST: Dr. Steacie will be here on Thursday at 9.30?

Dr. STEACIE: I will be here all the time, except next Monday and Tuesday.

Mr. BEST: Could we decide our program for next week on Thursday?

The CHAIRMAN: I think that would be quite all right.

Thanks very much, Dr. Steacie. This has been an extremely interesting meeting.

Mr. BRUNSDEN: Will this be at 9.30 in the same place?

The CHAIRMAN: I do not know. We will know ahead of time.

HOUSE OF COMMONS

Third Session—Twenty-fourth Parliament

1960

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: J. W. MURPHY, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 4

NATIONAL RESEARCH COUNCIL

THURSDAY, JUNE 16, 1960

WITNESS:

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

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1960

23324-7—1

SPECIAL COMMITTEE ON RESEARCH

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

MINUTES OF PROCEEDINGS

THURSDAY, June 16, 1960.
(5)

The Special Committee on Research met at 9.50 a.m. The Vice-Chairman, Mr. C. A. Best, presided.

Members present: Messrs. Aiken, Batten, Best, Brunsden, Dumas, Grafftey, MacLellan, McQuillan and Payne.—9.

In attendance: From the National Research Council of Canada: Dr. E. W. R. Steacie, President, Dr. F. T. Rosser, Vice-President (Administration); Mr. F. L. W. McKim, Administrative Services; and Dr. J. B. Marshall, Awards and Grants.

Dr. Steacie continued his review of the booklet entitled "Organization and Activities" and was questioned concerning the preparation, publication and distribution of scientific journals, patents, scientific liaison activities, and the Technical Information Service of the National Research Council.

At 11.00 a.m. the Committee adjourned to the call of the Chair.

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

23324-7—1½

EVIDENCE

THURSDAY, June 16, 1960.
9.30 a.m.

The VICE-CHAIRMAN: Gentlemen, it would appear that we have a quorum this morning.

Again, we are running into the problem of overlapping with other committees. This seems to present a continuing problem.

Our chairman, Mr. Murphy, is away today; he has meetings in Sarnia and other places for the next few days. However, he should be back some time next week.

Dr. Steacie and some of the staff members are again with us.

I propose that we might continue, commencing at page 41 in your grey book, on organization and activities.

Before we commence, I think I might draw your attention to the publication that was passed out at the last meeting, and any members who were not here at that time may obtain a copy from the Clerk. It is entitled Industrial Research Development Expenditures in Canada. It is published by the dominion bureau of statictics, and is a very useful publication.

Also, I would like to ask Dr. Steacie about this proposed publication. It is in the process of being made now, and concerns all types of research in Canada.

Dr. Steacie, could you indicate the possible differences in this publication, and when it might be distributed to the committee?

Dr. E. W. R. STEACIE (*President, National Research Council*): Mr. Chairman, the new one is not on all types. This one is industrial.

The new one is Federal Spending, and it is an attempt to break down the spending by the federal government into fields of research, to separate out research and development from testing and services, and to separate the administrative part out of estimates. If you merely look at the total figures, you do not get an indication of the amount of scientific work we are doing. There are many things which are regulatory, and do not involve research.

This is being prepared in cooperation with ourselves, and the aim is to produce a document something like one put out by the United States government each year, called Federal Funds for Science. This breaks down the expenditures of the American government.

As a start, we are trying this one, and it should be published within a few weeks. This will break down the federal government expenditures on science into units; in other words, subtract off from each department the things that are not scientific, and then correlate, by fields of work, research in physics, electrical engineering, and so on, and try to get a general picture of the total government expenditure on science.

The VICE-CHAIRMAN: That will be of unusual value, since this is the first time this has been done.

Dr. STEACIE: Yes.

I, personally, had on previous occasions made rough summaries of this, which I have given in various places. However, this is a proper statistical job, and a proper attempt to break the budget down.

The VICE-CHAIRMAN: Gentlemen, if we may proceed with page 41 now, we will complete this grey book.

I suggest that we could ask Dr. Steacie a few questions on these four or five sections which are left. Then, I suggest we might proceed to a more detailed study of some of these activities with Dr. Rosser, the head of the administration services.

Would you proceed, Dr. Steacie.

Dr. STEACIE: Page 41 is assistance to scientific publications.

Since our function is to aid science in Canada, publications obviously are important. Until the last 20 or 30 years, virtually all Canadian scientific work was published in foreign journals.

When you start new journals, you always have some difficulty, because they cannot become established immediately, as the best people will not publish in them until they are well establislhed. You experience a difficult period with a new journal.

If you look at table 10, I think the easiest thing would be to consider the last column. You will see, from 1945 to 1957, a matter of 12 years, that the total number of pages of these journals has gone up from 1,700 to 7,700. This is an indication of two things: first, the expansion of Canadian science and, secondly, the fact that these journals are now thoroughly established as first rate journals. I think the whole development of these journals which are published by the National Research Council has been very successful.

The council also gives aid to certain other Canadian journals which it does not, itself, publish. An example of this is mathematics, experimental psychology, and things of this sort.

Mr. BRUNSDEN: As a matter of interest, microbioloby came in only in 1954-56. Could you give the reason for that?

Dr. STEACIE: That is a split off from botany and zoology—as a matter of fact, from botany, zoology, biochemistry and physiology. Up to that time there was a tendency for microbiology to appear as botany, if it involved plants, to appear as zoology, if it involved animals, to appear as biochemistry and physiology, if it involved humans. In reality, these papers have been more or less withdrawn from the other three journals.

Mr. BATTEN: Dr. Steacie, what was the reason for discontinuing the publication on technology in 1957?

Dr. STEACIE: The trouble with the technology journal was that it was an omnibus publication; it included all branches of engineering, applied chemistry, applied physics and applied biology, and people do not like to publish any journals that are not specialized. The subscription is not sufficiently wide so that you are sure that people see your work. As a result, we were in trouble in so far as the technology journal was concerned. We were not quite sure where it should go. It began to appear that what was desirable was a journal for engineering, other than chemical engineering, and another journal for chemical engineering. Therefore, about this time, we gave some support to the Engineering Institute of Canada, when they began publishing a research supplement to their journal, and this took care of the publication needs in engineering, other than chemical engineering. We entered into an arrangement with the Chemical Institute of Canada whereby they took over the Canadian Journal of Technology, and changed its name to the Canadian Journal of Chemical Engineering. It then went ahead with the same volume number and so forth; in other words, just the name changed, rather than an abandonment. But, this is now financed by the Chemical Institute of Canada rather than ourselves, and I think it is working out quite satisfactorily.

Mr. BATTEN: Dr. Steacie, are these journals published in both the English and French languages?

Dr. STEACIE: Yes, papers are in English or French.

Mr. BATTEN: This may be off the point, but could I ask this question, Mr. Chairman?

The VICE-CHAIRMAN: Proceed.

Mr. BATTEN: Do you do any translation into English, for your own purposes, of papers from other countries?

Dr. STEACIE: Yes, we do quite a lot of translation. A large number of these are for our own purposes, but when they are translated for our own people, they are put out in a bound mimeographed form. We are on all the commonwealth, American and other lists, and they are available to anyone who wants them anywhere in the world.

In respect of our translations, so far as journals are concerned, it is assumed that everyone is able to read French and English. I think this is true universally in science. We do very little translation from German. In general all people with a degree in science must be able to read German; but this does not apply to engineers, and the engineering divisions do some translations of German papers. The main translations are from Russian and from the less usual languages. Most good Japanese work appears in English, but there are occasionally Japanese and Chinese papers. There are very few papers in Roumania which appear in Roumanian; they mostly will be published in Russian or German; but when one does appear a translation is made.

I think the Russian problem is getting easier. It is now becoming possible to buy a complete translation of Russian journals as they appear. You can buy in English complete Russian journals. Gradually the number of these is increasing and as this happens it lightens the load on our translation service.

The VICE-CHAIRMAN: Are these publications printed by the printing bureau?

Dr. STEACIE: No, not necessarily. They are printed under contract. In general we get prices from the printing bureau and from outside publishers. In addition to that we consider who best is competent to do it. The only place in Canada capable of doing complex mathematical printing is the University of Toronto Press. I believe at the present time the journals are published by the Queen's printer, the University of Toronto Press and the Mortimer Press. In each case we have quotations.

Mr. AIKEN: Are the translated journals translated in Russia or in the United States?

Dr. STEACIE: They are translated almost entirely in the United States or the United Kingdom, and are done with considerable subsidy from various organizations—mostly government. They still are very expensive. For instance, a journal that would cost $15 a year in Russian will probably cost $200 a year in the English translation. If there were not a government subsidy, however, it would cost a great deal more.

Mr. AIKEN: I do not know whether or not you noticed in the newspapers yesterday that there is the development of a machine in the United States which translates roughly from Russian into English. This has been developed by a computing firm.

Dr. STEACIE: Yes.

Mr. AIKEN: This may improve the speed of the translations.

Mr. BATTEN: Was that a western or Russian invention?

Mr. AIKEN: It is a United States invention.

Dr. STEACIE: There is a great deal of work going on in France, England, Germany, the United States and Russia on machine translation; but I would say that it has another twenty years to go. The difficulty is to feed the machine a formula which will enable it to put ideas into good idiomatic English. The present machines will produce a highly inaccurate sort of pidgin English. There is, however, a great deal of effort going into this, and in the long run I think machine translation has possibilities.

The VICE-CHAIRMAN: Are there any further questions on page 41?

Mr. MACLELLAN: I am wondering what is the circulation of your journals; how many copies go out, for instance.

Dr. STEACIE: The chemistry journal has a circulation of 3,000 copies.

Mr. MACLELLAN: Is it distributed by means of a mailing list.

Dr. STEACIE: This is done in the standard way in which scientific publications are circulated. First of all we would send out certain complimentary copies to other government departments and places of that sort. Then we have subscriptions from libraries, institutions and individuals. I think, to take an example, that this type of circulation of a really specialized journal is about what you get with most of the scientific journals. In other words the circulation is about as good as most. There are some exceptions. The American chemical society journal has a very large subscription, but this is due to the fact that the members get it cheap as part of the membership fee. We also have an arrangement of this sort with the chemical institute of Canada whereby we give a cheap rate to the institute on the condition that a block of more than a certain number of people will subscribe.

Mr. MACLELLAN: What do you charge for your journals?

Dr. STEACIE: It would vary according to the number of pages. Also some are monthly and others are bimonthly. The chemistry journal is published twelve times a year and is $12.

Dr. J. B. MARSHALL, (*Secretary, National Research Council*): They are $12, $9, $6 and $5, depending on the number of issues per year.

The VICE-CHAIRMAN: Would it be of any interest if it could be arranged that we have the circulation and the cost of these various journals for the last three years?

Dr. STEACIE: We would be glad to do that.

Mr. BRUNSDEN: Is the cost of the publication of these journals a heavy drain on the council?

Dr. STEACIE: No. It is about $275,000 for all journals. That is out of pocket expenses.

Mr. BRUNSDEN: After the journals have been printed.

Dr. STEACIE: Yes. That is the net cost; actually it is quite low. All scientific societies which run journals find that you cannot publish a first rate journal without a subsidy. For one thing there is what you might call dignity, if you like. No one will publish a paper in a journal which is 50 per cent advertising. When it comes to a scientific journal you expect it to contain scientific matter and not advertising. You can get away with an advertisement on the back cover or some thing of that sort; but no one is willing to publish in a journal which contains any amount of advertising.

Mr. PAYNE: I would be interested in Dr. Steacie saying a word or two regarding the author source. Are there scientists in the various fields whose work you are unable to publish due to lack of funds and facilities.

Dr. STEACIE: I would be very glad to answer that. First of all, may I say that Dr. Marshall will be appearing later and at that time if you so wish he could produce the figures in respect of the journals.

The VICE-CHAIRMAN: That would be helpful.

Dr. STEACIE: In the advisory council we have an editorial committee; then we have an editorial board composed of editors of all the journals. The editors all are Canadians. In common with normal scientific trends each journal has a board of about eight associated editors—something around this number. In general the associate editors are partly Canadian and partly from other countries. Again, this is in accordance with normal scientific procedure. Papers are considered in the normal way; that is, they go to the editors, are sent to referees and on the basis of the comment of the referees they are returned to the author with a number of them being rejected and a considerable number amended as a result of the discussion. At the present time we are running no backlog. That is why we are publishing everything that the editors recommend as being worth publishing. Therefore, there is no problem of that sort. The contents of the journal would vary. The major content would be papers by Canadians. Also there is a fair number of papers submitted from outside and there is no ban on this. Canadians are publishing in foreign journals. We are glad to get these papers ourselves and there is an increasing number of papers from outside Canada appearing in our journals.

Mr. AIKEN: Would these be papers which are not published elsewhere?

Dr. STEACIE: None of them would be published elsewhere. The journal would not publish anything that had been published elsewhere.

Mr. PAYNE: Do you anticipate trouble with reference to the volume of contributors whose papers you would like to see published in the journals, due to financial difficulties or otherwise.

Dr. STEACIE: No. I do not think so. Actually at the present time we are anxious to have these journals reach a mature stage. Once you pass a certain point you get to the stage where everyone has to subscribe to the journal and it has to be in all the libraries. Once you reach that point your journal is a success. What we are concerned with primarily is getting each of these journals to the stage where it appears monthly. Gradually there is a build-up. You will notice that the physics journal went from 200 pages to 1,557 pages and now appears monthly rather than bimonthly. Similarly chemistry has reached and botany and zoology are reaching the level at which this can happen. We would hope there would be an expansion. In a way this is the end result of everything we are spending, and consequently I think it would be awfully foolish if we were stingy about these journals. Actually the total cost of $275,000 for journals in our budget of roughly $35 million, is not a very big item. This includes editorial and printing costs. Also as the journals expand you save money as your subscriptions go up; the subscription is larger than the additional cost of the editing and printing. I think we could double the total circulation without coming anywhere close to doubling our total expenditure.

The VICE-CHAIRMAN: Are these all followed by such names as the Canadian Journal of Botany? For instance, do they all have similar titles?

Dr. STEACIE: Yes. They all started as the Canadian Journal of Research—section "A" chemistry, section "B" physics, and so on.

Mr. AIKEN: This is when it had to be in one volume.

Dr. STEACIE: Yes. Then they broke into separate journals and substituted the name of Canadian journal of this, that and the other.

Mr. BRUNSDEN: Is there any tangible reaction from abroad in respect of the journal? In other words do you make contacts or do you receive comments to any large degree from similar organizations elsewhere?

Dr. STEACIE: Well, I think the main thing is that what you are concerned with is the development of publication by Canadians, irrespective of where it is. That is the first thing. Then you want your journal to contain a good share of the best material. In the first place, I think that the reputation of Canadian science, in general, has been rising rapidly; and these journals have now come to a stage where they are existing in all libraries of any importance. They are a major journal in those fields in which Canada has strong groups.

Mr. BRUNSDEN: We are concerned with the status of Canadian science abroad.

Dr. STEACIE: Yes. There is an awkward point. There is a time in the early stages where you are hiding what you are doing, when you publish it in your own journal, if it is not widely circulated. Then, as time goes on, you are not hiding it any longer. I would say that 80 per cent of the papers from our own labs were not published in our own journals 15 years ago. We did not exercise any compulsion on our own people to publish in our own journal. As the journal developed more and more of our own people decided this was a good place to publish. As far as I was concerned, I was publishing about one paper in four in our own journal at the end of the war. By 1950 or 1952 I was publishing, essentially everything I did in our own journal. I think its reputation has grown, and we have a very wide distribution. I am not quite sure, but I think the latest figure for the Soviet Union was 160 copies.

Dr. F. T. ROSSER (*Vice-President, Administration, National Research Council*): The figures for the Soviet Union are 294 subscriptions going into 52 institutions—these are paid. On an exchange basis the figures are, 64 into 12 institutions.

The VICE-CHAIRMAN: What would you forecast for the future—the need for more journals, more money?

Dr. STEACIE: Our attitude on journals has been that you should never start them unless the need is absolutely assured. You can get into a great deal of trouble by starting a journal without too much thought and finding it is very slim, and having difficulty getting enough material. Then the thing becomes quite a problem. In the case of the journal of microbiology we required a great deal of information from the microbiologists to forecast the number of papers that would be available each year. We delayed for at least two years, until we were sure from the figures that there was no danger of this journal not being a success. As the journals have come up, more and more Canadian papers are being published in Canada rather than in American and British journals, particularly. So there will be a rise by diversion. There will also be a rise due to increase in Canadian scientific work.

At the rate scientific publication is going, I would expect that for at least the next forty or fifty years the rate of increase will be as rapid as shown here. This shows an increase factor of nearly five in 12 years. I would think we would continue to multiply by five every 12 years, and probably continue to start new journals every four or five years.

Mr. PAYNE: Your budget situation is not limiting? Any problems you have are of a technical nature?

Dr. STEACIE: No. Our overall budget, actually, is rising, I think, just as rapidly as publication costs. In other words, this is not an out-of-the-way budget cost.

The VICE-CHAIRMAN: Are there any further questions on this aspect?

Mr. AIKEN: Just one more question, Mr. Chairman.

I think we did have a figure of the total issue of the journals; but could we have some idea of the number of countries and institutions into which the journals are distributed?

Dr. STEACIE: Could we get this for you?

Mr. AIKEN: I wonder if today, without detailing the actual countries, we could have the number of countries and institutions, outside of Canada, into which the journal is distributed?

Dr. ROSSER: The journals go into every country in the world that has important scientific institutions. I have given you the figures for Russia, and the Chinese figures are even larger than Russia's. There are 315 subscriptions going into 14 institutions in China; and, on exchange, there are 19 subscriptions in 5 institutions. This is true all around the world. The same is happening in every country that is progressing scientifically. We could get the actual figures, but we would have to compile them.

Mr. AIKEN: I do not think it is really important, as to the actual countries, but I thought it would be interesting to know the number of instances.

Dr. STEACIE: Really, this is just a reflection of the fact that Canadian science has come ahead. Thirty or forty years ago there were just the odd small groups which were internationally well-known. There has been a very big increase since. The net result is that scientifically, rather than being in the backwoods we have now become one of the important scientific countries in the world; and, therefore, anybody starting a scientific library anywhere simply has to buy these journals.

Mr. AIKEN: That is what I was hoping was the case.

Dr. STEACIE: This is the position we are coming to.

Mr. DUMAS: I wonder if a few of the most recent issues of each of these journals could be tabled, so we could have a look at them?

Dr. STEACIE: Certainly.

The VICE-CHAIRMAN: That is a good idea.

Mr. McQUILLAN: Mr. Chairman, I would like to ask Dr. Steacie this: If somebody writes to you concerning some specific scientific problem that the council has not done work on, but it is one upon which there are departmental papers—such as, the Department of Agriculture, or forestry or something like that—do you have a record of those publications, and can you give them information?

Dr. STEACIE: In general, what will happen is that if we have no one who knows anything about the subject we would then say, "Write to the Department of Agriculture." If we have someone who knows vaguely something about the subject, we would say, "Write to Dr. Smith in the Department of Agriculture, who is engaged in work in this field." In other words, we would try to be a little more helpful than merely passing him on. However, you do come down to small industries or people who have no particular technical background themselves. However, I would like to discuss this under "technical information services", on the last page, because we have a special mechanism there. Is that satisfactory?

Mr. McQUILLAN: Yes. I gather from your remarks there is no central clearing house on scientific information covering all the departmental and government scientific research?

Dr. STEACIE: No, I think this would be rather useless, because what you want to advise the man is what is being done in the world, and not what is being done in a government department in Ottawa. Your problem is not to centralize government scientific publications, but to give information based on all of them. We have an information service which will do this; but if it is agriculture, agriculture has one too. So we would not try to step into a field in which we are not expert, but we would refer to those departments that were concerned. In general, it will not matter very much whether the paper has been published in Ottawa or Hong Kong. You have your scientific literature organized so that you can find out what is happening on a given problem from anywhere in the world. It is a bigger problem than just the government.

Mr. McQUILLAN: And you have it organized?

Dr. STEACIE: We have an information service that will do this.

Mr. MACLELLAN: One point intrigues me. You have been getting these journals from all over the world. I am wondering if the journals you get from China show a rise in scientific capability as shown to us by what we had in the newspapers?

Dr. STEACIE: I think there has been a very marked increase, both in quality and quantity, in the scientific work in China.

Mr. MACLELLAN: How would you say it would compare with our own progress in Canada, from reading these journals—or could you compare the two?

Dr. STEACIE: It is a little difficult. There is and always has been some good work going on in China. This has been true for a long time. For the size of the country, there has not been a very big scientific effort. This is developing now. It has not developed yet to the stage where China is a major scientific power; but the effort being put into science by the Chinese is such that this development is unquestionably coming about. There is a very big expansion of universities, research institutions and scientific work. There is no question that ten or fifteen years from now the volume of good work coming from China is going to be very appreciable.

Mr. BRUNSDEN: Would you say the rise of China's science in the last few years is strictly a domestic effort, or is there an infusion of outside thought behind this scientific effort? For example, Russia—is Russia playing any part in China?

Dr. STEACIE: I would say it is a question of both. Canadian scientific effort, in the early days, drew on Britain, to a very large extent. That is, university professors were imported from Britain in the very early days; and this was the main source of people. To some degree the Chinese have done that with the major scientific nation with whom they are in contact and are next door, the U.S.S.R. There is no question they have called on Russia for assistance and advice, but the actual work is almost totally being done by the Chinese. It is more a technical aid program by Russia if you like.

Mr. BRUNSDEN: Is it a diversified program, as is ours?

Dr. STEACIE: Yes, it is.

Mr. MACLELLAN: Are you hearing anything from India?

Dr. STEACIE: Yes. Actually, I spent a month visiting Indian scientific labs a year ago January. Two people representing the council were in India last January.

There has been quite a big development in Indian science, particularly the Indian equivalent of the National Research Council, which was set up and has opened labs in a great many places. The development in the Indian universities is not as spectacular, and there is a long way to go; but Indian science is certainly moving up also.

Mr. MACLELLAN: Has it come along as fast as Chinese science?

Dr. STEACIE: No.

Mr. PAYNE: What about Japan?

Dr. STEACIE: Japanese science has always been good, and we have had quite a number of Japanese postdoctorate fellows in our lab who have been of a very high quality.

I think that the moment Japan started to become westernized the Japanese took to science very readily, and I think they are very competent. The net result is that I think Japanese science is very good.

The VICE-CHAIRMAN: Has Canada played a fairly considerable education or further training of Indian students, since the second world war?

Dr. STEACIE: I think, for our size, we have played quite a large part, under the Colombo plan and other things. We have quite a number of Indian students in Canada. We have had quite a lot of Indians on postdoctorate fellowships in our own labs, in universities and in some other government agencies.

When I visited India, I do not think that I was in a single lab during the month I was there which did not have one former N.R.C. postdoctorate fellow who had gone back after his time here. I think we have been of some help but, of course, the Indian development is intimately tied up with the whole major problem of education, which is a very great problem.

Mr. GRAFFTEY: Dr. Steacie, *vis à vis* the communist bloc, we know a lot of countries in the communist bloc—Czechoslovakia, Poland, and any you want to name. Before the war they had a high degree of research development. What would the case be today, sir? Is there quite an interchange of research scientists going on between Moscow and the satellite countries, or is it more centralized, or has there been any notable change in research development in the satellite countries in the post-war years?

Dr. STEACIE: There has always been good science in central Europe, and there still is. I think for a time, when the iron curtain was fairly impenetrable, there was a change in direction of the movement. Whereas Germany had been the center of European science, so that people from Czechoslovakia, Hungary, and so forth, would move to Germany and be well-known there, the move was to Moscow because it was only within this bloc that the movement was possible.

In the last few years the movement has been both ways, and it has become much easier, and there are more Canadians visiting the iron curtain countries, and more people from the iron curtain countries visiting Canada and the United States, Europe, Britain, and so on. So, I think, after the war Central Europe was in the same position as the U.S.S.R., in being cut off. I think the movement of people now has become quite free.

Mr. BRUNSDEN: Taking India as example, since you visited that country, do you foresee any impact on the sociology of the country as a result of growing scientific interest?

Dr. STEACIE: I think that is the only solution of their problems. That is, I think India must industrialize and they must also improve their agriculture and the use of natural resources; and all of this, as a technological development, is based on science.

Mr. BRUNSDEN: And the beginnings of this are apparent, are they?

Dr. STEACIE: Yes, the beginnings of this are apparent.

The VICE-CHAIRMAN: We are straying quite widely from publications, but this is an important and interesting field. Probably I could err a little further. Perhaps it is not our responsibility, Dr. Steacie, but you mentioned China was increasing its scientific production at a faster rate than India. Do you feel that has started at a lower level in the Indian training in science?

Dr. STEACIE: This is difficult to answer. I think that there has always, perhaps, been a misconception in regard to China as being not technologically minded. A great many of the major "inventions" of the seventeenth century had been made in China a thousand years earlier. In fact, they invented things like lock gates for canals, and the wheelbarrow. A very large number of things were invented in China, and they took at least a thousand years to get west. If China has not been technologically minded over the last three or four hundred years, there was, nevertheless, a background of technology earlier than ours. I see no reason why China's technology should not expand very rapidly.

Mr. PAYNE: If I might be pardoned again for broadening the subject, I would find it fascinating if Dr. Steacie would comment on any visible changes relative to scientific activity in the very backward nations of Africa, or South America and the Latin American region. Would that be in order at this time, Mr. Chairman?

The VICE-CHAIRMAN: I think that is fine, with the reservation we would like to complete this material today. There are two more pages.

Mr. PAYNE: The Chairman seems more anxious to complete this than we are.

Dr. STEACIE: First, I would say that I think there is a quite rapid expansion of science in Latin America at the moment, which varies from country to country, but it is quite noticeable. In Africa there are very considerable developments. I am a member of the British Commonwealth scientific committee, which consists of people with equivalent jobs to myself in all the commonwealth countries, and there is a noteworthy development of interest in Ghana and the newer independent countries. I think there is a rise of interest in all these countries, and that this is the forerunner of a rise in technology.

The VICE-CHAIRMAN: Could we go on then, gentlemen, to Interdepartmental Service, page 42?

Dr. STEACIE: I think there is little I need to say here, except that we do things for other government agencies. Research for defence is the business of the Defence Research Board. However, if we happen to have people or facilities that may be able to help we are frequently called on to do something for them. This is true for a number of government agencies. We have been involved with the St. Lawrence seaway, at one time, and so on. In general, when we do this we charge the department concerned for the cost of the work, and that then shows up as council income and is not part of our estimates.

The VICE-CHAIRMAN: Are there any questions on this field, gentlemen?

Mr. PAYNE: Yes, Mr. Chairman. This statement that Dr. Steacie made relative to the studies of the St. Lawrence. This, I believe, was a matter of a scale model, was it not, doctor?

Dr. STEACIE: Yes.

Mr. PAYNE: Has there been any move or approach to your council relative to possible studies on the upper Columbia, in conjunction with the American studies lower downstream, or on the Fraser?

Dr. STEACIE: There have been discussions, and I think we do not have the capability to go in for the design of major hydro electric developments. This would be somebody else's job; but when it comes down to the water diversion and the hydraulic problems, then, I think our hydraulics people can be extremely interested. I would suspect we would come in at a little later stage of development. We have also been involved in the design of lock gates and the design of dams and so forth for hydro electric developments. We have given advice in regard to the *William Carson* ferry and *Port aux Basques*, and things of that type.

The VICE-CHAIRMAN: That is of considerable interest to Mr. Batten.

Mr. PAYNE: Have you had anything to do in connection with the fish problems on the Fraser river, or is that entirely a problem of the Department of Fisheries?

Dr. STEACIE: This is a problem belonging to the Department of Fisheries, but it has been discussed by our organization. I cannot answer your question directly as to whether we have actually done anything in this regard.

The VICE-CHAIRMAN: Are there any further questions in regard to this section? If there are no further questions we will move now to the section on Patents.

Mr. DUMAS: In regard to the section concerning patents I would like to receive some information in respect of the new plotting machine or instrument which has been produced by the applied physics section for making maps from aerial photographs. Was this machine developed as a result of the efforts of one man, or a group of men?

Dr. STEACIE: It was developed by a group.

Mr. DUMAS: Have you applied for a patent in this regard?

Dr. STEACIE: I think we have, yes.

I wonder if I could perhaps answer this question briefly and then ask to defer questions in regard to this patent section until Dr. Rosser comes before this commitee. Dr. Rosser is president of the crown company, Canadian Patents and Development Limited, which handles our patents.

To answer the general question, I think there is a little bit of misconception about the question of bonuses to inventors. Most of our work is long-term and is therefore not patentable. The inventions that are patentable are rarely things from which we make a lot of money commercially. We are mainly interested in getting these inventions into use. There is a great deal of difference between a sweeper who invents a new kind of floor mop, but who is hired to sweep, and a man who is hired to do a job of developing something and does it. In other words, from our point of view the bonus that a man will receive for doing something of this sort in respect of salary increases and promotions will be much greater than he would ever receive from royalties.

Under the Public Servants Inventions Act royalty bonuses are laid down. We have never had anyone yet invent anything which brought us in an enormous amount of revenue. In fact, in a great many cases the only way to get an invention into use is to assign a patent without a fee. Our whole outlook in this regard is that the taxpayer has paid for the development and we feel that we should make its use feasible. We write a reasonable commercial contract from which we receive some revenue.

Mr. WINCH: I understand that this is a very up to date instrument.

Dr. STEACIE: Yes.

Mr. DUMAS: Has it been licensed or patented? Has it been licensed to a company for production?

Dr. STEACIE: Could I refer that question to Dr. Rosser?

Dr. ROSSER: I am not sure in that regard. I would like to look this up.

Mr. DUMAS: I understand a model is being built and will be shown at the international society of photogrammetry in September 1960 in London, England.

Dr. STEACIE: Yes, I believe that is right, but it is my information that it has been licensed to an Italian company.

Mr. MACLELLAN: Are any patents applied for in Canada through the National Research Council?

Dr. STEACIE: No, we have no responsibility in that regard whatever. As far as the National Research Council is concerned we assign all patent rights to Canadian Patents and Development Limited. This is a crown company wholly owned by the National Research Council. I would like Dr. Rosser to discuss that. Canadian Patents and Development Limited have control of these things for some other government departments as well, but we have nothing to do with the patent office. This we would like to avoid at all costs because, being a research institution, I think you can see the trouble we would get into.

Mr. MACLELLAN: I notice that you have 10 employees doing patent and legal work. Are those people employed by Canadian Patents and Development Limited?

Dr. STEACIE: They would be working partly for the council and partly for Canadian Patents and Development Limited. I think Dr. Rosser will discuss the Canadian Patents and Development Limited subject. Being the president, he will be able to do that much better than I can.

The VICE-CHAIRMAN: Gentlemen, can we move to a consideration of the scientific liaison officer item?

Dr. STEACIE: I think the basic information in this regard is that to a considerable degree we are scientific advisers to the Department of External Affairs. We have an office in Washington. The man in charge of that office is also the scientific attaché to the Canadian embassy in Washington. We have an office in London, and the man in charge there is the adviser to the High Commissioner and also acts as an adviser to the NATO delegation spending part of his time in Paris. These offices have been established firstly for our own purposes and secondly as scientific advisers to NATO and OEEC, and to the high commissioner's office in London and, again, the embassy in Washington.

Mr. BRUNSDEN: What would be the function of a liaison officer in regard to the Department of External Affairs in Ottawa?

Dr. STEACIE: Here in Ottawa we act in an advisory capacity whenever the Department of External Affairs consults us. Dr. Babbitt, who is in charge of the scientific liaison offices, keeps in close touch with the Department of External Affairs. This is very informal. There is no need for the external affairs department to consult us about anything, but they find increasingly, and so do we, that scientific subjects begin to impinge on international subjects. We find that international political questions impinge on some questions of scientific origin. We have a very good relationship with the Department of External Affairs through this arrangement.

The VICE-CHAIRMAN: Are these individuals employees of the National Research Council?

Dr. STEACIE: They are employees of the National Research Council, yes; but we would not appoint our liaison officer to Washington or London without first consulting the Department of External Affairs and knowing that the appointment was satisfactory to them. In other words, if a man is going to act in a dual capacity, as our representative and their adviser, it is essential that he be acceptable to them.

The VICE-CHAIRMAN: Could you tell us how many officers there are in how many countries?

Dr. STEACIE: The only countries involved are the United States and Great Britain. The officer in London covers Paris as well. The senior liaison officer visits Paris. We have two liaison officers in London and one in Washington, and there is a very small stenographic and clerical staff.

The VICE-CHAIRMAN: I realize that most of the scientific information is distributed through scientific journals, but do you feel it would be helpful to have liaison officers in west Germany, for example, and other places?

Dr. STEACIE: No, I do not think that is necessary. I think that with the development of things involving the OEEC, the EPA, UNESCO and NATO, we may come to the stage where we have to put a man in Paris; but I can see no intention at the present time of expanding beyond that.

Mr. PAYNE: Do you feel that the provision of two men in London and one in Washington is adequate?

Dr. STEACIE: Yes.

Mr. PAYNE: You are not hampered due to the limitation of funds?

Dr. STEACIE: No, we are holding this down ourselves. We feel this is adequate, with the rider that it may become necessary to put a man in Paris some day. At the present time, Dr. Malloch, who is the chief scientific liaison officer in London, has reached the stage where he is spending 50 per cent of his time in Paris, and the time may come when we will want a man full-time there.

Mr. PAYNE: Is the primary function of these individuals to assist the National Research Council in regard to scientific information as far as Canada is concerned, or in an advisory capacity?

Dr. STEACIE: Generally the job that these officers perform is making arrangements for Canadian engineers and scientists, not necessarily government employees, who need help. They act in this same manner on behalf of industries and university people. They will look up specific information at the specific request of an industry or other bodies, and to a certain degree for commonwealth companies and so on.

The commonwealth liaison officers in London are all located in the same building. They are not attached to their embassies. This results in very good exchange of material. This is a small operation, not a major one. We feel it is very worth while to have this office. It is quite small. We have not built up a colossal network of red tape and accumulated papers.

Mr. PAYNE: Does the National Defence research board undertake its own liaison work?

Dr. STEACIE: Yes.

Mr. PAYNE: It does this apart from your organization?

Dr. STEACIE: Yes, this is done through the Canadian joint staff in London and Washington. There is a member for each of the three services and also a member for the defence research board.

Mr. MCQUILLAN: Are you satisfied that the exchange of information as far as Canada is concerned with other nations of the world is as good as it can be?

Dr. STEACIE: I think you have to distinguish two things. One is science and the other is technology. In the scientific field everything that is worth while is published, and therefore your exchange depends on two things: the establishment of a first rate library and personal contact with individuals so as to know what individuals are doing before the information is published. Everything that can be done in this regard is being done.

Mr. MCQUILLAN: Would that apply to the iron curtain countries as well?

Dr. STEACIE: Yes, our information from the iron curtain countries is very good, bearing the one difficulty of translation in mind.

In regard to the technological field, you have to proceed on a somewhat ad hoc basis. There is not the same formal publication. There exists industrial secrecy as well as military secrecy. Our information services and our liaison officers spend most of their time in tracing down this type of information. They will receive a request from an industry in Canada to find out what is happening in Britain in a given field and they must make personal contacts in order to get this information. The scientific problem in this regard is simple. It is complex in detail but it is simple in principle. The technological problem is more difficult. You have to depend on people who are in the engineering field so that the engineers will know what is happening in the rest of the world.

The VICE-CHAIRMAN: Could we consider the technical information service item now, gentlemen. I might add here, Dr. Steacie, that I think Mr. Grafftey is filling out an application for your Paris office.

Dr. STEACIE: I would be glad to consider him very seriously.

The VICE-CHAIRMAN: Shall we consider the item headed technical information service?

Dr. STEACIE: We handle information requests in two separate ways. It is obvious that if a director of research in a large Canadian company wants to discuss something he will go to the head of one of the scientific divisions and this will be handled on a personal basis by the technical people.

Mr. MCQUILLAN: Dr. Steacie, do you feel that the students, particularly in our high schools, and many of whom do not go beyond that, are making good use of the scientific information that is available, and are being made aware of how to acquire this information? It seems to me that wherever I travel I see instances where this scientific information would be of tremendous advantage to people in small businesses and industries, but due to our educational system they are not aware of how to acquire that information. I am not referring necessarily to scientists particularly. I know the information is distributed to the scientists and the universities, and so on, but I feel there is a weakness in our secondary school scientific education program in that the students are not made aware of how to find the information which they may need at some future date.

Dr. STEACIE: I believe in some schools there is a definite attempt to teach the student how to use reference libraries. I think this is really the problem. If you can teach a student how to dig up some obscure information that he requires this would solve the problem, but how do you go about this? This is something that I think all lawyers, scientists, historians and various people in those categories learn. Perhaps something should be done in this regard in the high schools.

Mr. MCQUILLAN: Unless we can show the average person how to make use of this scientific information, we are not accomplishing anything.

Dr. STEACIE: I would just like to explain what we are doing here. With the thoroughly technical industries you can depend on them to know when they have problems and to know where to go to solve them. They may not know the answer to the problem but they know how to go about acquiring it. We deal with a very large number of people in this way. A problem arose particularly at the end of the war when there was a big transfer from war to peacetime manufacture which caused trouble in regard to the method of getting information to the little industries. We have set this system up of a technical information service in an effort to solve this problem. We maintain a central information service. In some provinces we have field officers, and in other provinces we have contracts with provincial research organizations. These organizations perform aggressively by making visits to plants in an effort to find out if they have any problems. I think this approach has been quite useful. We are getting more and more of this type of organization, and are cooperating with the small business branch of the Department of Trade and Commerce which, in a sense, is attempting to give the same kind of service at the economic level. I think this is a partial solution to this problem.

Mr. MCQUILLAN: I realize that it is a partial solution, and I feel that an individual in a sizeable industry needing information will find someone who does know how to get the information; but what I am concerned with is that it seems to me that our high school students are not made aware of the information that is available and the method of acquiring it when at some future date they need it. I would venture to state that a great percentage of the high school teachers in Canada do not know what the National Research Council is.

Dr. STEACIE: We actually conduct an embarrassingly large number of classes through our laboratories. I say embarrassingly large, because the man in the laboratory must be able to do some work and there is a limit to the number of visitors that can be accommodated. The number of people who visit our laboratories is quite high. Included among the visitors are groups from high schools who come from points as far away as Hamilton, Toronto, Montreal and Quebec.

Mr. McQuillan: Do you have visitors from west of the great lakes?

Dr. Steacie: It would be quite expensive for visitors to travel from that distance away. There is, however, an effort on the part of quite a number of schools to have their classes visit scientific laboratories in industries, universities and government departments in an attempt to show the students what a laboratory looks like, and that sort of thing. We do this to a limited extent, but we have to draw the line somewhere.

Mr. Brunsden: This question gives rise to another question in respect of the absorbative powers of the students. There is quite a wide gap between a secondary school student and a man in the National Research Council. Is it possible that a finding made by the National Research Council could be absorbed by a high school student?

Dr. Steacie: I think the answer is probably no. I think that Mr. McQuillan meant that some of these students will eventually be engaged in small industries, and that it would be nice if they knew, not how to answer problems but how to find the answer.

Mr. McQuillan: That is exactly what I had in mind.

Dr. Steacie: In other words, who to consult in regard to these problems. Actually, based upon the inquiries that we receive, I think that our general function is pretty widely known.

Mr. McQuillan: I am not criticizing the National Research Council in any way at all, but I feel there is a gap somewhere in our primary scientific education program in high school classes.

The Vice-Chairman: I would like to interrupt here, gentlemen. We have one or two minutes left before the House of Common's bell rings. Do you wish to conclude the consideration of this material now or leave it to some later date?

Mr. MacLellan: When will we be meeting again?

The Vice-Chairman: Dr. Steacie will be at the west coast this week attending a meeting.

Dr. Steacie: I am just going out to the west coast to attend the opening of the dominion radioastronomy observatory.

The Vice-Chairman: The chairman will be away next week and I will be in the United States giving lectures. Perhaps our next meeting will be one week from today. That is next Thursday at 9.30 a.m., would that be agreeable?

Some hon. Members: Agreed.

HOUSE OF COMMONS

Third Session—Twenty-fourth Parliament

1960

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: J. W. MURPHY, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 5

NATIONAL RESEARCH COUNCIL

THURSDAY, JUNE 23, 1960

WITNESSES:

Dr. E. W. R. Steacie, President, National Research Council; Dr. F. T. Rosser, Vice-President (Administration); and Mr. F. R. Charles, General Counsel and Chief Patents Officer.

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1960

23390-8—1

SPECIAL COMMITTEE ON RESEARCH

Chairman: J. W. Murphy, Esq.

and Messrs.

Aiken	Dumas	Nielsen
Batten	Forgie	Payne
Best	Godin	Peters
Bourget	Grafftey	Smith
Bruchési	MacLellan	(*Winnipeg North*)
Brunsden	McQuillan	Stewart
Cadieu	McIlraith	

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

MINUTES OF PROCEEDINGS

THURSDAY, June 23, 1960.
(6)

The Special Committee on Research met at 9.55 a.m. this day. The Chairman, Mr. J. W. Murphy, presided.

Members present: Messrs. Aiken, Brunsden, Cadieu, Forgie, Grafftey, McQuillan, Murphy and Payne—8.

In attendance: From the National Research Council of Canada: Dr. E. W. R. Steacie, President; Dr. F. T. Rosser, Vice-President (Administration); Mr. F. L. W. McKim, Administrative Services; Dr. J. B. Marshall, Awards and Grants; and Mr. F. R. Charles, General Counsel and Chief Patents Officer.

Dr. Rosser was introduced and explained the role of the administrator in a scientific organization. He outlined the administrative structure of the National Research Council including the Administrative Services, Patents, and Plant Engineering Services.

A copy of a booklet entitled "Patents Handbook" was tabled and copies distributed to Members of the Committee.

Dr. Rosser then reviewed the objectives of the Awards and Grants Office and filed with the Committee a set of the most recently published scientific journals. He then discussed the Information Branch and called upon Mr. Charles to answer questions concerning the Public Servants' Inventions Act.

Doctors Steacie and Rosser elaborated on its application and discussed patents and copyrights in general.

Doctors Steacie and Rosser were questioned in connection with the stockpiling of parts and equipment and the system of inventory control.

At 11.00 a.m. the Committee adjourned to the call of the Chair.

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

23390-8—1½

EVIDENCE

THURSDAY, June 23, 1960.

The CHAIRMAN: Gentlemen, we have a quorum. We have with us this morning Dr. F. T. Rosser, vice-president (administration).

I think if you have your little grey books with you—what page is it, doctor?

Dr. F. T. ROSSER: Turn back to page 29.

The CHAIRMAN: Dr. Rosser will make a statement, and then you are free to question him.

Dr. ROSSER: Mr. Chairman, this page deals with the organization of the administrative services.

Dr. Steacie, you will recall, pointed out, at an earlier meeting, that administration in the National Research Council was a service to science, and that the administrator was in no position to exercise authority over the scientist. This is the way it should be in the well-run scientific institution. Administration in the National Research Council is an integral part of the National Research Council organization and, therefore, the reason for its existence is the same as that of the council—namely, to promote science in Canada. The job of the administrator, therefore, is to relieve the scientist of time-consuming non-scientific work so that he has as much time as possible to devote to the research work for which he is trained. At the same time, it is important for the administrator to strive constantly to improve the efficiency of his service and to effect savings of public expenditures wherever it can be done, without interfering with scientific effort.

It is of vital importance for a scientific organization to control its ancillary services if the organization is to function properly. The framers of the Research Council Act understood the importance of this principle and set up the National Research Council as an independent government agency in control of all its scientific and administrative functions. The administration division is a centralized group that serves all the divisions of the National Research Council. The soundness of this organization has been proven and has been followed by many other countries throughout the world in setting up similar organizations for their national scientific effort.

The first service, on page 29, is the administrative services. This is under the direction of Mr. McKim. This branch performs all the normal administrative duties.

The first administrative service mentioned is that of purchasing. There are two ways of organizing purchasing for a scientific institution. The first is to appoint professional scientists or engineers as buyers, whose principal duty would be to advise and assist the scientists in selecting the equipment they need. The second way is to select non-professional buyers who specialize rather on the business side of the operations and know sources of supply.

The council has adopted the second system because under the first it would be inevitable that the professional man who is neither a bench scientist nor an administrator would probably exert too much influence on the scientist.

Our purchasing branch is organized into five sections, each of which is headed by a non-professional buyer, who receives requisitions from the scientists stating what they want purchased, and it is the buyer's job to get each particular item at the best possible price. In order to effect savings we have established a warehouse to stock the commonly used items of all divisions. Last year the stock in the warehouse was turned over two-and-a-half times; and this we consider very good. The bulk purchasing of commonly used items saved many thousands of dollars.

The second section in administrative services is personnel, and this is one of the most important. I think we all recognize that inferior staff can render the best equipped laboratory in the world scientifically impotent. The success of a scientific laboratory depends fundamentally upon the quality of its scientists. The best qualified people to assess the training and ability of scientists are scientists who are active in the specialized fields to which the appointments are to be made.

The Research Council Act gives the Honorary Advisory Council the power to make all appointments and promotions. The president has the right to nominate and the minister has the right to approve apointments. In this way both the president and the minister have the right to exercise a veto, but only the council has the right to appoint. The Honorary Advisory Council has maintained, throughout the years, a very high standard of quality in all its appointments, and this has been of inestimable value to the reputation of the council.

The personnel department is responsible for advertising of positions, the receipt and distribution of applications, the preparation of data for presentation to members of the council's board of selection, and for matters relating to the welfare of staff.

The third section mentioned under the administrative services is accounting. This is not a large section, and has been set up chiefly to take care of the accounting for revenue. The council's revenue is derived from contracts with industry and other government departments for work performed in the laboratories, from the sale of scientific publications and miscellaneous items.

The office is also responsible for the preparation of estimates and handles the accounting for Canadian Patents and Development Limited. However, the general bookkeeping for the National Research Council, including the issuing of pay cheques, is handled by an office of the comptroller of the Treasury.

The Central Registry handles the mail and records for the Ottawa area buildings. The Transport Office is responsible for looking after the transportation needs of the staff of the Ottawa area, and for arranging for the travel of staff and postdoctorate fellows. I would like to stress the importance of the Duplication Service in relation to the operation of the National Research Council and its many committees. It would be very difficult for the Honorary Advisory Council to deal with awards and grants, scholarships, appointments and promotions without the service of an efficient duplication unit. The reproduction of documents must be handled on short notice and in large volume if the Council and the many committees are to function properly.

The Legal and Patents Branch is responsible for the processing of patents and the handling of all legal matters affecting the Council's operations.

We have the head of that branch with us this morning, Mr. F. R. Charles.

Under the authority of the Research Council Act, Canadian Patents and Development Limited was set up as a wholly subsidiary company of the National Research Council for the purpose of obtaining patents on the inventions of scientific workers in government departments and agencies and for promoting the use of those inventions by industry through licensing arrangements.

Since its inception in 1948, the Company has processed 717 patents; 384 of these were for the inventions of workers in the National Research Council laboratories; 248 were on behalf of other government departments; and 85 were for the Canadian universities that had entered into an agreement with the Company whereby the Company obtains and exploits patents for the inventions of their staff members. In addition, Canadian Patents and Development Limited has acquired licensing rights on 833 patents from other government departments and agencies and foreign government organizations. Altogether, 318 patents have been licensed to industrial companies.

Money received from the licensing of patents accounts for all but a small fraction of the company's revenue. The income is used for operating expenses, for the cost of filing and maintaining patents, for making awards to inventors in accordance with the Regulations of the Public Servants Inventions Act, and for the further development of inventions. For nine of its twelve years of operation the Company has shown a small net profit.

It must be recognized that bringing new inventions from the laboratory stage to actual production and sale to the public is normally a long slow process. Furthermore most of the inventions handled by the Company have limited markets in specialized fields and many patents are taken out to protect the public interest rather than to produce revenue. Only when an invention has universal application, coupled with a huge volume of sales, do the royalties amount to appreciable sums, and such inventions are indeed very rare. Since the life of a patent is only seventeen years in Canada and the United States the time for collecting royalties is also very short.

An earlier question regarding the work of the ten people in the Patents Section was deferred. The Patents staff is divided into three groups: the Secretary-Treasurer of the Company who is also Legal Counsel for the National Research Council, and his secretary;—that is Mr. Charles—the patents processing group which has four people, two professional investigators, who examine inventions, do patent searches, and process patents, and their secretaries; and finally, the promotion group, again with four people, two professionals and their secretaries. This group is responsible for the sale and licensing of patents to industry. All the employees are on the Council staff but since the latter group,—the promotion group—is working mainly for the benefit of the Company their salaries are recovered from Canadian Patents and Development Limited.

The other day Mr. Dumas raised a question regarding a patent which we hold for a photogrammetric plotting device. Perhaps I could use the patenting and licensing of this particular invention as an example of the way the work is handled. The plotting device was an invention of a member of the photogrammetry section of the National Research Council laboratories. The invention was made in July 1956 and submitted to our Patents Examiners to determine patentability. A thorough search was made for patents that might have anticipated the idea and none were found, therefore, we proceeded to apply for a patent. Since the invention seemed to have considerable possibilities, patent applications were made in the following countries—Canada, United States, Great Britain, France, Italy, Germany, Switzerland and Japan.

As soon as the first application was filed the case was turned over to the Promotion Section for exploitation. The Promotion Section publishes a Patents Handbook which receives wide distribution.

I brought copies of these this morning. There is a copy for every member if they would like to have it.

The CHAIRMAN: We will have them distributed now.

Dr. ROSSER: Approximately 1300 copies are sent to Canadian manufacturers and about 475 copies to foreign manufacturers. This patent application was listed in the handbook and distributed to the mailing list. In addition, all those companies in Canada that might have been interested in the invention were informed that it was available for licensing. All the Canadian firms declined to take out a licence. What was said by one company in declining the offer sets out the position of the Canadian firms very clearly, they wrote as follows:

> We regret that, although of undoubted merit, we cannot justify taking out a licence to build this equipment. The very considerable expense that would be involved in bringing the equipment into production, plus the further expense in placing it on the market could be offset only by a company which already is deeply engrossed in this type of endeavour, and with world wide outlets. We hope eventually to be in such a position, but at this stage in our progress would be unable to provide the effort which you would be entitled to should we have acquired the licence.

After having given Canadian manufacturers the opportunity to license the patent and being convinced that no Canadian firm was at present in a position to do the development work, the promotion officers turned to foreign manufacturers and contacted five companies with world wide interests that might be interested in handling the development of this invention, and an agreement was eventually signed with one of these, the Ottico Mechanica Italiana Company of Rome, Italy. This company has outlets all over the world and their American subsidiary soon interested the American armed services in the apparatus and an order has already been obtained for a prototype model. If the development is successful, it is possible that the royalties from the sale of this patent may bring us a considerable sum in the future.

If you look back at page 29 again, the largest administrative unit, from the point of view of numbers of personnel is the Plant Engineering Services. These are the craftsmen who maintain the utility services of all kinds, operate the heating plant, do cleaning in those laboratories which are not cared for by the Public Works Department, and in addition the unit provides drafting and engineering services for minor alterations and additions which are required from time to time.

The next large unit is the awards and grants office, which is responsible for the administration of the Council's scholarships and grants. It is headed by Dr. J. B. Marshall who will later report on the details of the program. Many aspects of this work have already been discussed.

The training of scientists is fundamental to the promotion of science. The Council—as has been stated here before—has never granted money for the support of undergraduate students since this field is in the educational jurisdiction of the provinces. As a result of the first world war it was clearly recognized that scientific research effort is a national problem. The professional requirement for most research work—as you know—is a doctor's degree. The Council's problem, therefore, is to help provide a sufficient number of qualified research workers to meet Canadian needs. To do this the Council established a system of scholarships for postgraduate students. These include Bursaries for students in their first year of graduate work, studentships for the subsequent years of study leading to the doctorate degree, and Postdoctorate Fellowships. The Council is now one of the larger granting bodies in the world in this field.

A second method of promoting research in the universities is to give grants to research professors to enable them to hire help for their research programs, and to purchase scientific equipment which the universities might not otherwise be able to obtain. Most of the help hired by professors is student help, and in one sense the grants in aid program has supported as many or more students than the scholarships program.

The final product of scientific research is publication and the National Research Council provides an outlet for Canadian scientists by editing and publishing six Canadian journals of research, and giving financial assistance to other journals. At the last meeting it was asked if these journals might be tabled, and the latest numbers published this year are there in front of you —examples of all six.

The CHAIRMAN: Are they available for all members of the committee?

Dr. ROSSER: There are not enough here for every member of the committee. This is one set.

Mr. AIKEN: I would think, Mr. Chairman, it would be good enough if we examined them.

Dr. ROSSER: We would have to duplicate this 25 times, for every member of the committee.

Mr. PAYNE: I think these highly technical journals would be of very little assistance to the group of laymen gathered here.

Mr. BRUNSDEN: You mean our I.Q. is not high enough?

Mr. PAYNE: Our special fields do not quite cover it, I am afraid.

Dr. ROSSER: As we noted the other day, these journals have been kept at a very high standard and they have world-wide distribution. Finally, the Information Branch is responsible for the Library, the Liaison Offices, Public Relations Office, Technical Information Service, Economic Studies and International Relations.

The National Research Council Library is being developed as the scientific arm of the National Library of Canada, and as such its entire resources are available to scientists anywhere in Canada through interlibrary loans and by a rapid photocopying service. There are about 400,000 volumes in our present holdings and over 7,000 technical journals are received in the Library. Exchange services are maintained with universities' libraries and other scientific libraries throughout Canada, and indeed, throughout the world. Another important service to the country generally is the translation service, translating scientific papers written in the major languages of the world. At the present itme we are translating, in cooperation with the U.S. National Science Foundation and the U.K. Department of Scientific and Industrial Research, the Russian Journal "Severa". This journal has to do with Arctic research.

The Library maintains, for the convenience of all scientists the Canadian index of scientific translations. This index now contains over 40,000 entries and shows the location of translations prepared in Canada, other countries of the Commonwealth and the United States.

Dr. Steacie pointed out earlier that the Liaison Offices which we maintain in London and Washington are playing an increasingly important role in international scientific developments, as well as assisting in the collection and distribution of scientific information.

The Technical Information Service was established in 1945 to encourage the utilization of scientific and technical information by the industries—particularly of small industries—of Canada. The Service consisted of field representatives in the various provinces whose duty it was to call on industries in their areas to learn of their technical problems and to assist them wherever possible. In the course of time these field services were taken over by the provinces, but the provincial organizations continue to cooperate with the Council's central office. The only provinces in which the Council now has field representatives are Manitoba and Quebec. When it is not possible for the field man to deal directly with a problem the enquiry is referred to the Council's central staff of information officers. These officers prepare replies to the enquiries from scientific literature that is available in the Library or by referring the problems to scientific officers in the Council's laboratories.

On subjects that are of general interest the information officers have prepared general reports which have been very favourably received. Sixty-three such reports have been written to date. In addition, short notes of two or three pages only, dealing with subjects that were known to be of fairly wide interest but which could be dealt with adequately in fewer pages than a report, have been prepared. Altogether, there are about eighty of these notes. Similar single page bulletins are issued frequently. Last year over 4,000 enquiries were handled by the Ottawa office. All ten provinces were visited by field officers and, in addition, calls were made in the Yukon and Northwest Territories. The field representatives dealt with over 7,500 enquiries on their own in the past year, bringing the total number of enquiries to approximately 11,500. The work of Technical Information Services is also coordinated with that of similar services in various other countries.

The Public Relations Office is responsible for the preparation of the Council's official reports, for handling press relations, radio and television programs, and making arrangements for numerous visitors from all over the world who visit the Council's laboratories during the year.

The Office of Economic Studies is engaged in the gathering of information on scientific support in Canada and elsewhere.

This is a one-man office. He works very closely with the dominion bureau of statistics.

Finally, if you are interested in the organization of the division of administration, you will find an outline of the organization and the names of the officers in charge of the administrative sections in the Council's review of activities, on page 309.

The CHAIRMAN: Gentlemen, you have heard Dr. Rosser. I am sure there will be plenty of questions.

Mr. BRUNSDEN: The doctor made mention of the Public Servants Inventions Act. I wonder, Doctor, if you would mind taking a moment or two to give us a brief run down of that act.

Dr. ROSSER: You have asked me a very difficult question that I am not qualified to answer. I do not know whether I may refer this to Mr. Charles, or not. Can you do that, Mr. Charles?

Mr. F. R. CHARLES (*General Counsel, National Research Council*): The Public Servants Inventions Act was passed in 1955 after an inter-departmental committee had been formed to study the patent practices in various departments. The Research Council Act dealt with patents of its own members. The National Defence Act had a slightly different section, concerning inventions of the armed forces; and the Atomic Energy Act was very similar to the National Research Council Act.

The rest of the civil servants were under section 47 of the Patent Act; so civil servants in the various departments had different rights in their own inventions.

This committee got together and studied the best way to unify this throughout the public service, including the armed forces and the R.C.M.P. As a result, that act was passed, and it provided that inventions made by public servants—it defines who they are—shall belong to Her Majesty; but they may be waived back to the public servant under certain circumstances, or turned over by the various departments to a corporate agency for exploitation on behalf of Her Majesty.

This has resulted in various government departments turning many inventions over to Canadian Patents and Development Limited, a crown corporate agency, to exploit on behalf of Her Majesty.

Mr. AIKEN: I assume these would be inventions made during the course of employment only?

Mr. CHARLES: I could read from the act, if you wish.

Dr. ROSSER: That is true; it is during the course of employment.

Mr. FORGIE: The National Research Council does not file any private applications for patents for individuals, beyond those in the departments or in the research organization itself?

Dr. ROSSER: That is true: we handle no private applications.

Mr. BRUNSDEN: We touched on this the other day.

Dr. STEACIE: No private applications, provided you agree that provincial research councils and universities are public. The facilities are open to them, and quite a few universities have asked the company to take things over on their behalf.

Mr. GRAFFTEY: Do you use the expression "during the course of employment" as meaning during the hours of employment?

Mr. CHARLES: Do you want me to read the section of the act?

Dr. ROSSER: All right.

Mr. CHARLES: This is section 3 of the Public Servants Inventions Act:

> The following inventions, and all rights with respect thereto in Canada or elsewhere, are vested in Her Majesty in right of Canada, namely,
>
> (*a*) an invention made by a public servant
>
> (i) while acting within the scope of his duties or employment, or
>
> (ii) with facilities, equipment or financial aid provided by or on behalf of Her Majesty, and
>
> (*b*) an invention made by a public servant that resulted from or is connected with his duties or employment.

Dr. E. W. R. STEACIE (*President, National Research Council*): Could I just speak to this momentarily, Mr. Chairman. I think you will see the difficulty Mr. Grafftey has in mind. It is obvious that in the extreme case of, as I mentioned before, say a floor sweeper who invents a mop in his spare time, the government has no right whatever to this. He was not hired to make inventions, and there you are.

You run into a rather difficult zone in the case of the man who is employed to work in a specific field and then does something in the same field in his garage. You might very well run into a difficult situation where, in fact, everything that led up to this invention had been done on public funds, and then the man did the last stage at home. I think you have got to protect the crown in this case and treat each case on its own merits. There are methods by which the minister can waive rights, if he feels this is the thing to do.

The third thing is that in departments such as mines, agriculture, and in agencies like the National Research Council, Atomic Energy of Canada, and Defence Research Board, you have people who are really employed for the purpose of making developments, and they obviously are entitled only to a small bonus, since they are doing the work for which they were hired. The scale of awards under the Public Servants Inventions Act really takes this into account.

I think it is certainly true that in our case, if a man does a first-rate job and this leads to an invention, the bonus he gets will be small, compared with what he will get in the way of promotion, salary increases and internal recognition for doing a good job. So I think the whole difficulty in the act was to separate out the case of the man who is employed, as I say, in an administrative position and has an idea in his spare time, from the man who is employed to carry out development and does it. I think, myself, that the act is equitable in this respect.

Mr. BRUNSDEN: That has been the experience over the years?

Dr. STEACIE: That has been the experience.

Mr. AIKEN: Mr. Chairman, may I ask a question which is sort of on a theoretical line. The distinction between scientific discoveries and scientific papers which are made freely available to everyone, and the case of patents or inventions which are immediately restricted, raises in my mind a question of why there is the difference.

It may be an historical difference, where science has always made the information available, and mechanics have not. But I wonder if anyone would care to answer the theoretical question that is basic in this.

Dr. STEACIE: I think what really happens is this, broadly—I do not know that a patent attorney would agree with this: you could say that you cannot patent the discovery of a principle of nature, but you can patent a gadget. Therefore, it is very often true that the major discoveries which lead to inventions are not patented.

There are various examples: one of these is that fundamental discoveries over a period from 1890, roughly, to 1920 odd led to the whole knowledge of electrons and their behaviour. The first patent was the radio tube. None of the previous people could have patented anything they did; but the moment you got to a tube, which had a practical application, you had a patent.

Atomic energy is the most beautiful example—you can draw your line wherever you like. The original work was done by the Curies. This was obviously unpatentable. It was followed by work by Rutherford, the discovery of the neutron by Chadwick, and so on; and ultimately it got to the stage where you might be able to do something, and the first patent was on the chain reacting pile.

Whether this patent is valid, or not, is, I think, ultimately going to be the subject of a great deal of expensive litigation. But I think this is the real situation.

The other thing is that there is normally a long time lag between the first break in a given field and the time that you can use this. And this very often will be the full 17 years. Consequently, it may often simply be not worth the expense of trying to patent something in the very early stages. For one thing, further development may show that this patent would not be valid—and there you are.

So, broadly, I think, the product patent is simple; the process, or principle, is very hard to patent—and this is where the difficulty comes in.

Mr. AIKEN: If I may make it even more difficult: there was another question I raised the other day, and that concerned copyright. I am wondering if there are any situations in which a copyright of papers is actually registered, in contrast to patents.

Dr. STEACIE: In general, journals are copyright, so that the paper is copyrighted by the journal. One question, I think, where revenue might come into this is the care of books. The general policy in the Research Council—and, I think, certainly throughout the whole government service—is that the author is entitled to copyright the book. It is a private arrangement between the author and the publisher, and he is entitled to receive royalties.

I think one can argue that the publication of a book brings a great deal of credit, if it is a good book, to the institution; and the institution is therefore a gainer by this. When you combine this with the fact that royalties are more or less negligible on scientific monographs, I think it would be very foolish to interfere with the author's right to copyright.

Mr. AIKEN: The Research Council, for example, very seldom, if ever, copyrights any journals or material?

Dr. STEACIE: We would copyright our own journals for the sole purpose of protection against very widespread photographic reproduction. For example, if we did not copyright it, someone might photograph the journal. He would have had no editorial costs—and then he could sell it at a cut rate.

There are very great difficulties with scientific journals. One thing is that it is universally recognized that it is all right to make photostats for individuals. People write to us from places where they have no libraries, for obscure journals, and we make photostats and send them back. In principle, this is breaking the copyright; but there is a combination of an agreement in various places, plus a recognition that this is all right.

On the other hand, if we were to take a semi-obscure journal and start making 500 copies and selling these at 10 cents apiece to a large number of Canadian libraries, we would be prosecuted immediately. This is the only purpose of copyrighting journals.

Mr. AIKEN: It provides general protection against improper use—commercial use, I should say, I suppose, of journals?

Dr. STEACIE: Yes. This does not extend to the U.S.S.R., where copyrights are not recognized, and a great many foreign journals are reproduced within the U.S.S.R. and distributed.

Mr. BRUNSDEN: You mentioned a period of 17 years as the life of a patent, Doctor. What is the actual position at the end of the 17 years: is there such a process of repatenting, or is the field wide open at the end of the period?

Dr. ROSSER: It may, or may not be. As I understand it, during the life of the patent you may make certain improvements to your process, which in turn you patent.

Mr. BRUNSDEN: Presume, for the sake of argument, that there are no improvements.

Dr. ROSSER: Then it is wide open.

Mr. FORGIE: That is the rule in all countries?

Dr. ROSSER: Canada and the United States have the 17-year clause. I am not sure about all over the world. It varies a bit, does it not?

Mr. CHARLES: Yes, it varies. There is just a limited period for a patent monopoly, and then the invention becomes public.

Mr. GRAFFTEY: Are there any circumstances under which you can apply for an extension after the 17-year period?

Mr. CHARLES: No, not on the same development.

Mr. AIKEN: There is one other question that interests me, as a lawyer, concerning Canadian Patents and Development Limited. Do they engage patent attorneys, or do they do their own legal work?

Mr. CHARLES: They engage patent attorneys.

Mr. BRUNSDEN: You have to engage lawyers for everything!

Dr. STEACIE: I think I might amplify that, though; they also employ the services of outside firms to a very considerable extent.

Mr. CHARLES: That is what I meant.

Mr. AIKEN: That was the purport of my question. I notice there are lawyers and patent attorneys in the company, who, undoubtedly, do most of the basic preparation but, in each case a patent attorney is engaged to apply for the patent.

Mr. BRUNSDEN: There was one intriguing thought in connection with the machines you used as an illustration. It went to Italy and came back to the armed services of the United States. Was it offered to the United States before it went abroad?

Dr. ROSSER: It was advertised through the patents handbook, and I am not sure whether or not American companies were contacted. Do you know?

Mr. CHARLES: Yes, they were.

Dr. ROSSER: They were not interested.

This Italian company is a large company. I should say an estimate of the cost of constructing the equipment is between $50,000 and $100,000. This is an expensive apparatus, and the development costs will be high. The field of sale in Canada is rather small. We can foresee possibly three or four being sold over the next few years. However, there is not a large opportunity here for its sale. But, there is in the United States, and in other countries.

Mr. AIKEN: There is another thing that interested me, and that was the necessity of one crown company to patent their crown inventions. Is this part of the Patent Act? I have not examined it closely, but it seems somewhat of an anomaly that a patent held by the crown should have to be patented in Canada.

Mr. CHARLES: Under the Public Servants Inventions Act, the invention belongs to Her Majesty, and the only practical way the invention can be protected is by patenting it.

Mr. AIKEN: So, the crown is bound by the Patent Act?

Mr. CHARLES: Yes, the Public Servants Inventions Act.

Dr. STEACIE: May I make a remark which has a bearing on this?

If you throw an invention open, and you adopt it as a government policy that all inventions could be freely used, this is not an advantage to industry, because the difficulty is that one industrial firm can take up this patent, spend a lot of money on development, and then find that everyone else can walk in on it. The experience, particularly in the United States, where this used to be true, was that it was very difficult to get any industrial firms to take up something which had been thrown open to the public. Therefore, I think it is essential that crown-owned inventions be patented to protect the licensee who spends a lot of money on development.

Mr. AIKEN: This is to protect the assignee of the patent rather than the crown.

Dr. STEACIE: Yes.

The CHAIRMAN: Do you have the same respect for Russian patents that they have for ours?

Dr. STEACIE: Really, I know nothing about this situation. Of course, your rights in Russia are nil. I do not know really what the general provision is. However, I think it is simply that everything done in Russia is used by other people, without reference to patents. Everything we do is used by them.

Mr. CHARLES: Last fall the United Kingdom comptroller general of the patent office, the assistant comptroller of the industrial property department, and Mr. H. R. Mathys, a fellow of the chartered institute of patent agents and a director of Courtaulds, visited Russia and discussed the patent system. However, to date, Russia is not a member of the international convention on patents, although they have expressed an interest in it, and may come into it eventually.

However, there are patents in Russia. If an individual dedicates it to the state, he is more likely to get a patent.

Last year, the United States commissioner of patents told us 4,000 authors certificates were granted, and eight individual patents, where the individual kept the right. However, I would not be sure of the figures I have just given.

Mr. Brunsden: Would the 4,000 rise from individuals, or through the academy?

Mr. Charles: Through the academy, really—the workers for the state.

Mr. Payne: Is this situation peculiar to Russia, or are there many other nations operating on the same basis of non-recognition of patent rights?

Mr. Charles: No. The South American countries are not members of the international convention, with the exception of Brazil. However, generally speaking, they recognize patents of their own individuals, and they recognize private ownership of patents, and allow the individual to keep it.

It is really peculiar to Russia.

Mr. Payne: How about Japan?

Mr. Charles: It has much the same type of patent system, or the usual type of patent system.

Mr. Payne: Do they recognize patents from Canada? Say, you apply for a Japanese patent, can they be obtained?

Mr. Charles: Yes.

Dr. Steacie: We have an application in connection with this one which Dr. Rosser used as an example.

Mr. Aiken: Did I understand the rewards to an individual public servant are rather small under the act?

Mr. Charles: They are set down in section 11 of the regulations of the Public Servants Inventions Act.

Mr. Aiken: Does he receive anything, if the patent is used, in addition to what he receives if it is not?

Mr. Charles: Yes, he receives 15 per cent. Where any money is received by Her Majesty, upon the licensing or other disposal of an invention vested in Her Majesty, an award may be paid to the inventor based on the amount, from time to time, received; but such awards, in the aggregate, shall not exceed 15 per cent, if the amount does not exceed $10,000. However, we must bear in mind one other thing—and it is that this is gross, The patent may have cost $1,000; if it is licensed for $500—and, say, that is all the licence brings in—he gets 15 per cent of that $500, although the crown has a net loss of $500, plus 15 per cent of it.

Mr. Aiken: What I am trying to get at is whether in respect of an invention in a marginal case, which Dr. Steacie mentioned, it would be just as far ahead to patent it through Canadian Patents and Development Limited, or try to go about doing it himself, and get all the profits?

Mr. Charles: Usually we have found, when patents have been waived back to the inventors, they had not proceeded with the patent application, because it is too expensive. It is roughly $500 in each country. In Canada and the United States, it is $1,000.

Dr. Steacie: I think it is fair to say that in every case, up until now, the inventor has done better by getting the 15 per cent, than he would have done if he had spent all the money necessary on patenting the invention and then collecting the total royalties.

Mr. Aiken: He is in the position of a lot of private inventors, who spend a great deal of time running around getting someone to develop it for them.

Dr. Steacie: Yes. There may come a case—and this may cause trouble—if someone invents something that is a marginal case, which then becomes one of these very rare things which makes an enormous amount of money. I am sure that you may have to have special action taken in such a case.

Mr. Aiken: Well, I do not think we will worry about that at this time.

The CHAIRMAN: Are there any other questions on this same subject, gentlemen?

We will try and adjourn at five minutes to eleven.

Just to open up another subject, Dr. Rosser, you mentioned, I think, keeping a stock for the scientists' requirements in your warehouse, and the turnover is about two and a half times a year.

What would be the approximate amount of stock in the warehouse?

Dr. ROSSER: I think our warehouse stock is $300,000 now. We started off with $200,000; raised it up to $250,000, and now it is up to $300,000.

The items in the warehouse are the commonly used items, such as tubes, glassware and brass.

The CHAIRMAN: Do you have to go out of Canada to get any of these products?

Dr. ROSSER: Our glassware is largely out of Canada, but bought through Canadian distributors.

Mr. FORGIE: Do you carry insurance on that stock?

Dr. ROSSER: We carry no insurance.

Dr. STEACIE: It is the general policy of the government that it takes its own risk.

Mr. FORGIE: Yes.

Dr. STEACIE: I think one of the main savings in connection with the central warehouse is this. Take a thing like radio tubes; if a stock is not carried, the man who is operating a piece of equipment would have to have a good supply of spares into his own laboratory and, in many cases, it would be necessary to carry throughout the organization a very large number of spares. The central organization can keep a reasonable inventory of all the commonly used tubes, and this cuts down enormously on the total inventory you have at any one time.

Dr. ROSSER: There are large discounts obtainable, particularly in glassware, if we buy in more or less, carload lots.

Mr. AIKEN: Do you have any reason to believe that any of these stocks are privately used beyond research use?

Dr. ROSSER: I would say no. I think we have very good control on that. However, our staff are human, and we may run into that occasionally.

Mr. AIKEN: But you do have a stock warehouse system where each item has to be approved by someone in the council?

Dr. ROSSER: The stock records are very well kept, and the amount that we have to write off, by way of losses each year, is extremely low. I doubt if we could get it any better.

Dr. STEACIE: If I may say a word, there is a proper inventory control on each of the divisional store-rooms and, under the Financial Administration Act, the Auditor General is responsible for an inventory audit, as well as a financial audit. So, there is an audit of the inventory going on as well.

Mr. AIKEN: I have one more question, Mr. Chairman, but it is in connection with a different subject.

One of the first things that Dr. Rosser mentioned was the question of appointments, which he said were made by the council. However, in effect, he said there was a veto by the president or the minister. In fact, is that veto ever applied?

Dr. STEACIE: The way the act is worded, the council appoints, on my recommendation, with the approval of the minister. Therefore, what this means is that the council cannot appoint people against my wishes. In fact, we have quite an elaborate system set up, which imposes additional checks; in other words, before our selection board meets, we have a network of committees internally.

Take, for example, the scientific staff. The director of the division makes certain proposals. Then, there is a meeting of the directors of all the scientific divisions, who look at each other's proposals. This makes sure there is no suggestion of overpaying somebody unfairly. Also, they are a very tough body, when it comes to the qualifications of the staff. They look at each other's appointments very carefully, and a large fraction of the people who are thrown out as not being up to standard is due to this committee. Well then, this committee recommends to the council's selection board. Nominally, I am the one who recommends; in other words, in effect, I have delegated this right to those committees and, in principle, I certainly look them over. Also, I can exercise the right of veto. Then, the council selection committee sits, and goes over the recommendations that are made. It also checks on applicants who have applied but are not recommended for appointment.

Then, the final result is that the council—the whole council—considers the selection board's recommendations, and appoints. It then goes to the minister for approval.

The final answer to your question is no, that it would be very rare, indeed, for the minister not to approve the appointment as suggested by the council.

Mr. AIKEN: Then, in the system you have set up, it is not just one person in the council, who is immediately superior to someone else, and might hold him back?

Dr. STEACIE: No.

Mr. AIKEN: It is done by a committee of people, who may have observed, latterly, the actions of some person.

Dr. STEACIE: Yes. In addition to this, at intervals, the council selection board takes divisions as a whole, and looks over the whole set-up in the division. It does a great deal of cross-comparisons of the rate at which people are advancing; in other words, if one director tends to be a little conservative in recommending people for promotion, relative to someone else, this will come to the attention of the selection board as well.

Mr. AIKEN: I have heard that the research council's method of promotion is very satisfactory.

Dr. STEACIE: I think it is. Everyone is very interested in making sure, first, that we get the best men possible and, secondly, that we keep them; and this involves not only taking great care with your appointments, as to quality, but it also means you have to be very alert to make sure that the really outstanding people advance more rapidly than normally.

The CHAIRMAN: Gentlemen, it is time to adjourn.

Mr. BRUNSDEN: Are these appointments all made by application, or are certain men pinpointed by the director or yourself as being suitable candidates for more rapid promotion, perhaps, than they themselves envisage?

Dr. STEACIE: Are these appointments or promotions?

Mr. BRUNSDEN: Well, more, promotion.

Dr. STEACIE: In connection with promotion, the pressure normally will come from the divisions; that is normal—and I think this is the proper way it should be. The division will be trying to promote its better people faster than anyone is willing to go along with. However, if there is any sign the division is lagging, the pressure will come the other way. We keep an eye on the relative positions of the people in the divisions, and if we feel the divisions are lagging, we put on the pressure from the outside. As you know however, it is usually the people who know them who are pushing them hardest.

The CHAIRMAN: Would it be agreeable to the members of the committee if we left the copies of the journals that are tabled in the hands of the clerk? In that way anyone who wishes to refer to them, can call up the committee clerk and make the necessary arrangements.

Some Hon. MEMBERS: Agreed.

The CHAIRMAN: Now gentlemen, I looked over the time table this morning and, as some suggestions already have been made that we might be finishing the session within three weeks—and that may be wishful thinking; however, we must be concerned about even that idea—it would appear that we would have only three more meetings. These would be on June 28, June 30 and July 5.

In regard to the members who are concerned about the report, we would expect your cooperation in this—and your party too, Mr. Forgie; naturally we would expect cooperation from you, and any suggestions you care to make, as we did before on other committees.

I am hoping that you will agree to call Dr. Marshall for the next meeting. I know this committee has a considerable interest in scholarships and grants—and I am concerned vitally about various aspects of it.

Would it be all right to have Dr. Marshall here at the next meeting?

Mr. BRUNSDEN: Will that be next Tuesday?

The CHAIRMAN: Yes.

Gentlemen, we will endeavour to start the meeting on time. We hoped yesterday to have eight of our own party here this morning; however, it did not work out that way.

In the meantime, we will arrange for the next meeting—and I think we should start working on the report, so we could have it ready for July 5.

HOUSE OF COMMONS

Third Session—Twenty-fourth Parliament

1960

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: J. W. MURPHY, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 6

NATIONAL RESEARCH COUNCIL

TUESDAY, JUNE 28, 1960

WITNESSES:

Dr. E. W. R. Steacie, President, National Research Council; and Dr. J. B. Marshall, Secretary and Awards Officer.

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1960

23392-4—1

SPECIAL COMMITTEE ON RESEARCH

Chairman: J. W. Murphy, Esq.

and Messrs.

Aiken
Batten
Best
Bourget
Bruchési
Brunsden
Cadieu
Dumas
Forgie
Godin
Grafftey
MacLellan
McQuillan
McIlraith
Nielsen
Payne
Peters
Smith (*Winnipeg North*)
Stewart

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

MINUTES OF PROCEEDINGS

TUESDAY, June 28, 1960.

The Special Committee on Research met at 9.40 a.m. this day. The Chairman, Mr. J. W. Murphy, presided.

Members present: Messrs. Brunsden, Dumas, Forgie, Godin, MacLellan, McQuillan, Murphy, Nielsen, Payne, Peters and Smith (*Winnipeg North*).—11

In attendance: From the National Research Council of Canada: Dr. E. W. R. Steacie, President; Dr. F. T. Rosser, Vice-President (Administration); Mr. F. L. W. McKim, Administrative Services; and Dr. J. B. Marshall, Secretary and Awards Officer.

The Chairman read a statement concerning the feasibility of requesting the House to expand its Order of Reference when it is again constituted early in the next Session of Parliament.

Agreed,—That the future role of the Committee will be discussed by the Subcommittee on Agenda and Procedure and that a report will be made to the Committee by July 5th.

Dr. Marshall was called and tabled for printing a document entitled "National Research Council Assistance to Scientific Publications". He then read a statement outlining the Council's grants programme and system of scholarships and awards.

Following the questioning of Doctors Marshall and Steacie, the Dominion Bureau of Statistics publication entitled "Industrial Research-Development Expenditures in Canada—1957" was filed with the Committee, copies having previously been distributed to Members on Tuesday, June 14, 1960.

The Chairman thanked Doctor Steacie and officers of the National Research Council for their assistance in the Committee's deliberations, and stated that, at its next meeting to be held Thursday, June 30th, the Committee would hear a statement by Mr. J. L. Gray, President of Atomic Energy of Canada Ltd.

At 10.55 a.m. the Committee adjourned to the call of the Chair.

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

23392-4—1½

EVIDENCE

TUESDAY, June 28, 1960.

The CHAIRMAN: Gentlemen, we have a quorum.

Before calling Dr. Marshall, I would like to make a statement.

The Hon. Gordon Churchill, M.P., Minister of Trade and Commerce, indicated to me the other day that this research committee could and should be an excellent medium for all phases of labour and industry to make their representations, and that the committee would be set up early next session.

Memorandum re Suggestions to Committee on Research

In view of the interest throughout Canada in the matters of employment, trade, development of secondary industries, and other relative matters pertinent to the continued development of Canada, consideration should be given at this time to enlarging the scope of the committee on research, with a view to ascertaining what can be done in this direction to assist the directly interested segments in our economy to contribute towards our common objective.

It is recognized that research can play a very important part in the trade picture, to the extent that it contributes to the improvement of efficiency of existing operations, to the production of new and better products, and particularly to the further processing in Canada of numerous raw materials which we possess.

Action taken in this direction is not, and should not be interpreted as the sole responsibility of the government. The problem, and any measure of assistance to be devised, should be evolved by the cooperative effort of government, labour and industry.

The committee might consider asking parliament to enlarge its terms of reference, with the view of requesting leaders and interested associations and organizations in Canada, in the sphere of industry, labour, agriculture, and so on, to undertake studies relative to their own particular activities, with a view to submitting considered briefs and proposals to the committee during its sittings at the next session of parliament.

It is clear that the magnitude of the problem requires the cooperative effort of all Canadians, and it is my view that the committee on research could be the medium to give the leaders in the various segments of our economy an opportunity to make suggestions that could be worked out cooperatively in the interests of Canada.

It is felt that the committee on research could make in cooperation, as mentioned above, a significant contribution towards a better understanding and ultimate solution to these problems.

Mr. BRUNSDEN: Mr. Chairman, is this from the Minister of Trade and Commerce?

The CHAIRMAN: The first part is from the Minister of Trade and Commerce, where he indicated to me that this research committee could and should be an excellent medium for all phases of labour and industry to make their representations, and that the committee would be set up early next session.

Mr. BRUNSDEN: Well, Mr. Chairman, as a member of the committee, I think we are flapping our wings quite a long way.

My interest, in this committee, is in research.

The CHAIRMAN: This would be research.

Mr. BRUNSDEN: But research into labour and management.

Mr. FORGIE: Or, into the cause of unemployment.

The CHAIRMAN: The situation, as we discussed it, Mr. Brunsden, was that other countries are using research media, with the idea of a cooperative effort on the part of industry, labour and government, to work out their problems.

Mr. BRUNSDEN: We all are agreed on that but, when we get into the field of labour and unemployment, as a member of this committee, I am not interested.

The CHAIRMAN: I hope there will be other expressions in connection with this.

Mr. PAYNE: Mr. Chairman, I would think a very clearly defined position, on the part of the committee's activities, would have to be taken. If we are going to embark on a study of industrial relations, unemployment, and the various factors involved in the employment picture, I would feel this a long way from the role and purpose of this committee. If, on the other hand, we are confining ourselves to the technical phases, where it is entirely a matter of the practice of research to industry and its application to the production and marketing, possibly, this is a phase which may be a proper function for this committee to go into. However, I think it would have to be clearly defined, and clearly understood.

Mr. NIELSEN: Mr. Chairman, may I suggest this matter be discussed further in the steering committee and then, perhaps, it could be brought before the committee again at our next meeting.

The CHAIRMAN: That is all right.

As Mr. Dumas will recall—

Mr. DUMAS: Mr. Chairman, if I may interrupt, I think we should give more thought to this suggestion of yours. It is quite an elaborate one.

I would like to know right now if it is the intention of the committee to adjourn the hearings soon, or are we going to keep on.

The CHAIRMAN: No, Mr. Dumas; I think we should have our report in early next week.

Mr. DUMAS: I mentioned this because, starting next week, we will be having longer hours so that we may we able to complete the business of the house around July 15 or 18. If that is the case, I think this will be a little too much.

The CHAIRMAN: I agree with you. I have expressed the opinion to several of our members that we should get the report in the first of next week.

Mr. Dumas will recall—and, perhaps, Mr. Forgie—that in all the debates, over the years, on research, that both the old parties, in their various discussions with the parliamentary secretary, and even Mr. Howe, expressed the idea that research would be a big factor in enabling labour and industry to overcome the problems they may have and they could be put on a level because we would hear representations from all segments of labour as well as industry. They all are in trouble; they cannot do it alone. Neither labour nor industry can meet this problem. With the three agencies, including the government, I think the problem at least could be gone over thoroughly with some hope of success.

I know that both the old parties are on record that this should be done by the research committee over the years.

Mr. NIELSEN: Could I put in the form of a motion that we defer this matter for discussion in the steering committee.

Mr. DUMAS: Mr. Chairman, I think this can be done right here by the whole committee. I am afraid we may be stretching our wings a little too much.

Mr. BRUNSDEN: Would you define the line of demarcation between this committee and the industrial relations committee? My concept of the work of this committee is that it is in research—and I would like to say that this has been one of the most interesting committees I have ever been on. Where is the line of demarcation between ourselves and the industrial relations committee?

Mr. MACLELLAN: I think I take a different interpretation of your statement, Mr. Chairman, than does Mr. Brunsden. I think what you have said is that we should invite labour and management to work with us to see how we can help in the way of developing research in industry.

Mr. NIELSEN: We have an industrial relations committee which possibly would investigate that aspect of the problem, but I think Mr. MacLellan has a point. I really do feel, however, that we could embark on a lengthy discussion here which would use up the time we have for this meeting. This matter very well could be discussed in the steering committee and a report brought back to the main committee at our next meeting.

The CHAIRMAN: There have been many indications both by labour and management that they would welcome an opportunity to make representations at this level.

Mr. MACLELLAN: I think it is a very good idea.

The CHAIRMAN: I am quite agreeable that we discuss this at a meeting of the steering committee.

Mr. DUMAS: I do not object to that. I am thinking the time right now is short. Maybe at the next session, at the beginning of the session, we could plan exactly what we intend to do.

The CHAIRMAN: The idea, as I discussed it with the minister, who has been very much interested in the proposal, was that if we adopted this idea it would give labour and industry six months in which to prepare their representations.

Mr. PAYNE: I still think there has to be much consultation in a matter of this nature, because the general tendency today in the use of the word "research" is that it be of a very broad nature, and there is quite a misuse of the basic word itself. I think in this committee we must confine ourselves to the basic. I am not quite in the position of Mr. Brunsden, that I say no, it should not be done; nor do I follow the suggestion that it is basically good; but if we do embark on such a program I say it must be clearly defined so that what we have submitted to us from labour, management and industry, or any other source, basically must be within the realm of research. I would not look forward to receiving submissions which have nothing to do with the subject.

Dr. E. W. R. STEACIE, (*President, National Research Council*): Mr. Chairman, I think you have to distinguish between research in the natural sciences, which would include engineering, physics, chemistry, agriculture, forestry and all those things in which government scientists as a group are expert. If the committee did this broadly they would have to call persons from the departments of Mines, Agriculture and various others.

Then you have research in the social sciences. This would involve a totally different set of experts. For example, this is something in which the research council has no competence whatever. Then there is the third use of the word as we find it in the motion picture industry and so on, where research does not mean anything original but merely is the looking up of things you would find in a library. If you extend research to this, then it involves everything in the country, without limit. If you limit yourselves to social and natural sciences then it has to be an investigation of something. If you limit yourselves to the natural sciences than you get the effect of science on technology.

Mr. NIELSEN: What Dr. Steacie, and other members of the committee, have said points up the need for compiling precise terms of reference in respect of what you have suggested. Again, I would suggest that the place to prepare these terms of reference, for submission to the committee for a full and complete discussion, is in the steering committee. Afterwards we could report to the main-committee and could discuss it fully and completely there.

Mr. SMITH (*Winnipeg North*): Once the terms of reference are drawn up I think we would welcome representations within the terms from labour, management and industry. I think it would be a great deal of benefit to the committee within the terms of reference.

The CHAIRMAN: It is the intention that the terms of reference will be wide enough to include that. Representations have been made by labour as well as management, and that points to the fact that they would be very happy to participate in this and to make representations in the hope that cooperatively something can be accomplished.

Mr. DUMAS: Do you mean that representations have been made to you, Mr. Chairman?

The CHAIRMAN: Representations have been made as a matter of fact publicly, that they would welcome the opportunity.

Mr. DUMAS: Over the years, yes; not lately.

The CHAIRMAN: Yes; in the press lately.

Mr. FORGIE: Would we be duplicating the work in the Senate by the committee on labour?

The CHAIRMAN: No. They are concerned more with automation.

The idea here would be to hear the three groups, labour, management and government, so that cooperatively they could help solve the problems with which this country is faced.

Mr. BRUNSDEN: Mr. Chairman, may I clarify my position. My concept of the work of this committee is the study of pure science as it infringes on the national economy. Certainly the field of labour—management relations is an entirely different field. There is a group interested in agriculture research in the agriculture committee, and so on, and I feel that has no part in the work of this committee.

The CHAIRMAN: Mr. Dumas, would it suit you if we discuss this at the steering committee.

Mr. DUMAS: Yes.

The CHAIRMAN: Is it agreed? We would have a meeting some time on Monday.

Mr. BRUNSDEN: Would you give us the names of the members of the steering committee?

The CHAIRMAN: Messrs Aiken, Best, Dumas, McIlraith, Payne, Peters and myself.

Mr. PAYNE: I do not want to take up the time of the committee and hold up our other studies at this time. However, the problem that you have raised has many wide ramifications, and unfortunately I will not be here next week. I would like to offer a word of caution, because research as frequently thought of by members of the House of Commons represents, in my mind, very little more than the old fashioned term "study"—it does not matter what we do, it is research. In many instances today it is a fundamental study and does not have anything to do with research. I think we have to be most cautious in considering these terms of reference or otherwise we will have a committee which basically duplicate the schlemozzle that the industrial relations committee went through last year, and we would be doing a disservice to the basic duty of this committee and certainly would not be doing very much good for industry or labour. Also, I would like to point out that there are many other committees—some of which I know nothing about and some of which I have had a fair contact with—which go extensively into a review of industrial and commercial research in the true sense of the word. For instance, there is the committee on mines, forests and waters relating to the forest industry; the agricultural committee relating to matters of agriculture. I think there is a grave danger, not only of getting this committee completely off the track, but also the danger of duplicating work done by a committee such as the mines, forests and waters committee in relation to the coal mining industry, the forestry industry and the technical phases of commerce connected with the ocean. We have a great possibility of duplicating work that could be and is being done by a committee such as the fisheries committee. I think we have to be very careful to know where we are heading.

The CHAIRMAN: It is agreed that this will be brought up before the steering committee.

Mr. PAYNE: I am saying this because I will not be here next week, and will not be able to express these views at that time.

The CHAIRMAN: This morning we have with us Dr. Marshall. He is the awards officer and secretary of the National Research Council.

Dr. J. B. MARSHALL (*Secretary and Awards Officer, National Research Council*): Mr. Chairman and gentlemen, I have another statement here which has been prepared in answer to some questions which were raised in connection with the research journals and the assistance of the council to scientific publications.

The CHAIRMAN: Is it agreed that this be incorporated in the minutes?

Agreed.

NATIONAL RESEARCH COUNCIL
ASSISTANCE TO SCIENTIFIC PUBLICATIONS

Examples of the six scientific journals published by the National Research Council were available here last Thursday for examination. Information regarding policy, membership of the editorial board, current frequency of publication, and subscription rates, is in the inside front cover of each number. Some of this information, together with recent "circulation" figures, are summarized in the following Table:

Journals	No. of Copies per year	Price $/year	Distribution—May 1960 Canada	U.S.	U.K.	Foreign	Total
Chemistry	12	12.00	1,402	701	246	621	2,970
Physics	12	9.00	843	619	229	592	2,283
Biochemistry and Physiology	12	9.00	818	445	181	347	1,791
Botany	6	6.00	227	320	194	328	1,069
Microbiology	6	6.00	557	441	170	311	1,479
Zoology	6	5.00	177	278	134	194	783

Contributions to the journals may be submitted as research papers, notes, or letters to the editor. During one recent year (1957), 773 papers were published in the six journals. Of these, approximately 11 per cent were contributed from outside Canada, 43 per cent from Canadian universities and colleges, 20 per cent from N.R.C. laboratories, 22 per cent from other federal and provincial government laboratories, between 3 and 4 per cent from industrial laboratories, and the balance by private individuals and collaborative efforts by individuals from two or more of the groups.

The number of foreign contributions increased to 15 per cent in 1959. This may be interpreted as a compliment to the journals, but it is also an indication of the great pressure on the outlets for scientific papers as well. The Canadian journals have a very fine reputation for prompt editorial attention. Manuscripts are usually processed and appear in the printed journals in less than three months from the time they are received in the editorial office. This is a very unusual record. A Table showing the numbers of papers and pages published in each journal since 1956 is given below.

	Papers				Pages			
Journals	1956	1957	1958	1959	1956	1957	1958	1959
Chemistry	236	210	254	310	1,837	1,581	1,746	2,103
Physics	165	150	172	177	1,500	1,394	1,713	1,565
Biochemistry and Physiology	129	152	139	170	1,273	1,320	1,279	1,526
Botany	76	80	76	109	987	993	1,009	1,278
Microbiology	88	114	69	79	758	1,029	648	669
Zoology	67	67	82	98	726	819	983	1,126
TOTALS	761	773	792	943	7,081	7,136	7,378	8,267

The cost of printing the journals has increased from $179,000 in 1956-57 to $277,000 in 1959-60. Part of the increase is due to a rise in printing costs, and part to the number of pages printed.

In addition to the journals published by the council, annual grants are made by council towards the cost of publishing the following periodicals:

1. CANADIAN JOURNAL OF MATHEMATICS	$ 6,000
CANADIAN MATHEMATICAL BULLETIN Canadian Mathematical Congress	1,500
2. CANADIAN JOURNAL OF PSYCHOLOGY Canadian Psychological Association	2,000
3. CANADIAN JOURNAL OF GENETICS AND CYTOLOGY Genetics Society of Canada	4,500
4. ENGINEERING JOURNAL Engineering Institute of Canada	2,500
5. CANADIAN GEOGRAPHER Canadian Association of Geographers	1,200

The National Research Council's program of university support since its inception in 1917, was described in the report of the special committee on research of 1956. Details of the administrative responsibilities of the awards office at the time were included, and an attempt made to relate them to the postwar growth of research in the universities. In his review of the booklet, "Organization and Activities", Dr. Steacie has referred to developments since that time and given some data concerning the contribution made by the National Research Council.

A more detailed record of support for science, engineering and medicine in the universities during 1958-59 is contained in the green covered book that was distributed at the first meeting. In addition to details of scholarships and grants awarded in that year, this report contains an introductory section which describes the various extra-mural activities of the council that are related directly and indirectly to the universities. A similar report for the fiscal year just ended will be available for distribution in a few weeks' time, and on an annual basis in subsequent years.

Since 1955-56, total expenditures for grants and scholarships have increased by $5,825,146, from nearly $2.6 million to just under $8.4 million in 1959-60. This year, the estimated expenditure is nearly $9.2 million. In 1956, at the March meeting of council, 337 applications for grants in science and engineering were considered; 307 awards were approved, amounting to $1,219,-648. Last March, there were 938 requests, and 716 grants totalling $5,746,878 were approved. The corresponding figures for medical research are 178 requests, and 148 grants amounting to $701,126 in 1956, compared with 318, 271 and $1,818,732 in 1960. Together, the totals for 1960 are 2.44 times the number of requests in 1956, 2.18 times as many grants, and almost 4 times as much money.

The foregoing figures do not include requests dealt with at other times of the year, hence there is a small discrepancy between them and the figures relating increases in numbers of grants and institutions at which they are held. In 1956-57, 522 grants were held at 21 universities and university affiliates, 15 hospitals and other institutions. In 1959-60, the corresponding figures are 884, 27 and 16, and for 1960-61 there has been a further increase to 916, 30 and 16. Assumption University appeared first in 1957, with 2 grants. This year there are 16; Waterloo had 2 grants last year and this year has 6; Carleton started in 1957 with one and now receives 10; at the larger universities, Toronto, McGill, British Columbia, Montreal, the numbers of grants have increased substantially, by 65-100 per cent.

As the volume of applications has increased, council has begun to use committees of specialists, i.e. chemists, physicists and biologists, engineers, etc., to review applications for grants.

These committees are known as "grant screening committees" and their recommendations have been presented to the standing committee on assisted research of council in 1959 and 1960. The work of these committees and their memberships are described in the report of university support. In 1959 there were four such committees—biology, chemistry, physics and engineering. This year, a committee on earth sciences was added, and for the next year, the chemistry committee has been divided to provide a new group to review applications in chemical engineering, and another new committee on computers has been named to give advice in a rapidly changing area of great importance to all branches of science. This committee will also review applications for grants for computers.

Each of these committees reviews applications for operating and equipment grants in the subject of its competence. Equipment grants have been arbitrarily set at $5,000 or more, and have included such items as liquid air machines, electron microscopes, various types of spectrophotometers, nuclear magnetic resonance apparatus, and so on.

These items of equipment are of the order of $10,000 to $50,000.

Equipment for modern research is expensive and has a high rate of obsolescence.

It is worthwhile to comment on the increase in research in the various branches of engineering, as indicated by the need for the committees mentioned above. Since 1956 there have been a number of new staff appointments in engineering faculties across Canada; the research interests of these men are quite evident in the requests they are making for grants themselves and in requests from their new colleagues, whom they have stimulated into an active state.

So far, I have referred only to the grants programme. There has been a similar increase in the volume of scholarship applications and awards. From 1952 to 1955 the numbers of applications increased from 444 to 546, and then fell to 511 in 1957.

That was the fall off after the big enrolment of the veteran students.

In 1958, 602 students applied and this year 860 applications were considered. There were no particularly noticeable changes in the distribution by subject of study. Foreign students resident in Canada can apply for council scholarships—and it is interesting to note that about ¼ of all the applications are from non-Canadian candidates.

I have not made any reference to the post-doctorate fellowship program. This question of post-doctorate fellowships in universities and government laboratories was thoroughly discussed at a previous meeting.

The CHAIRMAN: Have you any further comments you wish to make, Dr. Marshall?

Dr. MARSHALL: No, not at this time.

The CHAIRMAN: I am sorry that we do not have enough copies of Dr. Marshall's statement to circulate to every-one. I did not know this situation existed until this morning. It is the usual custom to have a copy for each member of the committee.

I believe the members of this committee would like to ask Dr. Marshall questions.

Dr. STEACIE: May I just point out that in this green book is indicated in the beginning what has been done in respect of the organization. It describes the committees and the structure, and so on. Then in the latter part of the book appears a list of every grant that has been made, and to whom, and how much. Everyone who has been awarded a scholarship appears there.

The first part deals with organization, and the main thing here is that we have had to decentralize quite largely as the program increased in the part the scholarship committee was confronted with say, 180 applications. The committee could sit down fairly cold and deal with them. When they are faced with 900 you must have a lot of previous screenings and you must decentralize your organization. This increase of a factor of four in four years, or so, in respect of our university support has meant a great deal of decentralization. In fact we have had to reorganize almost the entire method of handling the program.

Mr. BRUNSDEN: What lays behind the awarding of scholarships as between the various branches of science? You mentioned this morning mechanical engineering, or chemistry as compared to biology. Is there any pattern that you estabish with respect to the importance that you place on each department?

Dr. STEACIE: I think, sir, what we tried to do is to back the good people.

Mr. BRUNSDEN: You come back to a consideration of the individual?

Dr. STEACIE: We consider the individual.

We support more students under grants to university professors than we support under scholarships. What we have tried to do is take what we thought were the best students and give them scholarships. Many of the others who were turned down for scholarships have been hired by individual professors under grants.

Mr. BRUNSDEN: In other words, both activities are supplemental to the individual.

Dr. STEACIE: Yes.

The CHAIRMAN: There was a matter mentioned this morning a couple of times in respect of these professor scholarships. Is this an innovation of the last few years by the National Research Council? This is something that I believe has been urged for some time.

Dr. STEACIE: I am not clear, Mr. Murphy, as I mentioned before, of the meaning of "professor scholarships".

The CHAIRMAN: I am speaking of giving the professors in our own universities grants or scholarships to further their education in science in order that they may become better instructors and teachers.

Dr. STEACIE: In general, if you use "professor" in the technical sense,—i.e. all assistant professors, associate professors and full professors,—we never give them scholarships, as we assume that they are already educated before they receive these jobs. We will give them money to enable them to carry out research. In certain cases we would send them on lecture tours, or send them abroad to meetings or symposiums.

If you take the junior university staff or demonstrators, these are graduate students who are doing a little teaching but who are essentially still students and, therefore, our scholarship holders would be in this category. We allow a man who has a scholarship to do a very small amount of teaching because we think this is good experience. In general we do not give money to university professors to further their education. We assume that they are educated before they become university professors. We do give them grants to enable them to get assistants and equipment to carry out research.

The CHAIRMAN: In respect of another point, Dr. Steacie, considering a university, we will say like McMaster, which is interested in one phase of science, are the efforts of your council behind them?

Dr. STEACIE: Oh, very much so.

The CHAIRMAN: Grants are made to further the studies of that particular science?

Dr. STEACIE: Mr. Murphy, what we have in Canada, as in any other country, are many strong points, and many weak points, and the consideration of grants is based on a question of the individual. If you have a very good man, provided he receives a minimum of support from his university so that his teaching load is not too heavy, and provided the basic facilities are available and he is good enough, students will want to work with him, and he will build up quite a large group. Our feeling is that we would like to see the largest possible number of good men surrounded by groups of this type.

I think you will see that our support to universities falls into two categories. One category is that of trying to encourage the small university that is starting out, or the young man who has just got a university job. This is the encouragement aspect. The other aspect is the supporting of the man who is established. Here the grant would tend to be much larger. There is nothing that we are happier about than seeing the development of one of these groups headed by someone with an international reputation. This is the thing we are trying to get behind to the maximum possible degree. In the case of these people, we give grants on a term basis so that we can guarantee support for three years at a given level. This gives the investigator the assurance of continuity.

In the case of a younger man, or a man who is not established with a reputation, the grants are annual. If he does not appear to be doing much he may receive less the following year.

Mr. PAYNE: Last year, Mr. Chairman, there was a case in the university of British Columbia where a rather distinguished scientist, I believe from India—his name escapes me at this time—left Canada to go to the United

States. There was immediately a great hue and cry went forth in respect to the lack of support of his scientific research endeavours. Would you be able to throw any light on this matter at all?

Dr. STEACIE: The man you are speaking of was Dr. Khorana. He was an employee of the British Columbia research council, not of the university.

In general our feeling has been that it was not our fundamental duty to support a provincial government institution. We have given small grants to the provincial institutions to enable them to do a certain amount of fundamental work. In fact there was a grant of $25,000 per year to the British Columbia research council which they were using entirely to support Dr. Khorana.

When Dr. Khorana did some rather spectacular work, and it was obvious that he was receiving offers from other places, we agreed, as a special case, to increase the support very largely to him, provided he would get a university appointment. The university of British Columbia appointed him as a sort of professor at large in order to give him status in the university and enable him to take graduate students. We made a large grant to him and a capital grant was also made from some other source of government funds, or at least it was under discussion and would have been made. That is, there were some other funds available. Unfortunately, although this meant a very large increase in his support, the offers that he received from the United States—which were essentially the building of an institute to set him up—were of such a nature that he felt he had to accept them.

I might say that our own correspondence with the British Columbia research council discloses that they thought it was extremely encouraging that we were able and willing to step in and do something. In spite of the fact that they lost him they felt that we had done everything we could.

Mr. PAYNE: Is there any basic truth to the publicity in respect of the lack of financial support and facilities, or would Dr. Khorana, in moving to the United States, be associated with great minds that were in keeping with his own ability?

Dr. STEACIE: He received attractive offers from two of the largest American universities. There is no question that there would be a very large number of people in related fields with which he would come in contact. I think there is no question that he did not leave because of personal financial reasons. I also do not think he left because of the lack of support. He left simply because he felt he was able to get into a major spot where there was a great deal of activity in the related fields.

We made every effort to do what we could to persuade him to turn down these offers but unfortunately we were unsuccessful.

Mr. PAYNE: Do we have comparable institutions in eastern Canada, for example, where he could have been brought into contact with colleagues who were advanced in the same science as that in which he himself was working?

Dr. STEACIE: There are places, yes; but I do not think there are places that are comparable in the specific field in which he is involved. He has moved into a very major spot. I think this was very unfortunate, but we did everything we could.

Mr. PAYNE: In other words, this points out that we can expect to lose, in our normal mortality experience, certain outstanding scientists to greater institutions?

Dr. STEACIE: I think that this does indicate that. Actually the record is encouraging from the reverse point of view. That is, as Canadian science develops, we get more and more distinguished people who will stay at home in spite of the offers they receive from outside. I think that the general picture is quite encouraging. We are beginning to get into the position where we can attract outstanding people from the United States and from Britain to our Canadian universities. We are bound to lose some, but I think that the general picture is quite encouraging.

The recent additions to university staffs in Canada, including young men who have taken their degrees entirely in the United States, but who have come back to Canada and also including Americans and people from Britain who moved to the United States and took university jobs, but then accepted jobs in Canada, is very striking. Part of this encouraging situation is certainly due to the increase in university salaries. The university salary position five years ago was simply hopeless. Universities have been able to find money in order to pay salaries on a level which is more comparable with the salaries in the United States. I believe that most Canadians will stay home, provided the discrepancy is not too great in respect of both professional possibilities and salaries, and in general we can be hopeful about the situation.

Mr. BRUNSDEN: What was the particular field of science in which Dr. Khorana was involved?

Dr. STEACIE: He was involved in biochemistry.

Mr. BRUNSDEN: I beg your pardon?

Dr. STEACIE: He was a biochemist, or an organic chemist on the boundary of biochemistry.

Mr. BRUNSDEN: I remember the specific case, but there are so many strange things happening in British Columbia that I cannot keep up with them all.

The CHAIRMAN: Dr. Steacie, I am interested, as I am sure the members of this committee are, in the section of Dr. Marshall's report which indicates that since 1955 the total expenditures for grants and scholarships have increased by $5,825,000 odd—from nearly $2.6 million to just under $8.4 million—and that this year the estimated expenditure is nearly $9.2 million. I hope and expect that you are not finding it difficult to obtain funds in order to further this program, and that in years to come the increase will no doubt be natural.

Dr. STEACIE: The estimates, of course, are always a double-barrelled game, in that it is our responsibility to ask for everything we think we need, and it is the government's responsibility, once they have every department's estimates in, to decide what the country can afford to spend. These two things, of necessity, are not quite compatible, but I think the fact that over the past few years we have been able to expand at the rate we have done, has meant that we have had very sympathetic treatment.

It is absolutely essential that this kind of rate of growth continue because the universities are still expanding. In addition to that they have recruited a great many first class young people, and as their reputations build up, they will need more support. Also, the undergraduate flood is just beginning to hit, and the graduate student flood should follow four years behind it, so that one would anticipate two or three years from now a very great rise in the number of graduate students. The number is already growing, but this will accelerate it.

I think it is indicated that, if we do intend to continue to support university research effectively, we must have a continuation of quite considerable increases in the estimates for this purpose.

The CHAIRMAN: In regard to a further point along the same line, and from your observations in respect of the increases in the enrolment in universities in scientific fields, what in your opinion would that increase amount to five years from now?

Dr. STEACIE: Perhaps Dr. Marshall could answer that question.

Dr. MARSHALL: I think we could expect to have very nearly double the number of graduate students; they will come both from the increased enrolment of under-graduates and from students coming from foreign countries.

Mr. PAYNE: Mr. Chairman, earlier on in the proceedings, Dr. Steacie stated, based on a policy, which certainly I am not quarrelling with, that rather than have a duplication of federal support, the defence colleges were not included in this program.

My question is this: as a result of this policy, is there any ill effect—any lack of facility or equipment, or interest in scientific work resulting from this policy, or are you familiar with the procedures in the defence colleges?

Dr. STEACIE: R.M.C. is now a university. In effect, C.M.R. and Royal Roads are junior colleges, in the sense that the students take part of their instruction there, and go on to R.M.C. to finish. However, R.M.C. is the major service college.

This policy is, to some extent, a transfer of funds rather than a change in attitude. What has happened is this. Since these are defence colleges, the Defence Research Board feels they have a special responsibility towards R.M.C. and the other service colleges. What has been happening in recent years, since the defence research board's funds for grants have not risen as rapidly as ours, is that we have gradually been taking over from the defence research board those grants which were of marginal defence interest. So, the change in two or three years, has been really that the board has sloughed off to us certain grants in which the defence interest was not particularly pronounced, and is concentrating more on those things where there is a real defence interest. They regard themselves as having a special responsibility for R.M.C. and, therefore, I think that R.M.C. is being supported at an appropriate rate. Certainly, the build-up of scientific research in R.M.C. has been quite impressive over the last ten years, and I feel there is a great deal of first class work being done there. It is financed partly out of their own vote and partly by grants from the Defence Research Board.

Mr. PAYNE: So, there are grants being paid?

Dr. STEACIE: Yes.

Mr. BRUNSDEN: In regard to your question about the next five years, could Dr. Steacie foresee the need for a partial withdrawal from the support of universities in favour of more direct work by the research council itself?

Dr. STEACIE: No.

Mr. BRUNSDEN: I am speaking about money.

Dr. STEACIE: Yes.

I feel that what is needed, so far as the Research Council itself is concerned, is a reasonably slow steady growth. We have no particular desire to expand very largely and suddenly; we would like to make sure that we expand only as we can get first rate people. I would like to see a slow but healthy growth. The university side is just as much our responsibility as our own laboratories, and there the growth must be much more spectacular.

I would like to see, estimate-wise, a steady increase in the estimates for the lab, but I would like to see an increased percentage of the total estimates going to the universities over the next five or ten years. In other words a situation where both expanded at a reasonable rate, but university support would increase more rapidly. If you leave out capital—that is, for buildings—and consider only the operating budget, as it stands now, we are running something around—well, if you consider expenditures rather than estimates, because we have income—28 per cent on university support. I feel this should rise, probably, to 40 per cent or 45 per cent.

Mr. BRUNSDEN: Over a period of years?

Dr. STEACIE: Yes, over a period of years. However, this does not mean that I do not think the laboratories need to expand as well. I would not expect the laboratory budget to double in the next five years, but I would like to see the university budget double in that length of time, or do a little better than it has.

Mr. PAYNE: What is the reasoning behind this? Is the population of universities growing out of all relationship to plant laboratory and general facilities?

Dr. STEACIE: I think there are several things. The first is that research was not done to a very large degree in most Canadian universities before the war. This has been rising very rapidly, until the major Canadian universities are now on a footing in research that compares with the best institutions elsewhere. So, there is a big build-up in the amount of research, which is based on interest. Secondly, there is the build-up of the population of the universities. This is quite striking, and is going to continue to be striking. Then, there is another factor—as the reputation builds up, you get more foreign students. At the present time, you have about 25 per cent of the graduate students in Canadian universities in science and engineering, coming from abroad. I think this is very encouraging, because this is the situation you have in all major countries, from a research point of view.

Then, there is a further point. At the present time—and figures are hard to get—something of the order of half the Canadian graduate students take their degrees in the United States. This is very difficult to document. I think it is perfectly obvious that as Canadian university research expands, and as its reputation rises, we have to be prepared for far more Canadian students wanting to stay home. We are thus up against the expansion of the student population, and the expansion of research, as interest rises—in other words, and increase in the percentage of graduate students, an increase in foreign students, and a diversion of Canadians back to Canada.

With all these things combined, I think we have great opportunities of really going places, so far as research is concerned in Canadian universities, and they should soon be on a par with those anywhere in the world. This is going to involve a big increase in estimates.

Mr. BRUNSDEN: I would like to have Dr. Steacie's opinion on the respective emphasis of education in universities and research in universities. Is there not somewhere along the line danger that we may become top heavy, one way or the other?

Dr. STEACIE: I think this is possible. However, at the moment, I think we are bottom heavy. This is a very big question to argue, and if one stays clear altogether of the humanities and other phases of the university and just considers science, I do not think except in most unusual circumstances, that a man can do good teaching, if he does not do research. The two go together. A student who is educated in an institution that does no research, gets a false view of his subject, and does not realize it is continually developing; it becomes a matter of textbooks rather than a matter of something real. We have gone through the phase of setting up teaching institutions, which I think you always do in a pioneer country. In the past it was taken as a natural thing for a student to go abroad for higher education—post-graduate education. We still have, for example, a very long way to go, before we get our universities to the same ratio of research to teaching that they have in British universities; that is, the ratio is enormously high in the major British universities, as compared to ours. The question of teaching being too little emphasized is something that we in Canada do not have to think about for another 20 years.

Mr. BRUNSDEN: I would like to reduce this to an example. I am interested in the university of Alberta, and I hear a good deal more from the university about the tar sands in northern Alberta than I do about the humanities. I am not speaking critically, but just looking for information. I am interested in the humanities, and in educating people to become citizens, and I feel, in our own universities perhaps, that we are on that teetering point with respect to the dollar that goes into research and the dollar that goes into education.

Dr. STEACIE: This is a quite different subject. As I say, I think once you have many students in science and engineering, the need for expanding research is compelling. I personally, do not feel that one should be using propaganda to divert students from the humanities to the sciences. This is a thing that worries me. Some of the arguments about competing with the U.S.S.R. seem to imply that the student is wasted if he is not a scientist or an engineer. I do not believe this for a moment. I think there has been an encouraging change. The Canada Council has made quite a difference because, previously, there was no source of support for graduates working in the humanities or social sciences, comparable to the National Research Council—It seems to me also that universities themselves are paying attention to this. One thing is quite noteworthy. Up to five years ago, if you looked around the Canadian universities, all the new buildings were for science or engineering but, if you look around today, you will find a large fraction of them are libraries and arts buildings. I think what has happened, in the past, is that the publicity has all gone on the science and engineering side. However, I quite agree with you, and I think it would be a great tragedy if the universities turned into nothing but institutes of technology.

Mr. MACLELLAN: In connection with that point I find, from talking to some of the presidents of the maritime universities, that one of the biggest problems they are facing at the moment is funds for science buildings. They say the Canada Council is helping out in the humanities and, so far as research and so on is concerned, the small university has not as much to gain as the larger ones. A lot of people say that what they desperately need is some help to provide science buildings and laboratories. Has there been any thought given to setting up a branch of N.R.C. for the purpose of making grants for the construction of science buildings and to supply the needs of laboratories in our universities?

I notice, from this green book, that very few of the grants seem to be going to maritime universities, and I imagine the reason is that they feel Dalhousie, St. Francis Xavier and Mount Allison are too small for research. However, there is a desire, on their part, to train scientists and engineering students. At the moment, there seems to be a gap, so far as the maritimes are concerned.

Dr. STEACIE: So far as the maritimes are concerned, the support there, per graduate student, compares favourably. There are increasing signs of activity. We recently have supported the founding of an institute of oceanography at Dalhousie, which involves a large grant, for example.

In connection with your general question, university building is a subject to which a lot of thought has been given. The original Canada Council grants were limited to the humanities and, I think, with justification. At that time, the idea was that industry would contribute to science buildings, but would not contribute to buildings for the humanities and, as a result, the need for buildings for the humanities was greater at the time. Now, it is perfectly obvious that people, like the Canadian Universities Foundation—the former National Conference of Canadian Universities—have been submitting briefs to the government, pointing out with great vigour, the need for buildings. The grants for buildings through the Canada Council come directly from the treasury to the Canada Council; this has had nothing to do with the National Research Council.

My own feeling is that there certainly is a need for a mechanism to help the universities build buildings for science, medicine, and other fields, and there is no question that the universities are bringing this to the attention of the government. Also, I think there is no question that if the government should decide, at any time, to do something about this, it would be done by a mechanism analogous to the Canada Council grants, and not through the National Research Council. Personally, I would not like to see this done through the National Research Council. Probably, it would have to be done on a formula, which is the present case. I feel the money can be just as well handled by other people. Over the period of 40 years, we have made grants to people in universities, but we never have made a grant to a university. As a result, we never have been engaged in the controversy between the federal government and the provincial governments in regard to education. In effect, our declared policy is that we have no interest in education; we are interested in research, and will support it. Obviously, this will have a bearing on education. However, we never touch under-graduates, for this reason; also, we do not make grants to universities, but to people, no matter where we find them.

I have a feeling that if, five years ago, we had made grants for buildings, through the N.R.C., we might have found ourselves in the position where, in some provinces, grants were not acceptable because of the federal-provincial controversy over education, and this might have meant that our whole program would be unacceptable in these provinces. We have felt this is something we should keep our hands off completely.

I would like to see some mechanism found somehow to make it easier for universities to build buildings, but I would like to keep the N.R.C. out of this, because I would like to keep it out of federal-provincial relations. We have stayed out for 43 years and, as long as we do not stick our necks out in this way, I do not see any reason why we should not continue to steer clear of trouble.

Mr. BRUNSDEN: How large a part does private endownment play in the capital structure of eastern universities?

Dr. STEACIE: I do not know if I can answer that, but it plays a considerable part.

Mr. MACLELLAN: In some eastern universities.

Dr. STEACIE: Of course, there are a great variety, in that the western universities are provincial whereas, in Ontario and Quebec, you have private universities supported by government grants. This varies from province to province.

Mr. BRUNSDEN: But, on the prairies, private endowment is almost unkown. That is my thought.

Dr. STEACIE: I think today that compensates for funds by universities which then are used to build buildings or make quite a major contribution.

Mr. BRUNSDEN: That is very largely in the field of the alumni of the university.

Dr. STEACIE: Yes; but endowment funds in universities have become, with inflation and university expansion, more and more a negligible part of the university budget. I think probably the only university in Canada at which the endowment is a major factor is McGill.

Mr. BRUNSDEN: I am thinking in terms of capital projects.

Dr. STEACIE: The university of Toronto, for example, is about to stage a campaign for $14 million which would be entirely devoted to buildings. All these grants through the Canada Council were matching grants and the university had to find the other half. In the case of the universities in the west—provincial universities—it was largely a matter of provincial support. In the case of Ontario universities, the other half is partly provided by provincial grants and partly money raised by campaigns for funds. Certainly the money raised by campaigns from the public and industry has not been a negligible figure; it has been considerable, but is far from being enough.

The CHAIRMAN: Dr. Steacie, before we adjourn, I wonder if you could tell us when this trend started to reverse itself, of Canadian graduates having to go to the United States or other countries in order to get higher education.

Dr. STEACIE: I think the trend started at the end of the first war. Up to that time graduate work really was always done abroad, except in the case of an occasional student who took a higher degree.

The CHAIRMAN: I wonder if you have any idea of the increase there has been in industrial research in Canada over the last few years—that is the research conducted by industry?

Dr. STEACIE: We had some figures on this.

Mr. GODIN: This issue of the dominion bureau of statistics entitled "Industrial research development in Canada 1957" would have figures in it which would be helpful in this problem.

Dr. STEACIE: That was distributed. There are quite a lot of figures in it.

The CHAIRMAN: Is it encouraging?

Dr. STEACIE: It is encouraging, yes—very much so, in that except in one or two places there was very little industrial research before the war. For example, ruling out cases where a company hires American consultants and so on, the research done within the companies during 1958 amounted to $133 million. This is money paid by industry itself. If you take the payments to others by industry, which would include payments to places like the National Research Council and other consultants you would have a figure of approximately $161 million in 1958. That compares with $149 million in 1957. In other words the increase was approximately $12 million which is an increase of approximately 8 per cent in one year. My feeling is that the increase from 1958 to 1959 probably would be about of the same order. So I think there is quite an encouraging picture.

The CHAIRMAN: Thank you very much.

Mr. PAYNE: Before we adjourn, would it be in order in some way to include in the minutes the pamphlet on industrial research so that it may form a part of the file of documents.

The CHAIRMAN: Yes. Is it agreed that the report be incorporated as a part of the documents filed with the clerk of the committee?

Agreed.

Mr. BRUNSDEN: What is the program for the next meeting?

The CHAIRMAN: We will have a meeting on Thursday, this week. We intend to have Mr. J. L. Gray, president of Atomic Energy of Canada Limited. I think he will be able to appear at only one meeting, because we are anxious to get our report into the house next week. With your consent we would have a steering committee meeting some time on Monday and go over the proposed report to the house. Then on Tuesday we would have a closed meeting to discuss and approve the report.

Mr. BRUNSDEN: Is this the last meeting at which we will have Dr. Steacie and his associates?

The CHAIRMAN: I believe so.

Mr. BRUNSDEN: I think we should go on record in thanking Dr. Steacie and his associates for giving us so much of their time and for the tremendous volume of information they have given us.

The CHAIRMAN: We are going to incorporate in our report the fact that it is unfortunate that time does not permit us to have the heads of the divisions of the Research Council before us and to go to various labs to see what is going on. That will be part of our program for the beginning of next year. I think next year the committee will be set up very early in the session and no doubt we will start again with the National Research Council, and then go into Atomic Energy of Canada and Eldorado and its subsidiaries.

HOUSE OF COMMONS

Third Session—Twenty-fourth Parliament

1960

SPECIAL COMMITTEE

ON

RESEARCH

Chairman: J. W. MURPHY, Esq.

MINUTES OF PROCEEDINGS AND EVIDENCE

No. 7

NATIONAL RESEARCH COUNCIL

ATOMIC ENERGY OF CANADA LIMITED

THURSDAY, JUNE 30, 1960

TUESDAY, JULY 5, 1960

Including SECOND REPORT

Statement by Mr. J. L. Gray, President, Atomic Energy of Canada Limited.

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1960

23432-8—1

SPECIAL COMMITTEE ON RESEARCH

Chairman: J. W. Murphy, Esq.

and Messrs.

Aiken	Dumas	Nielsen
Batten	Forgie	[2]Payne
Best	Godin	Peters
Bourget	Grafftey	Smith (*Winnipeg North*)
[1]Bruchési	MacLellan	Stewart
Brunsden	McQuillan	
Cadieu	McIlraith	

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

[1]Replaced on July 4, 1960 by Mr. Bissonnette.
[2]Replaced on July 4, 1960 by Mr. Browne (*Vancouver-Kingsway*).

ORDER OF REFERENCE

MONDAY, July 4, 1960.

Ordered,—That the names of Messrs. Browne (Vancouver-Kingsway) and Bissonnette be substituted for those of Messrs. Payne and Bruchési on the Special Committee on Research.

Attest

L.-J. Raymond,
Clerk of the House.

23432-8—1½

ORDER OF REFERENCE

MONDAY, July 2, [illegible]

Ordered,—That the report of Messrs. [illegible] ([illegible]) and [illegible] be [illegible] for those of Messrs. [illegible] and [illegible] on the Special Committee on Estimates.

Attest.

L. J. RAYMOND,
Clerk of the House.

The Special Committee on Research has the honour to present the following as its

SECOND REPORT

National Research Council

Your Committee met on six occasions to consider the organization and activities of the National Research Council. The witnesses called were the President, the Vice-President (Administration), and the Secretary and Awards Officer. The Directors of the scientific and engineering divisions were not called, nor did the Committee have an opportunity to visit the Council's laboratories. The Committee's attention was therefore confined to the general policies and philosophy of the Council, and to its organization and administration. It is recommended that the Committee have a further opportunity to examine the Council's scientific activities and other phases.

A booklet on the Organization and Activities of the Council had been prepared by its officers for the use of the Committee, and this served as a basis for most of the discussion. This booklet is reproduced in the Proceedings of the Committee.

The main subjects discussed in detail by the Committee were: the general organization, administration and policy of the Council; the advisory committees and their functions and membership; the support of university research by the Council, including grants-in-aid of research and post-doctorate scholarships; foreign students in Canada, including post-doctorate fellowships awarded by the Council and the exchange of scientists between Canada and the U.S.S.R.; the Council's publications; the patent policy of the Council; the Technical Information Service; and briefly, expenditures on research by Canadian industry.

The Committee feels, from the evidence thus far heard, that the policies of the Council are sound and that it is efficiently operated. The Committee commends the structure of the advisory committees established by the Council; these provide a method of co-ordination of university, industrial and government research, but at the same time avoid the dangers of over-organization and of tampering with academic freedom.

The Committee is of the opinion that the personnel policies of the Council are sound. It is essential that the Council be free to choose, hire, and promote its own staff. Any diminution in the Council's flexibility and freedom in this respect would be disastrous, and the Committee strongly recommends that there should be no change in this vital matter.

The Committee feels that the university support program is performing a vital and essential function in the development of Canadian science and it strongly recommends further substantial increases in this program, especially over the next five years. In fact, it appears to be essential that the funds available for this purpose be at least doubled in this period.

The Committee recommends that the Council's laboratories continue their steady, but not spectacular growth, limited mainly by the availability of first-rate staff. It is also essential that the scientific operations of the Council remain free from the stultifying effects of narrow administrative control. It is felt that the Council should continue to devote a considerable part of its effort to work of a fundamental nature.

It is recommended that all possible steps be taken to expand and improve the Technical Information Service in its work of assisting the smaller industries in their technical development.

The Committee was glad to note that budgetary restrictions are not hampering the development of the scientific journals published by the Council. These journals are essential to Canadian science in that they represent the end-product and permanent record of much of the work which is being done by Canadian scientists.

The Committee commends the post-doctorate fellowship plan which, together with scientific exchanges with other countries, is doing much to make Canadian institutions better known abroad. This activity also constitutes a major Canadian contribution to the development of science on an international and commonwealth basis.

Atomic Energy of Canada Limited

The Committee had one meeting to consider the policy, operations and expenditures of Atomic Energy of Canada Limited. The Members recognized that this is an important segment of their work, and, in particular, hope at the next Session to be able to visit Chalk River and other establishments of AECL.

The Committee met on Thursday, 30th June, and listened to an extensive statement by Mr. J. L. Gray, President of Atomic Energy of Canada Limited, covering the history, organization, responsibilities and general activities of the Company. Mr. Gray supplied the Committee with information additional to his broad statement, in the form of fifteen appendices covering in some detail the various divisions of the Company and their scope of work.

Your Committee recognizes that it has just begun its investigation on research in atomic energy and that it must devote considerable effort during the next Session to this matter.

The brief presented by Mr. Gray has given the Committee Members and the public a great deal of information which warrants serious and detailed study. It has answered many of the questions the Committee had in mind, but it has also raised new questions. It will form a good foundation for the next series of meetings.

This Committee recommends that it be reconstituted early in the next Session of Parliament in order that it may continue its deliberations.

In view of the interest throughout Canada in the matters of employment, trade, development of secondary industries, and other relative matters pertinent to the continued development of Canada, the Committee recommends that its terms of reference should be enlarged, and that leaders and interested associations and organizations in Canada, in the sphere of industry, labour, agriculture, etc., be requested to undertake studies relative to scientific research in their own particular activities, for the purpose of submitting considered briefs and proposals to the Committee during its sittings at the next Session of Parliament.

A copy of the Committee's Minutes of Proceedings and Evidence is appended hereto.

Respectfully submitted,

J. W. MURPHY,
Chairman.

MINUTES OF PROCEEDINGS

THURSDAY, June 30, 1960.
(8)

The Special Committee on Research met at 9.40 a.m. this day. The Chairman, Mr. J. W. Murphy, presided.

Members present: Messrs. Best, Bourget, Brunsden, Dumas, Forgie, Godin, Grafftey, MacLellan, McIlraith, Murphy, Nielsen and Smith (*Winnipeg North*).—12.

In attendance: From the Atomic Energy of Canada Limited: Mr. J. L. Gray, President; Mr. D. Watson, Secretary; and Mr. Clyde Kennedy, Public Relations Officer, Chalk River Project.

Mr. Gray read a brief, copies of which were distributed to Members of the Committee outlining the historical background, organization objectives and facilities of Atomic Energy of Canada Limited, and reviewing Canada's position in the field of nuclear science.

Agreed—That appendices to Mr. Gray's statement be printed as an appendix to the record of this day's proceedings.

Following Mr. Gray's questioning he was thanked by the Chairman and informed that the Committee would look forward to a further presentation from him early during the next Session of Parliament.

At 11.00 a.m. the Committee adjourned to meet again on Tuesday, July 5, 1960.

TUESDAY, July 5, 1960.
(9)

The Special Committee on Research met *in camera* at 9.30 a.m. this day. The Chairman, Mr. J. W. Murphy, presided.

Members present: Messrs. Aiken, Batten, Best, Browne (*Vancouver-Kingsway*), Brunsden, Dumas, Forgie, Godin, McQuillan and Murphy.—10.

The Chairman presented a Draft Report, which had been agreed upon by Members of the Subcommittee on Agenda and Procedure. Following its reading it was adopted, and ordered presented to the House as the Committee's Second Report.

At 9.40 a.m. the Committee adjourned to the call of the Chair.

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

EVIDENCE

THURSDAY, June 30, 1960.

The CHAIRMAN: Gentlemen, I see a quorum.

We have with us this morning the president of Atomic Energy of Canada Limited, Mr. J. L. Gray, and he has prepared a brief for our committee.

In view of the fact that this will be the only meeting we shall have with Atomic Energy officials at this session, it might be a good idea if the members, who no doubt will be on the committee next year, take advantage of the information contained in this brief, so that many of us, who are not familiar with the work that is being done by this very important organization, will be better equipped to understand what we are going to delve into.

Mr. J. L. GRAY (*President, Atomic Energy of Canada Limited*): Mr. Chairman and gentlemen:

1. I have assumed that it would be helpful if I were to give you a broad statement covering the history, organization, responsibilities and general activities of Atomic Energy of Canada Limited. This statement is rather lengthy but then our program is rather large and our responsibilities are widespread and important. I will break this report down under the following headings:

1. Brief Historical Background
2. The Objectives of AECL
3. The Organization of AECL to Meet the Objectives
4. The Facilities of AECL to Meet the Objectives
5. The Place of Atomic Power in Canada
6. The Canadian Atomic Power Program
7. Co-operation With Other Countries
8. Radiation Safety, Reactor Safety, and Waste Management.

2. I am sure that as many members of this Committee as possible should at some time visit the Chalk River Project and our Commercial Products Division here in Ottawa. For those of you who have a particular interest in the technical aspects of the design of nuclear power plants, a visit to our Nuclear Power Plant Division in Toronto and perhaps to the nuclear design office of the Canadian General Electric Co. Ltd. in Peterborough would be of value. If such a trip cannot be fitted in, I will arrange for some of the engineering staff concerned with nuclear power plant design to be available for discussions at Chalk River. While you are there, we would like to show you the results of some of this design work in the Nuclear Power Demonstration (NPD-2) plant which is under construction near Rolphton, Ontario, some twenty miles farther up the Ottawa River.

3. A visit to Douglas Point, near Kincardine, Ontario, is probably not warranted at this time. Although this is an important site, being the location of Canada's first full-scale nuclear power plant, major construction has not started and there would be very little to see other than the general beauty of Bruce County.

4. Similarly, a visit to Manitoba and the Whiteshell Nuclear Research Establishment at this time would be premature. Although the location has been selected and it seems to be ideal from a project point of view, there will not be any site work for at least another year.

Brief Historical Background

5. Most of you know that the atomic energy program in Canada began in the war years as part of a joint effort with the United Kingdom and the United States to develop the atom bomb. It was agreed that Canada should concentrate on developing a nuclear reactor moderated with heavy water to make plutonium, one of the materials that can be used to make an atom bomb. It is not found in nature but is formed in the uranium fuel of most types of atomic reactors.

6. The atomic energy program in Canada started under the direction of the National Research Council. Scientists and engineers from the United Kingdom and from other allied countries came to Canada and the joint "United Kingdom-Canadian" team began work in Montreal in 1942—first in modest quarters and then in a wing of the new building at the University of Montreal. In addition to basic research work in chemistry and physics, designs were prepared for a small Zero Energy Experimental Pile known as ZEEP and a much larger NRX (National Research Experimental) experimental reactor. It was realized that these reactors could not be built in Montreal owing to considerations of secrecy and lack of knowledge on safety requirements. After exhaustive examination of many possible locations, the present Chalk River site was selected.

7. The ZEEP reactor went into operation in September 1945. It was the first nuclear reactor to operate outside the United States. It is noteworthy that today, 15 years later, it is still much in demand and is being used continuously for reactor physics experiments.

8. The NRX reactor was commissioned in July 1947. The reactor was designed to produce at least 10,000 kilowatts of heat and to have very extensive experimental facilities. This reactor actually produced 20,000 kilowatts early in its history, and within three years was up to 30,000 kilowatts. In addition to the higher power output, it has become of far greater general value than its designers ever contemplated. After a major accident in December 1952, the reactor was rebuilt; a relatively minor modification allows it to operate now at 40,000 kilowatts. While NRX is still being used extensively for fundamental research experiments and for the production of radioisotopes, it has proved to be of significant value in the field of engineering testing. Fuel, coolants and materials to contain both the fuel and the coolant are tested under power reactor conditions of temperature, pressure and radiation.

9. Following the commissioning of the NRX reactor, a strong research team was built up at Chalk River centred around its unique experimental facilities. With the very able direction of the senior scientific staff, Chalk River gained for itself an excellent international reputation in fundamental science.

10. The designers of the NRX reactor were quite unable to estimate how long the reactor could continue to operate without a major breakdown. It was commonly feared that internal corrosion might limit the reactor's lifetime to five years. The question then arose whether NRX should be operated until it broke down completely and then look for some new facilities for further atomic energy research in Canada, or whether a new reactor should be built so that Chalk River could continue even if NRX did fail. Very careful consideration was given to this major matter of policy around 1950 and the government's decision was that atomic energy research must continue in Canada and, to ensure its output, a new reactor should be designed and constructed.

11. It was decided that the new reactor known as NRU (National Research Universal) would be a triple-purpose reactor. It should have five times the power (200,000 kilowatts) of NRX and even better experimental facilities;

it could produce large quantities of radioactive isotopes and it would produce plutonium in significant amounts. The United States Atomic Energy Commission were anxious to increase their stocks of plutonium and agreed to purchase all the plutonium which was produced in the proposed NRU reactor. A formal agreement was subsequently worked out and will be in effect until June 30, 1962. (It is the intent of both parties to extend this agreement for a further period on agreed terms.)

12. Owing to several factors, including the increased commercial aspects of the Chalk River program and the size of the Chalk River establishment compared to the National Research Council, it was agreed in early 1952 that the governmental atomic energy effort in Canada should be separated from the National Research Council, and Atomic Energy of Canada Limited was set up as a Crown company. Six months later, the division of Eldorado Mining and Refining Limited which had been formed to handle radium sales, but which was then also marketing radioisotopes, was transferred to AECL as its Commercial Products Division.

13. During 1951-52 it became increasingly clear that there was definite promise of producing electric power from atomic energy on an economic basis. The operation of nuclear reactors in Canada and abroad had demonstrated that it was possible to operate a reactor continuously and under adequate conditions of control. It remained to demonstrate that nuclear power could be made economic.

14. Early in 1953 the Board of Directors of AECL inaugurated a power reactor feasibility study. It was announced that AECL would welcome the participation of Canadian electric utilities in carrying out this study. A Nuclear Power Branch was established at Chalk River early in 1954, headed by an employee of the Hydro Electric Power Commission of Ontario. Five other utilities seconded staff to this Nuclear Power Branch. By the end of 1954 the feasibility study had advanced to the point where it was decided that a Nuclear Power Demonstration plant should be designed and constructed. It was further decided that the detailed design, engineering and construction of the reactor should be contracted to a manufacturing firm and that the electric utilities should be invited to participate in the project.

15. Proposals for the design and construction of the NPD reactor were invited from seven Canadian manufacturers and, following a thorough examination of the proposals received, the Canadian General Electric Company Limited was chosen. Shortly afterwards, the Hydro Electric Power Commission of Ontario was selected as the electric utility, and a partnership was arranged between AECL, the Canadian General Electric Company Limited and the Hydro Electric Power Commission of Ontario to build the NPD station.

16. At the completion of the feasibility study on NPD by the Nuclear Power Branch, it was decided that this branch would continue its work and consider a preliminary design of a larger power station. This work continued concurrently with the detailed design on NPD. The first report on the large reactor design study became available early in 1957. It proposed a conceptual design which offered excellent promise of producing power at near competitive cost under certain specific conditions. These conditions were met in at least one area of Canada. In certain important respects the conceptual design was unlike that of the NPD reactor. Pressure tubes to contain the pressure system were incorporated instead of an over-all pressure vessel specified for the NPD reactor. The substitution of pressure tubes for the pressue vessel would remove one of the major and perhaps insurmountable problems incidental to the design and manufacture of a large nuclear power station

using heavy water as the moderator and natural uranium as the fuel. A new method of fuel looding and unloading was also proposed, which was a decided improvement on the NPD design. The Board of Directors, after careful consideration, decided that the delay and increase in cost which would result from changing the NPD design to incorporate these new improvements were justified, since its new version, known as NPD-2, would then become a prototype for a large reactor. These design changes were made and the NPD-2 station, now under construction, is a prototype for the full-scale stations to follow.

17. In early 1958 a Nuclear Power Plant Division of AECL was established in Toronto, with the responsibility for directing the NPD-2 project and the design and development program for a large nuclear power station. At that time it was estimated that from 3½ to 4 years would be required before the detailed design of the large station CANDU (Canadian Deuterium Uranium) would have reached the stage where firm price bids could be expected from manufacturers. The plan was to complete the design of the station so that firm prices could be obtained for the cost of construction before a decision was made as to whether or not the station should be built. However, the government, on the recommendation of AECL, decided in June 1959 not to wait until the development phase on CANDU had been completed and, authorized the construction of the CANDU project. I will say more about this program later on in this brief.

18. We would not like the Committee to feel that while all this nuclear power work was developing the research program was dormant—far from it. The research and development program was increasing, and without the work of the fundamental and applied scientist there would be no power program. Although they contribute directly to the fundamental design of a reactor, such as the fuel configuration and probable life of the fuel, they also make a significant contribution as general consultants. The design engineers make continuous use of this large source of fundamental knowledge. Fuel development for power reactors is one field where Chalk River has concentrated a major effort for several years. The success of this work, particularly in the use of uranium oxide fuel, has given the nuclear power reactor designers much of their confidence in low fuel cost. This confidence is not based on theory alone. It is supported by years of practical testing under power reactor conditions. This could not have been accomplished without the support of a strong team of scientists and engineers and, of course, some very good test facilities.

The Objectives of AECL

19. As the government agency responsible for research and development in the field of atomic energy, AECL has several objectives and responsibilities. It must conduct fundamental research studies at its own facilities and must encourage research at other Canadian establishments, particularly the universities. The main emphasis on fundamental research within the Company is associated with special equipment such as the research reactors and large accelerators or in the fields of work where ready access to varied amounts and kinds of radioactive material is required.

20. Applied research and development is another general area where substantial effort is required to promote the practical use of atomic energy. Atomic power is the most obvious final use, and this entails the development of materials and equipment to operate under conditions not previously encountered. Fuel for reactors opens up a whole new field for chemists, metallurgists, physicists and applied engineers. Mechanical components, as commonplace as pumps and valves, must be redesigned and thoroughly tested to meet

much more stringent conditions than have been required before. A very substantial effort both within the Company organization and in Canadian industry is directed to the solution of the many applied problems.

21. The Company has another objective, even though it may not be a defined responsibility—the development of an awareness of the need and value of research and development sections as an integral part of Canadian industry. To this end, a concerted effort is made to have development work undertaken by industry, where there is the necessary interest and support by management to take development contracts. Our efforts are contributing, in part, to the formation of substantial and highly qualified industrial development groups which cannot but help to improve Canadian products, technically and economically.

22. Since AECL has the major nuclear energy research facilities in Canada and a strong group of experienced personnel, it is natural that one of our responsibilities is the training of scientists, engineers and technicians. This responsibility is recognized by the Company and is approached in several ways. Although AECL does not grant awards to universities to support scientific research, we are to some extent associated with the grants made by the National Research Council and the Atomic Energy Control Board. AECL does enter into small research contracts with universities for specific jobs and on an ad hoc basis. To help maintain close relations between our scientists and the research staffs of universities working in the atomic energy field, it has been agreed with the Atomic Energy Control Board and AECL that AECL staff should review the progress made under the AECB grants for research. Senior undergraduates, graduates and some university staff members are employed at Chalk River for summer work. During their stay, the students become familiar with the type of work we are doing and we hope many of them will retain a live interest in atomic energy. At the same time, our senior staff have the opportunity of observing potential new recruits. The university staff members either continue working with special Chalk River facilities on lines of research they have already started back at home or learn about new techniques and problems which they may well choose to study further on their return to university. Many of the university faculties include in their members "alumni" of Chalk River. Some of our very best people have transferred to other posts in Canada. Although this entails further training and development of personnel to fill these positions, we encourage a turn-over and consider it an essential part of our job. We arrange for visits of groups of students at all levels from high school upwards, and we give talks and lectures at a very great variety of gatherings, varying from school groups through service clubs to highly technical meetings.

23. In considering the role of AECL in the future of atomic power in Canada, it must be remembered that it is the function of the electric utilities across the country, whether publicly or privately owned, to provide electric power to their customers. The consumer's interest is that he should obtain all the electric power he needs at the lowest possible price. He is not concerned as to whether the power was generated from water, fossil fuels or from a nuclear reactor. The electric utilities must make the decision as to when they choose to incorporate nuclear power stations into their systems. The utilities will call for addiional units of power and the consulting engineers and manufacturers may recommend nuclear plants as the best solution. It may be assumed that they will do so when nuclear power has proved to be reliable, safe and economical as an alternative source.

24. We consider it to be the function of AECL to spearhead the research and development of atomic energy so that atomic power can be produced in plants that are technically sound, are safe, and have final costs which are acceptably low.

25. In view of the part electric utilities, engineers and manufacturers will have to play in the introduction of atomic power on a large scale in this country, AECL recognizes the importance of keeping them informed of the current state of atomic power development and the prospects. Symposia, both general and technical, are regularly held at Chalk River for these groups. Engineering consultants, manufacturers and utilities are invited to second staff for extended periods both at Chalk River and at the Nuclear Power Plant Division in Toronto. We consider that on-the-job training of this sort provides the best means of enabling the companies concerned to assess for themselves what part they wish to play in the future of atomic energy in Canada and, conversely, what part atomic energy can play in their future. We have also recently set up a reactor school at Chalk River which gives courses of three months' duration to provide specialized training in nuclear reactor technology.

26. One other specific resonsibility which must be assigned to AECL is the supply of radioactive isotopes to Canadian users. The supply of isotopes is quite clear-cut and, except for certain "free issues" to universities, is handled on normal commercial lines. The Commercial Products Division is not expected to make a profit but it has managed to break even over the last eight years of operation. Without the very large export business, 90 per cent of total sales, the wide range of materials and services available to Canadian users could not be supplied without a large annual subsidy or exorbitant prices.

27. The development of uses of isotopes is a field that is stimulated from several points. Commercial companies in Canada and abroad are quite active in this area. Medical and agricultural scientists have, through university work and through practical applied work, developed many uses. We feel that much better results are produced if the users themselves develop new applications and techniques. AECL is prepared to assist in any area where we might have specialized knowledge or equipment and the staffs are always available for consultation. We have, in fact, made substantial contributions to the development of many applications, but this is not considered a continuing field of major responsibility. One exception is our development of machines using Cobalt-60 both for medical and industrial use. This is an area where we have been particularly active and successful.

The Organization of AECL to Meet the Objectives

28. Pursuant to the Atomic Energy Control Act, Atomic Energy of Canada Limited was incorporated under the Companies Act in February 1952 as a crown company. It functions in much the same way as any other company except that the shares (excluding the qualifying shares for the Directors) are held by a Minister of the Crown in trust for Her Majesty, and that it can act only as an agent of the Crown.

29. The purposes and objects of AECL, under the 1954 amendment to the Atomic Energy Control Act, are as follows:

> "To exercise and perform on behalf of the Minister, as defined in the Atomic Energy Control Act, such of the powers conferred on the said Minister by subsection (1) of section 10 of the said Act as the said Minister may from time to time direct."

Subsection (1) of section 10 of the act authorizes the Minister to undertake or cause to be undertaken researches and investigations with respect to atomic energy and, with the approval of the Governor in Council, to utilize cause to be utilized, and prepare for the utilization of atomic energy, to acquire property for these purposes, and to deal with patent rights acquired by it.

30. The "Minister" in the Atomic Energy Control Act means "the Chairman of the Committee of the Privy Council on Scientific and Industrial Research as defined in the Research Council Act or other member of the Queen's Privey Council for Canada designated by the Governor in Council as the Minister for the purposes of this Act". As you are aware, the Minister of Trade and Commerce is the Chairman of the Committee of the Privy Council on Scientific and Industrial Research to whom AECL reports. The shares of AECL are issued in the name of the Chairman of this Committee.

31. As required by the Companies Act, an annual shareholders' meeting is held for the usual purposes, including the appointment of Directors. The by-laws of the Company specify that the term of office of the Directors "shall be for two years from the meeting at which they were elected or appointed or until their successors are appointed". The Board of Directors has the full responsibility for the operation of the Company. The number of Directors is eleven, and the present directors are—

J. S. Duncan, Chairman, The Hydro-Electric Power Commission of Ontario, Toronto, Ontario.

G. A. Gaherty, President, Calgary Power Limited, Calgary, Alberta.

A. R. Gordon, Head, Department of Graduate Studies, University of Toronto, Toronto, Ontario.

J. L. Gray, President, Atomic Energy of Canada Limited, Ottawa, Ontario.

R. L. Hearn, Consulting Engineer, Queenston, Ontario.

L. L. O'Sullivan, Commissioner, Quebec Hydro-Electric Power Commission, Montreal, P.Q.

C. S. Parsons, Consulting Engineer, Wolfville, N.S.

G. M. Shrum, Head, Department of Physics, University of British Columbia, Vancouver, B.C.

D. M. Stephens, Chairman and General Manager, The Manitoba Hydro-Electric Board, Winnipeg, Manitoba.

James Stewart, Director, Canadian Bank of Commerce, Toronto, Ontario.

F. C. Wallace, President, Canadian Pittsburgh Industries Limited, Toronto, Ontario.

32. You will see that the Directors represent varied walks of life and that they come from all parts of Canada.

33. Meetings of the board are held about four times a year, but an Executive Committee of the Board which consists of G. A. Gaherty, A. R. Gordon, J. L. Gray and R. L. Hearn meets about every four to six weeks.

34. The organization of AECL can best be seen from the organization chart appended to this report.

35. You will note that the various segments of the company are organized as divisions. The research and development divisions report to a Vice-President of the Company, Dr. W. B. Lewis. The reactor operations, general design and plant services report to the Works Manager, Mr. R. F. Wright. The other divisions report directly to the President. Details of size and classification of staff and division responsibilities and programs are given in the appended reports.

36. While AECL receives revenue from its operations, nevertheless it is largely dependent on Parliamentary appropriations. Moneys received from parliament fall into four categories or funds—

(a) Research Operations—The net cost of operating the research and development program and the supporting services.

(b) Research Capital—Buildings, works and equipment required to carry out the research program.

(c) Fundable Capital—Expenditures on assets which are expected to have an earning capicity (such as housing at Deep River and part of the cost of the NRU reactor).

(d) Working Capital—Fund for inventories of materials and equipment manufactured for sale.

37. Expenditures made under categories (a) and (b) are written off the Company books, with memorandum accounts maintained for the research capital items. Shares of capital stock or other obligations of the Company (such as interest-bearing notes) are issued annually for expenditures made under categories (c) and (d).

38. Estimates are prepared each year for the anticipated funds required for the following fiscal year and are submitted to the Board of Directors. After the Board of Directors has thoroughly reviewed the estimates and arrived at an agreed program, they are submitted to the Minister. He, in turn, after approval, passes them to the Treasury Board. The estimates of AECL are reviewed by the Treasury Board along with its annual review of government departments and other federal agencies and corporations. AECL estimates are included in the annual "Blue Book" and in due course are presented to Parliament for approval.

39. After the AECL annual budget has been approved, the Board of Directors has the responsibility for the administration of the funds. All capital items in excess of $5,000 are referred to the Board of Directors for individual consideration and approval.

40. The accounting system in effect in AECL is organized on industrial lines—for example, monthly financial statements are prepared, comparing expenditures made against prepared monthly budgets.

41. The financial operations of AECL are audited by the Auditor General of Canada.

42. Turning now to personnel matters, as of March 31, 1960, there were 2,712 persons on the AECL payroll. Of these, 518 were professional staff, 997 non-professional salaried staff, and 1,197 hourly-rate employees. The distribution by location was as follows:

	Professional	Non-Professional	Hourly Rate	Total
Head Office, Ottawa	4	4	—	8
Chalk River	413	825	1,123	2,361
Nuclear Power Plant Division, Toronto	49	55	—	104
Commercial Products Division, Ottawa	52	113	74	239
Totals	518	997	1,197	2,712

43. The general conditions of service for the professional and non-professional salaried staff are similar to those in the National Research Council. No substantial changes were made either at the time AECL separated from the National Research Council in 1952 or have been made since then. Close

touch is maintained with the National Research Council, the Defence Research Board and the Civil Service Commission on personnel matters. The Vice-President (Administration) of the National Research Council is a member of the Committee which reviews the salaries of AECL Research Division professional staff and which approves recommended promotions and new appointments.

44. The technicians, draftsmen and the hourly-rate employees at Chalk River are unionized and their conditions of service are agreed upon by collective bargaining. The Agreements now in effect are:—

(a) AECL and the Chalk River Technicians and Technologists, Local 1568 of the Canadian Labour Congress, for the period June 1st, 1960 to May 31, 1961.

(b) AECL and the Chalk River Atomic Energy Draftsmen, Local 1569 of the Canadian Labour Congress, for the period June 1, 1960, to September 30, 1961.

(c) AECL and the several Unions listed in the agreement with the Atomic Energy Allied Council AFL-CIO and CLC, for the period April 1, 1959, to March 31, 1961. (This agreement covers all the hourly-rate Unions at Chalk River.)

The Commercial Products Division in Ottawa has a separate union agreement with its hourly-rate employees. It is between the Commercial Products Division of AECL an dthe Ottawa Atomic Workers Union, Local 1541 of the Canadian Labour Congress, for the period April 1, 1959, to March 31, 1961.

45. While we have the usual differences of opinion over the bargaining table, I am glad to say that our relations with all these Unions have been cordial and there is much evidence of mutual respect and harmony.

The Facilities of AECL to Meet the Objectives

46. Reference has already been made to three experimental reactors at Chalk River—ZEEP, NRX and NRU. We have in addition two small experimental reactors at Chalk River—the Pool Test Reactor (PTR) and the ZED-2. You will be able to see all these reactors during your visit to Chalk River and to learn more about how they are used. Further details are also given in the appendices.

47. While much of the research at Chalk River is centred around the reactors, other major equipments are needed to round out the program, particularly in fundamental physics. A Van de Graaff Accelerator has been in operation at Chalk River for many years and recently a large Tandem Accelerator of 10 MeV has been installed. This machine, the first of its kind in the world, was built by High Voltage Engineering Corporation of Boston under an AECL contract. It has been so successful in its initial operation that about a dozen have been built or ordered by other research centres throughout the world. Last year a new Beta Ray Spectrometer of Chalk River design was also put into operation. This was built for us by Canadair Ltd.

48. We have many special facilities at Chalk River which are complementary to the reactors and the large research machines. For example, there are the "hot cells" and "caves" which are used for examining very highly radioactive materials such as irradiated fuel. Special mention should be made of what are known as "loops". There are seven of these in the NRX reactor and two in the NRU reactor. These loops are of great value in the atomic power research and development program. Tubes are inserted through the reactor core, and coolants at high temperature and pressure are passed along these tubes over experimental or prototype reactor fuel contained in the

tubes. In this way, conditions are produced which are the same as those which would be found in a power reactor. In other words, we have a section of a power reactor within a research reactor. Out-of-reactor tests using the desired temperatures, pressures, coolant flow and fuel design can be and are, of course, made, but only by doing these tests in a facility inside the reactor can we simulate the real conditions of an intense radiation field. These loops are much in demand and carefully planed programs are necessary to ensure maximum benefits from the equipment. The USAEC and the UKAEA have been accommodated as partners in the use of some of these facilities for some years. You may be interested to know that the fuel elements for the Nautilus and for the PWR power station at Shippingport were tested and, to a large degree, developed through the use of Chalk River loop facilities.

49. AECL has excellent facilities for the production and processing of a wide range of isotopes. The Chalk River reactors, coupled with the high intensity "cave" facilities, enable the production and handling of high quality material. We do not, however, process our spent fuel from the reactors and therefore do not have the radioactive isotopes from the residues, known as fission products, from such a process. We have the knowledge to carry out the necessary chemical separation processes and, in fact, operated such a plant for a number of years. This work has been discontinued on economic grounds and the isotopes needed which come from fission products are supplied through arrangements with the US or the UK.

50. Our Commercial Products Division in Ottawa has excellent laboratory facilities for certain specialized operations on isotopes, including radium-handling facilities.

51. Last summer the Directors and management of AECL considered the long-range expansion of research and development in the field of atomic energy. If Canada is to maintain its position as one of the leading atomic energy nations, a gradual but steady expansion of the research and development effort must take place. In about fifteen years Chalk River has expanded to approximately 2,400 workers and many major facilities, including research reactors, have been built. Over the next couple of decades it may be anticipated that several new major research and development facilities will be needed.

52. A research and development centre cannot expand indefinitely without loss of efficiency. It can become too large for effective administration. It can have too much in the way of equipment and facilities for efficient operation. While no precise figure can be given on the maximum desired size, there are indications that Chalk River is approaching the point where further additions of major items of equipment would be unwise.

53. With these long-range considerations in mind, the Directors and management of AECL recommended to the Government that we should not continue to expand Chalk River and that a new site should be selected at which future expansion could take place. On October 1, 1959, the Minister announced the Government's decision to commence planning for this new nuclear energy research and development centre in Manitoba. It is expected that the next major project by AECL may be an organic-cooled, natural-uranium-fuelled, heavy-water-moderated reactor experiment. Such a project would be the first major facility for the new site and would tend to set the early pattern of the program for this establishment. It is expected that over the coming years the new centre, known as the Whiteshell Nuclear Research Establishment, will expand into a major nuclear energy centre. The growth of such a centre in Manitoba will assist in the general scientific and technical development of Western Canada.

The Place of Atomic Power in Canada

54. As is well known, Canada has large untapped hydro resources and an abundance of low cost fossil fuels. If the total estimated demand for energy in Canada is compared to the total estimated reserves of hydro and of fossil fuels, it might be concluded that the conventional sources of energy are adequate to supply all of Canada's energy requirements for many years to come. However, these resources are not evenly distributed across the country, nor are they all located near regions of probable high energy demand. The regions which have exhausted their hydro resources and have no indigenous supplies of conventional thermal fuels will be forced to import fossil fuels unless an alternative source of energy is available at an acceptable cost. Atomic energy is such an alternative source and it will be used when its reliability and costs are established. Atomic stations should introduce a new ceiling on power costs and, under some circumstances, will reverse the trend of the ever-increasing cost of electric power. There is the possibility that atomic energy may provide a source of power to remote regions where the transportation cost of conventional fuels adds significantly to the price or creates logistic problems.

55. The rate of increase in the world demand for electricity has averaged about 7 per cent per year for several decades now, and this rate is expected to continue. In North America, where we already consume nearly half of the world's electricity, the continuing growth in demand shows no evidence of slowing down. As a practical example, the Ontario system is expected to have an annual rate of increase of over 6 per cent up until 1980. The result of this rate of increase can perhaps be seen more clearly in terms of capacity doubling time; a system that is increasing at 7 per cent per year will double in size in ten years. Considering all the power plants we have in Canada today, the task of adding an equivalent capacity in ten years looms quite large. To double again by, say, 1980 seems nearly unbelievable. However, there seems to be no doubt that this will happen and any source of power that is economical and reliable will find a rapidly increasing demand.

56. The best hydro-electric sites and the lowest cost fossil fuels will naturally be used first. Then new hydro-electric stations will have to be built farther away from the centres of demand and transmission lines will raise the cost of power. New thermal generating stations will depend on fuels which, of necessity, will increase in price as more uneconomical seams have to be mined, fewer wells are discovered, and transportation costs go up. The inescapable conclusion is that in the long run electric power from conventional sources will gradually increase in real cost.

57. In Ontario, the major hydraulic power sites have already been developed and Ontario Hydro has now to turn mainly to thermal power to meet the future demand. By 1980, the Hydro-Electric Power Commission of Ontario expects to have at least 20 million kilowatts installed capacity compared to the 6 million kilowatts capacity it has today. Of this 20 million kilowatts, 6 million kilowatts will be hydro electric and the remaining 14 million kilowatts will come from conventional thermal or other sources.

58. This, then, is the background, the circumstances, in which atomic power has to be considered. It is now well established that electricity can be produced from nuclear power plants. The continuing demand for more and more electric power is realized without question. The big uncertainty is the cost of nuclear power. No nuclear power station has yet been built which produces electricity as cheaply as that produced from conventional stations. Capital costs per kilowatt are decreasing as nuclear stations of the same basic design are

built successively, as demonstrated in the UK, and nuclear fuel costs are coming down as experience is gained in manufacture and in use at higher ratings. Evidence from design, development and actual plant construction all point to nuclear units being competitive under certain specific conditions.

59. Taking the long view, the costs of power from conventional power plants is going to rise. Nuclear power costs to date are relatively high, but they will be coming down owing to the scientific and engineering advances which accompany the early stages of a new technological development. At some time the two cost trends will cross and nuclear power will be cheaper than conventional power from the higher cost fossil fuels. Very few, if any, deny this. The difference between the optimists and the pessimists is the date they consider this cross-over will take place.

60. The cross-over will, of course, vary in different circumstances. It will be different in different countries, in different regions of the same country, for different size stations, and it will depend on the many cost elements which make up the cost of power produced. A careful analysis will have to be made in each individual case.

The Canadian Atomic Power Program

61. At this stage of atomic power development in Canada, practically all of the effort that is going into the design and construction of nuclear plants is wholly supported by the Federal Government. There has been a relatively small amount of effort by private engineering firms and some of the manufacturers in the area of preliminary design. However, this work has not advanced beyond design studies. In the development of any new technology such as nuclear power where there are so many unknowns and the costs are so high, it has been the normal practice in Canada for the Federal Government to pay the great majority of the initial costs. This situation will, of course, change and before long consulting engineering firms will be working with manufacturers to propose complete designs of nuclear power stations to meet the demands of utilities.

62. AECL has felt a prime responsibility for developing a nuclear system that will meet the general requirements of Canadian utilities. We were not in this business very long before we realized that it is very unlikely that a particular design of plant will be applicable to all utility systems because of the large differences in their character and conditions. The method of financing, the size of the system, the availability and cost of other power sources are some of the factors that must be very carefully assessed in deciding which type of nuclear plant might be applicable.

63. The AECL program, in addition to general development work at Chalk River, consists of four specific power reactor projects—NPD-2, the nuclear power demonstration station; the Douglas Point Generating Station, which includes the CANDU reactor; an organic-cooled heavy-water-moderated reactor experiment (OCDRE); and the study of small nuclear power units for possible application in remote regions.

64. NPD-2 and the Douglas Point Generating Station can be considered together, as they form the program directed towards the development of economic large stations, 200,000 kilowatts electric and up.

65. NPD-2, with an output of 20,000 kilowatts electric, is the prototype for larger stations. It is now under construction at Rolphton, Ontario, and is expected to be operating by midsummer 1961. It is a joint undertaking by Atomic Energy of Canada Limited, The Hydro-Electric Power Commission of Ontario and The Canadian General Electric Company Limited. AECL is responsible for the cost of the nuclear portion of the station, Ontario Hydro is responsible for the conventional power plant and will operate the plant when

it is completed, and Canadian General Electric is responsible for the detailed design and construction of the complete station and has contributed $2 million towards the cost of design and development. This station will not produce economical electric power. It is expected, however, to demonstrate the reliability of operation of this type of system, the economics of the fuel cycle, and it will provide training for operators.

66. The Douglas Point station will be Canada's first full-scale power plant, of 200,000 kilowatts electric capacity. Design and development of this project is well under way, the site is selected, and initial construction work is just starting. It is scheduled for completion in mid-1964 with full operation later in that year. AECL will own the complete station. It will be operated by Ontario Hydro staff, and the power output will be purchased by Ontario Hydro on the basis of an agreed formula. When the plant has demonstrated that it can be successfully operated in the Ontario Hydro system—estimated at three years—Hydro is committed to purchase the complete station at a price that will allow them to continue generation of electricity at the same cost as thought they were operating a modern coal-fired plant.

67. The OCDRE reactor project is being undertaken with the object of meeting the requirements of the smaller utilities where units of 50,000 to 150,000 kilowatts electric are more suitable. The use of an organic liquid in the place of heavy water as the cooling or heat-transfer medium offers major savings in capital cost, since it is a low-pressure, high-temperature system. The pressure components in the reactor need not be so robust and better heat rates may be achieved in the heat exchangers and turbines, giving generally higher plant efficiencies in operation. The present status of this project consists of a contract with the Canadian General Electric Co. Ltd. for a phase of development work coupled with preliminary designs. Concurrent with this work is a very active program in the chemical engineering and metallurgical groups at Chalk River directed towards a better understanding of the organic materials being considered as a coolant. The Company expects a report in August of this year which should indicate the course of work for the next phase. The report may recommend the approval of a specific reactor project. If the management and Directors are satisfied, they will recommend to the Government that the OCDRE project be approved and that it be located at the Whiteshell Nuclear Research Establishment as the first piece of major equipment. Final design could start in the spring of 1961 and initial field work in the summer or fall of 1962.

68. The work on the very small units for possible applications in remote sites has been primarily in the form of a study of the very large amount of existing data that is available in the United States. A contract has been issued to the Canadian Westinghouse Company to review all the pertinent information, which was made freely available by the USAEC, on these small enriched systems such as the "Army Package Power Reactor" and to make a detailed assessment as to the application of such systems in the Canadian North. Northern establishments are on the small side with respect to the efficient utilization of a nuclear plant. A specific analysis was made of the Frobisher Bay site and it was concluded that the installation of a nuclear plant would probably increase the cost of power for both generation of electricity and heat by about 25 per cent. As establishments in the North increase in size or load demand, or if the cost of fuel oil is substantially increased, we can expect considerable interest in the possible application of a nuclear plant.

69. It must be evident to the Committee members that AECL has placed major emphasis on power reactors moderated with heavy water. There are two fundamental reasons for this. It is the system which we know most about and about which we are in a position to have very valid opinions. What is more

important, we are absolutely convinced that it is the best system for the particular requirements in Canada at this time.

70. We are not blind to other nuclear power systems nor do we suggest that other systems will not be more successful than the heavy-water plants for other applications. There is nothing really mysterious about the application of atomic energy and I am convinced that any one of several different basic systems could be developed into a good working nuclear power unit by a strong group including scientists, engineers and industry, with ten years' work and with the expenditure of perhaps $100 million. Whether such a technically sound unit is economically attractive or not is another matter. Many new reactor concepts have been proposed and have been studied to various levels by our staff. To date, we have always found, after analysis, that the CANDU system is superior for today's conditions in Canada.

71. There is one aspect of the basic approach to power reactor systems that AECL emphasizes much more than many other organizations, and that is the value of the neutron. We believe that the neutron is extremely important in a nuclear system; for every one that is lost or captured, another atom of fissile material must be supplied. Heavy water is so much better than other moderating materials that it gives those working with this system a great advantage in the scientific or nuclear aspects of the design. To give you some feel for the relative merits of the normal materials used for moderators, there is a term called "moderating ratio"* which is an indication of the efficiency of the material, and the larger the number the better the material. Ordinary water has a "moderating ratio" of 72, beryllium has a "moderating ratio" of 159, the figure for graphite is 170, and for heavy water the "moderating ratio" is 12,000.

72. I think it is to our credit that we have taken a slightly different attitude towards reactor systems. Recognizing the importance of neutrons and having available to us such an excellent moderator, we are able to burn natural uranium in the large systems to such a high burn-up that the spent fuel may be discarded as waste. This has several important advantages in addition to competitive power cost. Natural uranium is now in abundant supply and is found in many parts of the world. Users may confidently expect the price to drop substantially in the next few years and the availability, even for importing nations, is assured. It will be unnecessary to rely on one or two sources as in the case of enriched uranium. Nuclear systems that cannot, economically, "throw away" spent fuel must face a fuel reprocessing step or arrange for such reprocessing under contract. Chemical processing of highly radioactive fuel and subsequent stockpiling of plutonium, re-enriching the downgraded uranium and disposing of the highly radioactive waste fission products not only add complications to the nuclear power system but can add significantly to the cost. The value of an inventory of plutonium alone can amount up to significant figures in a nuclear power complex, and carrying charges will continually grow until an economic plutonium-burning nuclear system is developed. This is not yet in evidence. I do not think there is any disagreement around the world that a natural uranium system that can be competitive with other sources and throw away spent fuel would be preferred over all other thermal reactors.

Co-operation with Other Countries

73. By the end of the first United Nations Conference on the Peaceful Uses of Atomic Energy held in Geneva in August 1955 almost all the atomic

* "Moderating ratio" is a number arrived at by a calculation involving scattering cross section, absorption cross section and the energy of neutrons before and after collision with the element being considered.

energy information relating to the peaceful uses had become classified. Essentially all the work of AECL is now free of security wraps. As a result, reports on technical work can be published and the program can be discussed with scientists and engineers of other countries.

74. There has been close and harmonious co-operation with the United Kingdom right from the early days. Frank discussions have continuously taken place between the staffs of AECL and the UK Atomic Energy Authority. This has been invaluable to Canada and I am sure has been equally appreciated by the UK. We have had the benefit of the inside story of the UK program and their scientific results. I should mention, in particular, the annual UK-Canada Technical Policy Conference which is held alternatively in the UK and Canada.

75. In India, as you are aware, the CIR (Canada-India Reactor) has been built at Trombay near Bombay under the aegis of the Colombo Plan. The reactor is modelled on the NRX reactor at Chalk River but modified to meet Indian conditions of cooling water and to include improvements based on NRX experience. AECL accepted the responsibility for this project and appointed the Foundation Company of Canada as the contractor and Shawinigan Engineering Company as the engineeer. The reactor is expected to start operating in two weeks under the direction and responsibility of AECL operators. AECL staff will continue to operate this reactor until it is up to power and all parties are satisfied that it should be turned over to the Indian staff. About forty Indian scientists, engineers and operators have been trained at Chalk River as part of the joint program. Dr. Homi Bhabha, head of the Indian Department of Atomic Energy, has on several occasions pointed with pride to this joint project, which he describes as the world's largest and most important international project in the peaceful uses of atomic energy.

76. The CIR will provide unique facilities for scientists and engineers in India and other countries, including the Colombo Plan countries in South-East Asia, to gain experience in atomic energy technology.

77. Canada has also been fortunate in its close collaboration with the United States since the war years. While the US Atomic Energy Act of 1946 limited the co-operation, a satisfactory modus operandi was worked out. The amendment of the US Act in 1954 opened the door to increased co-operation, and a bilateral agreement covering the civil uses of atomic energy was signed between Canada and the United States in June 1956.

78. Through our close contacts with the United States we have obtained full information on the US nuclear power program and have been able to study the technical aspects and the cost picture. Recently the USAEC has become increasingly interested in the natural-uranium heavy-water type of power reactor system and a Memorandum of Understanding has been signed between AECL and the USAEC covering the development of heavy-water-moderated power reactors. As a measure of its interest, the USAEC is undertaking to spend an additional $5 million on research and development work. This program of work is specifically directed towards the heavy-water power reactors to be constructed in Canada.

79. In the last five years there has been growing co-operation between AECL and the atomic energy research organizations in other countries. Particular reference may be made to the co-operation with Australia, France, India, Japan, Sweden, Switzerland and West Germany.

80. The International Atomic Energy Agency was established in 1956 and has its headquarters in Vienna. Its objectives are to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world and to ensure, so far as it is able, that its assistance is not used

to further any military purpose. AECL has been providing technical information as requested by the Agency Secretariat and has released two of its senior staff members to be directors of IAEA Divisions. AECL experts have also participated in many technical panels and symposia that the Agency has organized.

81. The secretary general of the United Nations has a U.N. Scientific Advisory Committee of seven leading scientists of international repute. AECL is honoured by having Dr. W. B. Lewis, vice-president, research and development, as Canada's member of this committee. I should mention that this committee was responsible for the first Geneva Conference in 1955 and also for the second conference which was held in 1958—also at Geneva. At this second conference some 7,000 persons attended, and there were 77 Conference sessions at which 714 papers were read. Forty-seven papers from Canada and two jointly with India were accepted and, of these, 24 papers were presented orally. AECL presented 15 of these oral papers. The proceedings of the conference have now been published in 33 volumes.

82. Six countries in Western Europe—Italy, France, West Germany, Belgium, the Netherlands and Luxembourg—have joined together as an organization known as Euratom, to promote a joint programme of nuclear energy, research and development. The Euratom programme is in addition to the national programmes of the countries concerned. Last October a bilateral agreement was signed bteween Canada and Euratom and a technical agreement was also signed between AECL and Euratom covering a joint programme of research and development in heavy water power reactors. Under this agreement AECL and Euratom will each spend up to $5 million over the next five years. The AECL contribution will be from its present programme and will be spent in Canada. Similarly, Euratom expenditures will be made in the Euratom countries. A joint Technical Board has been formed to formulate the detailed plans for co-operation and to review the work undertaken.

83. During 1959 approximately 1,700 technical staff visited Chalk River. We also have (May 1960) 78 attached staff stationed at Chalk River, 19 of these from Canada, 10 from the United Kingdom, 14 from the United States, and the remaining 35 from other countries. In addition, there are 25 staff attached to the Nuclear Power Plant Division in Toronto, 21 from Canada and 4 from other countries. While we recognize the desire of many experts from mother countries to work at AECL and are glad to accept as many as we can fit in, nevertheless we are near the saturation point and have had to limit the total number of attached staff to approximately the present level.

84. We exchange large numbers of technical reports with the United States and the United Kingdom and have established exchanges of technical literature with 30 other countries, prominent amongst which are France, Germany, Sweden and Italy. These exchanges are either with government agencies or with the principal atomic energy laboratories in the country. Several Iron Curtain countries are included.

85. The establishment of the Reactor School at Chalk River has opened another means of providing training in reactor technology to foreign students, as well as to Canadians.

Radiation Safety, Reactor Safety and Waste Management

86. We all know that radioactivity can be hazardous. This is particularly true as the presence of radioactivity cannot be detected by any of the five human senses. However, we are fortunate that instruments to detect radioactivity are extremely sensitive and the merest traces can be detected and measured. Thus, radioactivity can be measured at levels far below those which constitute any hazard.

87. Radioactive emanations are of four kinds—alpha rays, beta rays, gamma rays and neutrons—and a radioactive substance may emit one or more of these radiations at the same time. These different emanations have different properties. For example, alpha rays can be stopped by a thin piece of paper while gamma rays and neutrons penetrate inches of lead. Hence, if a radiation source is outside the body, a person can be protected from alpha rays by the wearing of suitable clothing and gloves, while greater protection, such as a wall of lead or concrete, is required to afford protection from gamma rays. On the other hand, it is quite a different story if radioactive material is taken into the body by breathing it into the lungs, swallowing it or absorbing it through the skin. When the radioactive material gets inside the body, the cells surrounding it will be constantly irradiated so long as it remains there. One of the main precautions, therefore, when working with radioactive material is to ensure that it is not ingested. For example, smoking or eating is not permitted in areas that could become contaminated. If airborne radioactive dust is present, gas masks must be worn. Workers are required to wear special clothing when handling radioactive materials in large quantities, and to remove this clothing and to wash thoroughly before leaving the working area.

88. There are several hundred different types of radioactive material, and each has different properties. Some decay in a matter of seconds, while others remain radioactive for thousands of years. Some have more intense radiations than others. Some radioactive materials are poorly absorbed by the body and are quickly excreted. The most dangerous materials are those which tend to concentrate in critical regions of the body. trontium-90, for example, is particularly dangerous, as it tends to become lodged in bones and causes damage to bone cells and to the blood-forming cells in the bone marrow.

89. Three quite distinct biological effects of radioactivity have therefore to be considered.

(a) The effects of an external source of radiation on a person himself.

(b) The effect of an external source of radiation on a person's reproductive tissues which might thereby cause genetic changes in future generations.

(c) The effects of an internal source of radiation that has been ingested into a person's body.

90. These hazards have been recognized and studied for many years, since the dangers of working with radium were learned at the beginning of the century. In 1928 an International Commission on Radiological Protection (ICRP) was established to consider the problem and to recommend radiation safety standards. Canada, along with most other countries, bases its regulations and practices for radiation safety on ICRP recommendations. Tolerances have been set for acceptable concentrations of all radioactive materials and limits established on the acceptable amount of radiation which can be received. The established radiation limit for an occupational worker in atomic energy is 5 roentgens per year averaged over his working lifetime. At AECL we do not permit a worker to receive more than 5 roentgens in any one year. For the general population the limit is 5 roentgens per person in 30 years averaged over the whole population.

91. How safe are these ICRP standards? It is not possible by clinical tests to discover any change in the bodies of persons exposed to as much as 25 roentgens in a single dose. It is therefore reasonably certain that the hazard to a person exposed to only 5 roentgens spread over a year is small compared with the hazards of conventional industry. There may be no risk whatever for the individual who receives 5 roentgens per year but until follow-up studies

have been carried out on an appropriate scale and over a long period it is impossible to distinguish between a very small risk and no risk at all.

92. The recommendations to limit future population exposures to an average of 5 roentgens per person per generation (30 years) is based on genetic considerations. As far as we know, hereditary changes are induced in direct proportion to the total dose received by the population. Implicit in this is the conclusion that even small doses will have some genetic effects. It is obvious, therefore, that this recommendation involves a compromise between deleterious effects and expected benefits. The ICRP states—"Furthermore, it must be realized that the factors influencing the balancing of risks and benefits will vary from country to country and that the final decision rests with each country."

93. Let us look, therefore, at the amount of radiation to which the population of Canada is exposed as a result of the operations of AECL. The fact that the maximum permissible exposure to radiation at AECL is 5 roentgens per year does not mean that every employee receives this annual dose. In 1959, for example, of the 2,400 employees at Chalk River half received no radiation at all and the average individual dose was 0.7 roentgens. When this is averaged over the whole population of Canada, it is equivalent to about 0.1 milliroentgens (one milliroentgen equals one thousandth of a roentgen) per individual per year. This may be compared with some other radiation exposures received by the whole population:

Source	*Milliroentgens per year*
Natural background	100
Medical X-rays	100
Luminous watch dials	1
Present fall-out	2
Contributed to Canada by AECL	0.1
Maximum recommended by ICRP for population (exclusive of background and medical uses)	167

It is obvious from this table that the atomic energy industry in Canada is making a negligible contribution to the direct irradiation of the population.

94. The other way in which an atomic energy installation may cause the public to be exposed to radiation is through dispersal of radioactive wastes into public waters or into the air. Procedures and regulations for the disposal of all solid and liquid wastes from AECL operations are described in the report of the Biology and Health Physics Division, attached as Appendix 5. No radioactive solids are put into the Ottawa River and no liquids are released with concentrations of radionuclides greater than the maximum permissible concentration for drinking water recommended by the ICRP for occupational workers. The most recent analyses of Ottawa River water show that upstream from the Chalk River plant (at Deep River) the concentration of Strontium-90 is one micro-micro-curie per litre, due to contamination from fall-out, and that downstream from the plant (at Pembroke) we have been unable to detect any increase over this value. In other words, the amount of Strontium-90 added to public waters in our Chalk River operations is so small as to be undetectable.

95. The Chalk River reactors, like other reactors, occasionally discharge through the stack detectable amounts of short-lived radioactive gases. The concentration of these has never yet been sufficient to constitute a health hazard. Moreover, frequent intensive searches for long-lived radioactive contamination on the ground both inside and outside the Plant area have failed to detect anything in addition to weapons fall-out.

96. You will have noticed that I have mentioned "fall-out" in three places. In looking for environmental contamination resulting from our operations, we inevitably measure radioactivity resulting from weapons testing. I should make it clear, however, that estimating levels of fall-out in Canada is a public health responsibility discharged by the Department of National Health and Welfare. Although it is not our responsibility, we frequently give technical help and advice on this subject to other government departments. In addition, several members of our staff serve on committees set up to consider problems of fall-out and radiation safety.

97. The first consideration in designing a reactor is to make it work, but equally important is the requirement that it work safely. A very great effort goes into analyzing all accidents that might conceivably result from the malfunction of any component, the breakdown of any material, or the fault of an operator, and ensuring the safety of the public and, as far as possible, the safety of the Plant.

98. The Atomic Energy Control Board at present assumes responsibility for the safety aspects of all nuclear reactors in Canada except those built at federal government sites. The AECB has set up a Reactor Safety Advisory Committee to help it discharge this function. Its members include reactor and health and safety experts from the federal and provincial health departments, from AECL, and engineers from non-government organizations.

99. When a nuclear reactor is proposed for a site other than at a federal government project, specific approval in the form of licences or permits must be obtained from the AECB before construction can start, and again before operation. The Reactor Safety Advisory Committee, in recommending on a construction permit, carefully assesses the reactor design not only as a facility but also as a facility to be built at a particular site. Similarly, the operating permit is only granted after the Committee is satisfied that the plant has been built in accordance with designs that have been accepted from the safety point of view and that properly trained operating crews are available. During subsequent operation of the plant, representatives of the Safety Committee carry out inspections to ensure that the actual procedures that are being followed are in accordance with the standard approved procedures.

100. The NPD station at Rolphton has been reviewed by the Reactor Safety Advisory Committee and a construction permit was issued. I can assure you that this review was not a casual one. A hazards evaluation report about four inches thick had first to be prepared and submitted to the Committee in July 1958, showing the detailed analyses which had been made of all the credible accidents which might occur and which had been considered. Many meetings both formal and informal have taken place since that time, and many hundreds of pages of technical reports, design analyses and safety assessments have been considered in detail.

101. While the reactors at Chalk River do not come within the purview of the Reactor Safety Advisory Committee, AECL has set up a standing committee to make similar exhaustive reviews of the safety aspects of our reactors. AECL is subject to the AECB Regulations one section of which provides that every user of radioactive material must "take all reasonable and proper precautions for the protection of persons and property against injury or damage". The Board has always regarded AECL as being responsible for ensuring the safety of its operations, and as being fully capable of discharging that responsibility.

102. One of the special problems of handling radioactivity is the disposal of radioactive waste. There is no practicable way of destroying the radioactivity. Only two courses of action are open. If the radioactive content is

very low, the waste can be diluted and dispersed; if the content is high, the waste can be concentrated and contained. I would like to emphasize, however, that the use of natural-uranium fuel in the Canadian design of heavy-water atomic power stations has great advantages over the use of enriched uranium fuel or other natural-uranium systems, from the point of view of waste management. After natural-uranium fuel has been used in a full-scale Canadian reactor, the fuel elements have been burned so efficiently that they may be withdrawn and stored under water as a waste or by-product. Spent fuel from such a plant may be accumulated over many years and safely stored in a relatively small space. This cannot be done when enriched fuel elements have been removed from a reactor—for two reasons. The first is that they have a higher content of fissile material and close packing under water might set off a chain reaction. The second is that, since they still contain substantial amounts of enriched uranium, they are far too valuable to be considered as waste. Similarly, for the graphite-moderated natural-uranium reactors in the U.K. the extent of burn-up of fuel is not sufficient to allow spent fuel to be treated as waste. It has to be removed to a chemical processing plant, dissolved, and the remaining unburned uranium separated out by chemical means for further use. By this process, all the highly radioactive fission products contained in the fuel elements end up in large volumes of solutions. The large bulk of intensely radioactive liquid presents a nasty problem in waste management.

103. AECL, in working towards economic nuclear power for Canada, makes every effort to ensure that this development will be safe both for the employees in the industry and for the public. With the establishment of good safety patterns and adequate forethought, there is every reason for confidence that we can have the benefits of nuclear power at much less risk than has been associated with undertakings of similar magnitude in the past. Usually, safety practices in other industries have come about through experience of accidents. To prevent further accidents, the industries have developed safety practices on their own initiative or have been forced to do so by government regulations. In the atomic energy field, those responsibile in Canada and in most other countries have set rigid standards at the outset in order to prevent accidents. We believe that this is the only prudent course to take. When greater knowledge and experience is gained, it might well be safe to relax the standards now in effect but no change will be made until we are absolutely sure. In fifteen years of operation the Company has not had a death or a lost-time injury due to radiation.

The CHAIRMAN: Thank you very much, Mr. Gray. This will give you some idea, gentlemen, of the interest you will find in pursuing the study of this very important project. We only have a few minutes, and I wonder if you would like to have the opportunity of asking some questions of Mr. Gray?

Mr. GRAFFTEY: Mr. Chairman, back on page 17—

The CHAIRMAN: Before you start, Mr. Grafftey: is it agreeable to the committee we have appended to the record appendices Nos. 1 to 15, including the summary of expenditure from parliamentary appropriations? Is that agreeable, gentlemen?

Agreed to.

Mr. GRAFFTEY: In section 59, sir, you say:

> At some time the two cost trends will cross and nuclear power will be cheaper than conventional power from the higher cost fossil fuels. Very few, if any, deny this. The difference between the optimists and the pessimists is the date they consider this cross-over will take place.

60. The cross-over will, of course, vary in different circumstances. Could you give us a general idea of the opinions expressed by the optimists and pessimists in this regard? What is the year figure?

Mr. GRAY: I think the real optimists probably say in 1965. In England, where they have a real knowledge of the subject, they are saying, before 1970. I think you would have to be a real pessimist to say that it would be much later than 1970 before you would find nuclear power economic under certain conditions, particularly in the U.K. and the Ontario hydro system.

Mr. GRAFFTEY: What are these considerations, in general outline?

Mr. GRAY: These are high capital cost stations, so where you have a public utility that can absorb large units of power—200, 300, 400 megawatts—that will be where nuclear power will be economic first.

Mr. GRAFFTEY: In large population areas?

Mr. GRAY: Yes, in large population areas.

The CHAIRMAN: Would you tell the committee what cooperation Canada gets from the iron curtain countries in this project? You have had two conferences in Geneva, and I believe they have presented papers?

Mr. GRAY: Yes, they have presented papers; and we have quite an extensive exchange of documents, including Russia and Czechoslovakia.

The CHAIRMAN: But a good deal of information is still classified by them?

Mr. GRAY: It is not classified, but it is just not made available.

The CHAIRMAN: That is what I meant.

Mr. GRAY: I have just come back from a trip to Russia, and they showed us all over their two nuclear power stations which are under construction, and answered all the reasonable questions we asked. So I would think there may be a tendancy to cooperate a little more, certainly in the field of atomic power. They are using enriched fuel on their two reactors; but they are building in Czechoslovakia a reactor of 150 megawatts, which is very much like the N.P.D.-2, using heavy water as the moderator and coolant in the reactor.

Mr. BEST: Has Mr. Gray ever been consulted or had inquiries from the Premier of Newfoundland with regard to his getting extra information from Russia on sources of power, regarding the development down there?

Mr. GRAY: No, we have had no inquiries from Newfoundland.

Mr. BEST: You have been travelling in recent weeks in Russia and, perhaps, Europe as well—France?

Mr. GRAY: Yes, my most recent trip was just to Russia, but in May I did a trip which took in England, West Germany and France.

Mr. BEST: Could you tell us as a general question, how you feel Canada's relative position in the atomic energy field is at this time—in the peaceful uses of atomic power; or what are the relative positions? Is our position improving, or are other countries gaining on us?

Mr. GRAY: I think it is very good. As far as the approach to economic power is concerned, I think that probably we are ahead of the United States, because we have a large public utility to work with, the Ontario hydro. In the U.K. they are definitely ahead of us. They have large stations under construction, which are not yet running, but they will have stations running in 1961 or 1962 which will be similar in size to our big Douglas Point station. Germany is away behind us, but they are doing good research work, and we have very good cooperation and collaboration with German labs. France is perhaps a little ahead of us. They have experienced some difficulties of construction—not nuclear difficulties, but mere construction difficulties. They have a very active program on the development of nuclear power in France. I think it is more a prestige program than a requirement, but they have some good work going on.

Mr. BEST: I gather that in recent years France, particularly, has pushed the industrial, peaceful development of atomic energy?

Mr. GRAY: Yes.

Mr. BOURGET: On page 17 you say:

> At this stage of atomic power development in Canada, practically all of the effort that is going into the design and construction of nuclear plants is wholly supported by the federal government. There has been a relatively small amount of effort by private engineering firms and some of the manufacturers in the area of preliminary design.

Does the same situation exist in the United States, or there do the manufacturers and the engineers show more interest?

Mr. GRAY: The manufacturers and engineers are more interested and more into this in the United States than they are here. The government is involved, to some extent, in practically all stations. I think there are two where they are not, but in practically all other stations the government is paying for at least the research and development cost, and in some cases they are paying the whole cost. But I think that in the United States the industry and engineering consultants are much more active or, at least, have much more money invested than in Canada.

Mr. BOURGET: Are Canadian manufacturers showing more interest here than they were a few years ago?

Mr. GRAY: They are showing a great deal of interest, so long as we support their program. We have some excellent teams being built up in Canadian industry now; they are pretty well fully employed, I would say.

Mr. BOURGET: Thank you.

Mr. GRAY: In the appendix here, the one on nuclear power plant division, there are the estimates. This is appendix 10. That appendix contains the estimates for the Douglas Point station which, I think, when you have some leisure time, you might find interesting reading.

Mr. MACLELLAN: As regards the Douglas Point station, there is one thing I do not quite understand here. You say: the optimists say it will be economic by 1965 and the pessimists by 1970. Yet on page 18 you suggest that after the Douglas Point station is built the Ontario Hydro will buy it when it has demonstrated that it can be successfully operated—estimated at 3 years. You say that they would be buying it at a price which would allow them to produce power which would be competitive with the price of coal power. Are you suggesting that in three years' time this station will be producing it at the same cost as coal produced power?

Mr. GRAY: The fueling costs will be at a much lower price than coal and, therefore, they will be able to operate the plant at a much lower cost than a similar coal-fired plant. But the capital costs are higher. The government will be absorbing the extra capital cost which will be charged up as research and development.

Mr. MACLELLAN: This Douglas Point station will be built at federal cost?

Mr. GRAY: Yes.

Mr. MACLELLAN: And as far as Ontario Hydro buying it is concerned, I would presume that in the agreement the capital cost would be included. Do you mean to say they are not going to buy it until such time as the cost, including capital cost, will show the same cost of producing power as if coal were burned?

Mr. GRAY: To use very rounded out figures, it will cost $80 million—that is the first one off—you could have the second, say, for $60 million. I would expect that Ontario Hydro could pay us something like $60 million and not pay the full $80 million. So that $20 million is really for research and development, including manufacturing development. That will all come out in the formula for costs.

Mr. MACLELLAN: In other words, Ontario Hydro will pay the price they would ordinarily pay for a coal plant to produce the same amount of electricity?

Mr. GRAY: No, they will pay a price that will allow them to produce power at, say 5.5 mills per kilowatt/hour. The fuel cost for power generated from coal is something like 3 to 3½ mills per kwhr. The fuel cost for Douglas Point will be about one mill per kwhr. Therefore, they will be able to pay more towards capital cost for this plant than the cost of a coal-fired plant.

Mr. MACLELLAN: What is the difference in capital cost to produce 200,000—

The CHAIRMAN: It is just a minute before 11, Mr. MacLellan, and I know you are interested in this subject; and I am glad to have you ask questions of Mr. Gray. However, as it is nearly 11, some of us may want to go to our offices before going into the house.

Mr. Gray, again, and your officials, thank you. We look forward to seeing you next January. Would you have enough copies of your brief to leave with the clerk, so that he can give them to the other members of the committee?

Mr. GRAY: Yes.

The CHAIRMAN: As I said before, Mr. Forgie, we will try to have a meeting on Monday of the steering committee and, if by chance the two members appointed are not available, you are authorized to substitute.

APPENDICES

Appendix 1	Nuclear Power Possibilities for Canada by W. B. Lewis, Vice-President, Research and Development
Appendix 2	Physics Division
Appendix 3	Reactor Research and Development Division
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Appendix 5	Biology and Health Physics Division
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NUCLEAR POWER POSSIBILITIES FOR CANADA

W. B. Lewis
Vice President - Research and Development

Introductory Survey

1.1 As the available hydro power is nearly all harnessed, the highly industrialized province of Ontario is taking the same course as some others such as Alberta and Manitoba in building large steam plants for electric power. The established close relation between the demand for electric power and the gross national product produces a measure of agreement between all forecasts that in the next twenty years the new generating capacity to be installed will be between 1.5 and 3.5 times the total generating capacity now existing.

1.2 It is generally agreed that a significant part of this vast new capacity throughout the whole country will be based on nuclear energy in addition to many new plants using water power, coal, oil and natural gas.

1.3 It is still difficult to forecast the exact course of development because conditions in the world change rapidly and the economic choice of plant type involves many factors such as current interest rates on money, forecast interest rates over the life of the plant, and the possible course of inflation that tends to favour plants such as water power and nuclear plants that have low operating cost. At the same time technological development has not reached comparable stages in the competing fields. For example, only relatively small gas turbines are yet in service and as yet no nuclear power plants.

1.4 It may, however, be helpful to recall the scales envisaged in past forecasts and to review the technological state of nuclear power development.

Ontario Hydro's Requirements

1.5 The Hydro Electric Power Commission of Ontario is on record as expecting to require 7 million kilowatts (or 7000 megawatts) of nuclear generating capacity in 1980. Their Chairman recently drew attention to this. Now the first full-scale nuclear plant, CANDU, with a generating capacity of 203 megawatts, is expected to come into operation in 1964. In the following seventeen years, therefore, 6800 megawatts would be needed to meet the forecast, so the average rate of installation would be 400 MW per year. Naturally the rate of installing new plants will be slower at first, but it is clear that the first reactor, although significant, is only a small contribution, and following reactors would be needed in fairly rapid succession.

1.6 The Ontario Hydro forecast was first presented to the Royal Commission on Canada's Economic Prospects in January 1956. Except in the United Kingdom, nuclear power reactors have not been put into construction as rapidly as forecast at that time, when the world was in general over-enthusiastic following the 1955 Geneva Conference. In our own program, at the time of the last review by a special Parliamentary Committee in June 1956, the Nuclear Power Demonstration (NPD) reactor was being built. Completion has been delayed by a very major advance in technology arising from the studies for a full-scale plant at Chalk River in 1956. In the presentation I made to that previous Committee I pointed out the advantage of heavy water for obtaining low fuel cost through the long irradiation of uranium. The 1956 studies showed how this could be increased to yield in a full-scale plant almost 1% of the total latent nuclear fission energy, or 10,000 megawatt days per tonne of natural uranium without reprocessing. The new conception of a full-scale heavy water reactor was so attractive that the NPD reactor design was completely revised to the new pattern, although this delayed its completion by almost two years.

1.7 The full-scale reactor, CANDU, now approved, should be completed in 1964 and so fits the 1956 projected program with a design of outstanding promise.

1.8 There is a problem that constantly faces all power utilities, namely changes in the pattern of the demand. For example, the widespread introduction of air-conditioning has in some U.S. cities changed the seasonal peak load from the winter to the summer. Moreover, the introduction of natural gas for domestic purposes changes not only the total load but the daily peaks. Even the introduction of television has raised the evening loads appreciably. The large users in Canada are the industries and here there are big differences between the load patterns of, for example, aluminum smelters and automobile factories.

Scope for Nuclear Power

1.9 Nuclear power is most suitable for continuous or base load and not at all suited to meeting daily peaks. In any large system it is necessary to provide enough generators to meet the peak load, but those operating for a short time are usually chosen to be associated with plants of allowably higher operating costs but with the lowest possible capital costs. Systems are therefore constantly being recast to introduce, for example, pumped-water storage, delayed water flow, gas turbine rapid response type plants, seasonal thermal plants, and so on. The special characteristics of nuclear power will require further recasting of this type.

1.10 On the other side of the picture, nuclear power possesses some very major potential advantages. For example, the CANDU reactor has been designed to achieve very low fuelling and operating costs totalling 1.5 to 2.0 mills/kWh, to be compared with 3.4 to 3.8 mills/kWh for the cheapest conventional fuel plants in Ontario. To appreciate the significance of this, consider the fuel cost projected for 1980 in the 1956 Ontario projection. With no nuclear power it would be $300,000,000 a year at today's coal prices. A large fraction, probably between a third and half the total addition may be assigned to nuclear power. A saving of $100,000,000 to $200,000,000 a year or foreign exchange would result. Nuclear fuel costs are expected to fall somewhat between 1964 and 1980 so that by that time the net saving on fuel could amount to $100,000,000 a year or more. Offsetting this annual saving is the higher capital cost of the nuclear plants, but a net saving is in prospect.

1.11 From a broad economic viewpoint, three important prospects are offered to Canada through nuclear power:

(a) keeping electric power costs low,

(b) developing an engineering industry to build nuclear reactors,

(c) developing markets for uranium.

<u>Technical Prospects</u>

1.12 Nuclear reactors are new in the world and initial technical troubles must be expected despite the best attempts to obviate them by foresight.

1.13 The experience at Chalk River over the years of testing fuel and pressurized-water systems under power-reactor conditions gives a basis for considerable confidence that the NPD reactor will operate smoothly. Experience from that reactor will be carried forward in the design and construction of CANDU so that assurance should increase. Each successive reactor should then show some reduction in construction and operating costs.

1.14 To illustrate the increasing experience, it has been announced that the U.S. nuclear-powered submarine SARGO has completed nearly a month of exploration under the Arctic ice, and reached the North Pole. This considerably extends the pioneer work of Skate and of Nautilus that reached the North Pole under the ice in 1958. These vessels have pressurized-water nuclear reactors. Their steam plants demand leak-tight condensers. The initial experience for fuel under these operating conditions was obtained in NRX at Chalk River. This experimental work has continued since 1950 and has recently been extended to systems with Zircaloy pressure tubes in the NRU reactor with fuel operating beyond the ratings envisaged for CANDU.

1.15 In design, the year 1959 saw very great advances in CANDU. The overall plant efficiency has been raised to 29.1% and the anticipated fuel burn-up raised to 9750 megawatt days per tonne of uranium. In combination this reduces the anticipated fuel cost to about 1.0 mill/kWh or less if fuel fabrication costs are brought down as expected by the present development program.

1.16 To bring the capital cost down there seems little that can have such a major effect as experience in building successive reactors. The unit cost per kilowatt may also be reduced when there is sufficient confidence to proceed to higher power reactors.

1.17 To those looking for smaller power plants, for which higher overall power costs are competitive, it seems hopeful that the organic-cooled heavy-water reactor now under study will offer advantages of lower capital costs than the CANDU type at powers below 200 eMW.

Other Canadian Provinces

1.18 The ultimate pattern of electric power generation in other provinces is expected to show some diversity, but nuclear power may well become important. The timing of such development depends principally on

(a) the local cost of conventional fuel;

(b) the local policy for financing, that is to say, tax and interest rates that determine the annual charges on capital;

(c) the rate at which nuclear power costs can be brought down by the two processes of technical advance and industrial manufacturing experience, and

(d) any inflation of the currency that acts to the detriment of conventional thermal power using solid fuel wherever this has to be transported to a distance from the mines and thereby becomes relatively costly.

1.19 No detailed forecasts will be attempted, but some general observations may help to bring the prospects into focus. General surveys have been presented in three papers to the United Nations Conferences in 1955 and 1958.

1.20 The general pattern presented is that nuclear power will find application where (a) large blocks of power are required, that is plants of 100 electrical megawatts capacity or more on a load factor of 70% or more, and (b) conventional fuel is not available locally at low cost. The plentiful supplies of low-cost fuel available in Alberta will postpone for at least several decades any major application of nuclear power there. In Nova Scotia, on the other hand, the local coal is not easy to mine and so is more expensive, but the demand for electric power is not rising so rapidly and large plants are not yet required. Quebec still has major hydro resources unharnessed, but progressively over the next 30 years it seems likely that the province will wish to follow a pattern of development of the same type that is now required in Ontario. British Columbia has vast unharnessed hydro potential but at some distance from the industrial areas. There are signs already that the pattern of power development there will be complex from the start. The Vancouver area is already committed to some plants consuming natural gas piped from a distance. Vancouver Island might profit from nuclear power before long. Technically the opportunities for an extensive system of low-cost power combining hydro, natural gas and nuclear plants in that province seem favourable. Some of the prospective hydro developments, however, involve very large capital expenditures and in practice this is likely to produce some compromise with the technical optimum.

1.21 Following Ontario it seems that Manitoba, then Quebec and the Maritimes are likely to benefit significantly from nuclear power. Saskatchewan and British Columbia, although in very different circumstances, may well include nuclear power in their complex development.

THE PHYSICS DIVISION

Director	-	Dr. L.G. Elliott	
Staff	-	Professional	52
		Technical	59
		Other Staff	9

Branches -
- Nuclear Physics
- Neutron Physics
- General Physics
- Theoretical Physics
- Electronics

2.1 Fundamental research is an investment for the future which also provides immediate returns. It is a severe intellectual discipline, which attracts intelligent young people with imagination and natural curiosity.

2.2 The major part of the work of the Physics Division is fundamental research that will add to existing knowledge of the physical world and, more particularly, to our knowledge of the structure of the elements found in nature or that can be made by nuclear processes. This field of investigation is oriented around the framework of the overall AECL program.

2.3 The Division also undertakes the development and design of new electronic instruments, the construction of devices for measuring radiation, and assists other groups within the Company with problems in which a training in the discipline of physics can be of service.

2.4 The Division is divided into five Branches, each of which is devoted to a broad aspect of fundamental research or to the development of new equipment. In all, more than fifty physicists assisted by a similar number of technicians carry on the work of the Division. These men and women form a pool of trained scientific workers and are of considerable potential value to the Company and to Canada's scientific effort as a whole. To them must go the credit for earning Chalk River an enviable reputation in world-wide scientific circles for work in basic experimental and theoretical physics research.

2.5 The progress of technology is dependent upon the application of the results of fundamental research. In each research project there lies the inherent possibility of what is commonly called a "break-through". The history of nuclear reactor development exemplifies the result of break-throughs made in the recent past. One does not have to wait, however, for the big break-through in order to assess the value of a body of fundamental research. The reputation enjoyed by Chalk River physicists is the result of a continual stream of sound theoretical and experimental work. Physicists in the Division are frequently invited to lecture in North America and Europe on the results of their individual researches. Their advice is being sought constantly by Canadian Universities and other scientific institutions. Younger scientists from all over the world are seeking opportunities to work in the laboratories.

2.6 The Physics Division is also participating in Canadian contributions to joint international scientific programs - for example, in the International Atomic Energy Agency and other nuclear centres. During the recent International Geophysical Year a station recording cosmic-ray information was operated by a group of physicists.

2.7 Liaison work is also carried out with Canadian industry, and several members of the staff are closely concerned with industrial development projects. The experience available within the Division is at the disposal of any company wishing to take advantage of it. Engineers and scientists directly or indirectly connected with the utilization of atomic energy or with the nuclear sciences or electronics visit the Division frequently.

2.8 Former members of the Division staff have gone, in the main, to university appointments but some have turned their attention to applied research within industry. It is interesting to note that Chalk River alumni are heads of Physics Departments at Toronto, Queen's, McGill and Ottawa Universities, and that others are senior faculty members at a number of Canadian universities.

2.9 Within the scope of his particular Branch, the Chalk River physicist follows his own research program. He may use, if he wishes, some of the finest research tools in Canada. The NRX and NRU Reactors provide facilities for experiments in which beams of neutrons are required. The 10 million electron volt Tandem Accelerator and the 3 million electron volt Van de Graaff Accelerator both provide streams of charged particles which are used to bombard targets of various materials. A high-speed electronic computer is available to provide the means of shortening the time to make complicated mathematical calculations.

2.10 The presence of fifty physicists doing truly creative work acts as a stimulus to the remainder of the staff on the Chalk River Project. Colloquia and open lectures are frequently held, and everyone doing applied research or development work is afforded many opportunities to apply fundamental scientific thinking to their day-to-day problems.

Nuclear Physics Branch

2. 11 Much of the fundamental physics research at Chalk River is concerned with elucidation of the structure of atomic nuclei. The idea that an atom consists of electrons revolving round a nucleus like planets round a sun is well established, but our knowledge of the structure of the nucleus itself still lacks information which can only come from experimental evidence. The first step in these investigations however, is to invent models which have properties resembling the real nucleus. If these models fail to satisfy experimental results they can be rearranged to give successively more accurate predictions of the structure of the real nucleus.

2. 12 The structure of an atomic nucleus is studied experimentally by bombarding it with projectiles such as gamma-rays, neutrons, protons, deuterons, alpha particles (helium nuclei) and heavy ions such as oxygen and carbon. The angular distributions of the scattered or ejected particles which result from these bombardments give information on the shape of the nucleus and on the average position of the nucleons in it. Careful measurements of the energies of these particles give information on the motions of the nucleons and on the forces acting on them in the nucleus.

2. 13 Nuclear Physics Branch uses a number of sources of particles or projectiles in its work. Slow (or thermal) neutrons are obtained through experimental holes in the NRX and NRU reactors. Fast neutrons and other particles are supplied by the 10-MeV and 3-MeV electrostatic particle accelerators. The advantage of using neutrons is that they have no electrical charge and therefore are not influenced by any electrical force from the nucleus. This makes it easier to study the other forces that are not so well understood and that are, in fact, the source of nuclear energy. Studies using neutrons as projectiles are, however, technically more difficult than studies using charged particles.

2. 14 To increase our understanding of the nuclear fission process it is necessary to make very detailed measurements of individual fission events to supplement our present knowledge of the results of many such events occurring simultaneously in a reactor. Such experiments are being carried out by a group of physicists in the Nuclear Physics Branch. An intense beam of slow (or thermal) neutrons from the NRU reactor impinges on a very thin foil of fissionable material. When one of the nuclei splits, measurements are made on the two fragments to determine their mass and energy and to study any further changes in them. By doing this for many thousands of individual fission events it is possible to obtain a clearer picture of the process.

2. 15 The 3-MeV particle accelerator is used mainly to accelerate charged particles such as protons and alpha particles into projectile beams to probe atomic nuclei of low atomic number. The machine has been in use for over seven years. Present techniques make studies with charged particles much more accurate than studies with neutrons. A recent modification to the machine allows it to accelerate electrons, and this technique is being used in studies of the changes that take place in certain organic chemicals when they absorb energy in the form of fast electrons. This work is being done in cooperation with the Chemistry and Metallurgy Division.

2. 16 The 10-MeV, or Tandem, machine is so named because it consists of two conventional 5-MeV electrostatic accelerators arranged in series. The machine has been operating for just over a year, and was the first of its kind to operate in the world. It is capable of accelerating a wide variety of charged particles and extends, in two ways, the field of research covered by the 3-MeV machine. First, it permits the study of the nuclei of higher atomic number, nuclei that could not be penetrated by less energetic particles. Second, it allows more energy to be added to the nuclei of low atomic number and hence to a more thorough study of their structure.

2. 17 An interesting discovery was recently made during an experiment with the Tandem machine. A target made of a carbon isotope (C^{12}) was bombarded by very high energy atoms of the same isotope. It was expected that two C^{12} atoms would merge to form a dumb-bell-shaped molecule which would coalesce quickly to become an isotope of magnesium (Mg^{24}). This coalescence did not, however, take place as predicted. Instead, the two C^{12} atoms were reformed from the dumb-bell. This unusual phenomenon is leading to investigations into other high-energy reactions between similar atoms, for it can be said that this phenomenon is the inverse of the fission process. Such investigations - using for example, heavier atoms, particularly those which coalesce to form uranium isotopes - may lead to a fuller understanding of the fission process and its direct application to nuclear power. At the present time experiments with the oxygen isotope (O^{16}) have shown that the phenomenon does not occur with this nucleus. The next experiments will be with the nitrogen isotope (N^{14}).

2. 18 The Nuclear Physics Branch also does work in collaboration with reactor physicists to bring together the results of pure and applied research. One such collaboration is part of a general study of neutron economy in reactors and is of importance in selecting suitable designs for power purposes.

Neutron Physics Branch

2.19 This Branch is principally concerned with fundamental research studies using neutron beams from the NRX and NRU reactors. These studies usually have no immediate application to reactor technology.

2.20 The three major fields of research in the Branch were all pioneered at Chalk River and have since been taken up by laboratories all over the world. These fields are the physics of the neutron, gamma-rays of neutron capture, and slow-neutron spectroscopy. In the face of this competition, Chalk River has continued to maintain a high reputation for experimental results.

2.21 The neutron is an unstable particle which decays into a proton, electron and (anti) neutrino in about twelve minutes from the time it is emitted from a fissioning nucleus in the reactor. The three particles fly apart in various directions. Their directions and energies are correlated with each other and with the magnetic moment of the original neutron. Several experiments have been done to measure these correlations and thus to determine the proper mathematical form of the forces involved. The experiments were very difficult to perform and the results were of great interest and value to physicists undertaking similar experiments in other research centres.

2.22 A program of measurement of the frequency of gamma-rays produced by neutron capture in all the elements of nature has been continuing at Chalk River for twelve years. When an element is exposed to an intense beam of neutrons, large numbers of the individual nuclei capture a neutron and are changed into a new nuclear species. The new nucleus, however, has excess energy and emits this energy in the form of gamma-rays. The frequency of these rays is intimately connected with the structure of the new nucleus concerned. This type of investigation is being carried out as part of a world-wide project in nuclear spectroscopy, which is an important means of investigating nuclear structure. The results have also provided useful data for reactor and experimental shielding. Two major types of apparatus for this work were first developed at Chalk River.

2.23 One of the groups in the Neutron Physics Branch has earned an international reputation for studies of the structure of solids and liquids and the motions of their constituent molecules. The atoms of a solid are held together by atomic forces but vibrate constantly about some fixed position. These vibrations travel from one atom to another in the same manner as waves on the surface of water disturbed by a falling stone. The vibrations have therefore both wave length and frequency; the former are extremely small, the latter extremely large. Wavelength and frequency depend upon the atomic forces, and if the forces are strong the frequency is large. Experiments of this kind have been carried out with lead using neutron beams from the NRU reactor. The neutrons are made to bounce off the lead, and, in so doing, many of them change their speed and direction. These changes are measured using a neutron spectrometer. When a neutron bounces off a solid and has its speed changed it must transfer some of its motion to the atoms and thus cause them to vibrate. Analyses of the results have indicated the strength of the forces and also how the motion of one atom is affected by neighbouring atoms.

2.24 Another group in this Branch has begun a new and exciting piece of research. Until recently, it was thought that when a gamma-ray is emitted or absorbed by a nucleus a small part of the transition energy is given as recoil energy to the nucleus. A German physicist Mössbauer, has discovered that in certain cases the energy lost to recoil is negligible when the nuclei are located at regular lattice positions in a crystal. This discovery means that under these conditions it may be possible to measure the frequency distribution of low-energy gamma-rays to a hitherto unheard-of precision, about a thousand times better than has been achieved in the so-called "atomic clocks". The group has carried out an exploratory study of this Mössbauer effect with results similar to the preliminary reports of other workers.

General Physics Branch

2.25 Information on nuclear structure can also be obtained from studies of radiations from radioactive nuclei. A $\pi\sqrt{2}$ Beta-ray Spectrometer, operated by a group in General Physics Branch, was designed for this field of investigation using a technique that measures the energy and intensity of the beta-rays and gamma-rays emitted by nuclei. This spectrometer is larger and more precise than any similar instrument at present in use elsewhere. It runs automatically and operates almost continuously. The spectrometer counter has recently been equipped with a very thin window for low-energy work. With this modification, detailed studies of the conversion electron spectra of Pu^{239}, Dy^{166} and Gd^{153} have recently been carried out.

2.26 A second group in this Branch enjoys an international reputation in the field of astrophysics, which makes use of existing theoretical and experimental knowledge and applies it to the birth and death of stars. Studies have been carried out at Chalk River to examine the role played by low-energy nuclear physics in the evolution of the stars and in the formation of the elements. For some time the fusion reactions which transform hydrogen into helium and helium into carbon have been fairly well understood. A study of the nuclear reactions and neutron production taking place when the carbon is destroyed has been carried out with the aid of the Datatron Computer at Chalk River. It was found at high densities that nuclear reaction rates become more sensitive to temperature, and it is believed that this may well provide a trigger mechanism setting off the observed nova explosions. Another high-density effect appears likely to trigger supernova explosions by causing the formation of a condensed stellar core of neutrons. In the subsequent implosion, heating and thermonuclear explosion of the entire star, almost all of the elements and isotopes of elements would be formed in the relative proportions in which they are found in the solar system.

2.27 Akin to astrophysical studies are cosmic-ray studies, which have been in progress at Chalk River for many years. The recent International Geophysical Year gave this work considerable prominence. A laboratory built a few years ago in Deep River has been used since 1957 as one of the cosmic-ray stations for the I. G. Y. Modern methods of automatic data recording and processing have been used to enable weekly preliminary listings of cosmic-ray neutron intensities to be issued internationally. These measurements are being used at Chalk River in studies of solar/terrestrial relationships, including the influence of the sun on the recently discovered radiation belts (for example, the Van Allen) surrounding the earth.

2.28 Another group in the General Physics Branch doing leading work on an international basis is the radioisotope standardization section. The section did, in fact, help to pioneer this field which is concerned with measuring the absolute disintegration rates of radioactive materials. The primary function of the section is to maintain and improve the methods of measurement. It cooperates with similar groups at the National Bureau of Standards in Washington, D. C., and with the National Physical Laboratory in Teddington, England, in organizing a program of international intercomparisons in which simultaneous measurements of samples of a radioactive preparation are compared. In addition, research is done to discover and eliminate possible sources of error in the methods of measurement. The second major function of the section is to standardize preparations for research groups at Chalk River and for the Commercial Products Division.

2.29 A form of applied research is carried on by the counter-development section of the Branch. This section is engaged in the development and fabrication of radioactivity detectors for reactor control, radiation hazard monitoring, and for a wide variety of research applications in radiochemistry, nuclear physics and cosmic rays. The section has recently enjoyed success with the development of new types of particle detectors which make use of semiconducting materials. These detectors have proved to be of great interest to the scientific world generally, and it is expected that they will have many applications.

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Theoretical Physics Branch

2.30 The work of this Branch may be classified, loosely, under two headings - Physical Theory and Applied Mathematics. Each theoretician in the Branch works on problems of both kinds.

2.31 Physical theory aims at providing a coherent description of inanimate nature, an aim that may never be completely fulfilled. The theory develops in steps. An hypothesis is first formed, based on observation and insight, and is then tested by comparing its predictions experimentally. If the hypothesis survives such tests and correlates a large body of experimental work it is accepted as part of physical theory. This knowledge is now available as a basis for future research and for later development into technology.

2.32 The main theoretical work at Chalk River is concerned with the theory of the structure of the atomic nucleus, its interaction with elementary particles, and the effects of the structure of matter on these interactions. Much of this work follows from close cooperation with the experimental physicists in the Division.

2.33 In the field of Applied Mathematics, a large amount of the work done is devoted to the development of methods for calculating the way neutrons move about in matter. This information is required to assist reactor designers and for the fuller understanding of the operating characteristics of reactors. It is derived from the results of experiments and from physical theory, and requires considerable mathematical ingenuity. In addition, work is done on reactor theory in cooperation with physicists from the Reactor Research and Development Division.

2.34 Theoretical Physics Branch has also assisted with the solution of a variety of problems such as the analysis and detailed specification for the design of the $\pi\sqrt{2}$ Beta-ray Spectrometer, the evaluation of the radiation hazard in uranium mines, the motion of active ions in soil, and problems in the safe handling of fissile materials.

2.35 The Branch operates the Chalk River Computation Centre which is available for use by all groups connected with the Project. The Centre contains a Burroughs Datatron computer and associated equipment. The staff has built up a library of standard routines which is without equal in Canada. A new system for using the computer more effectively has recently been devised and as a result it can accept algebraic as well as arithmetical problems.

Electronics Branch

2.36 This Branch designs and develops electronic instruments for use throughout the Chalk River Project. In some cases the work is required to meet specific and immediate requirements, but a fair proportion of the total effort of the Branch is directed towards the general investigation of techniques that may be of importance in the future.

2. 37 The Branch may also manufacture small production quantities of certain instruments, but, in general, quantity manufacture is carried out by Canadian industry. In some cases, the Branch is under contract to a firm in the development stages of a project. Commercial exploitation of Chalk River designs by industry is encouraged, and some AECL-designed instruments are now being sold by Canadian firms in the U.S.A. and Europe.

2. 38 The design and development work can be broken down into two broad categories - reactor electronics and fundamental research electronics. The former category includes reactor control and monitoring instruments, radiation monitoring instruments, instruments used in reactor material and fuel studies, and electronic methods of displaying data during reactor operation. The latter category is largely concerned with methods of radiation detection from nuclear processes and with the collection and analysis of experimental data, a field that has grown considerably with the need to run experiments automatically for long periods at a time.

2. 39 The extensive use of automatic data-recording and analyzing systems have been made possible through the use of transistors. These small highly reliable components replace radio tubes and result in compact and reliable units. Another new development widely used by the Branch is that of printed circuitry. The past few years have seen great strides made in pulse amplifiers and pulse counting systems for nuclear physics experiments. Nearly all units are now transistorized wherever possible. Electronics Branch has participated in this work.

2. 40 Recent work on the field of reactor control equipment has been concerned with the application of transistors to increase the reliability of reactor systems. The NPD-2 demonstration reactor may use circuits developed as part of this program. Start-up instrumentation for a small reactor has also been developed. In the future, the talents and experience of Electronics Branch will undoubtedly be used in the development of circuitry for the CANDU power reactor.

2. 41 This branch developed the instruments used to detect flaws in fuel rods in the NRU reactor and contamination monitors used to examine the surfaces of fuel rods prior to their use in the reactors.

2. 42 The Reactor Research and Development Division is conducting an experiment to investigate the scattering of neutrons by various reactor materials using a neutron beam from NRU. Electronics Branch has developed for this experiment the equipment required to record on magnetic tape data relating to the angle and speed of scattered neutrons. A system for sorting the events recorded on the tape into various categories has also been developed. This experiment will operate automatically for 24 hours per day for two years and the data amassed will be used in future reactor design calculations. This is a joint Atomic Energy of Canada Limited - United Kingdom Atomic Energy Authority - United States Atomic Energy Commission experiment for which the main part of the instrumentation was supplied by Atomic Energy of Canada Limited.

REACTOR RESEARCH AND DEVELOPMENT DIVISION

Director	-	Dr. G.C. Laurence	
Staff	-	Professional	48
		Technical Staff	39
		Other Staff	5

Branches -
Reactor Physics
Nuclear Engineering

3.1 The Division of Reactor Research and Development is a group of physicists and engineers. Their interest is the scientific and engineering background of reactor design. They are concerned with the basic ideas, the data and the facts from which the design of a reactor can emerge. Individually they are specialists in various aspects of reactor technology; together they cover all important aspects.

3.2 Their attention is given to nuclear plants for Canadian needs; they propose outline ideas for new design and they provide, by experiment and study, information needed for the design. They also follow closely progress in the development of nuclear reactors of all kinds, so that they are competent to judge what is the best type of reactor to meet any particular requirement in this country. They watch for the important new developments in reactor technology, whether in Canada or abroad, that might be adopted to advantage in our reactors.

3.3 First consideration in the design of nuclear reactors - and therefore one of particular importance in the work of this division - is neutron economy. The release of nuclear energy depends on neutrons - those parts of atoms that are expelled from the atom when fission occurs. The fission chain reaction is made possible by neutrons being released from the nuclear fuel and recaptured in the fuel.

3.4 Besides the fuel, the other materials in the reactor capture neutrons also. Neutrons are captured by the protective covering over the fuel, by the liquid that carries the heat from the reactor to the boiler, by the pressure tubing, by the moderator, - indeed by everything in the reactor. If too large a percentage of the neutrons is captured by these other materials, leaving too few to be captured by the fuel, the release of nuclear energy stops.

3.5 In constructing the reactor we must choose materials that do not waste too large a fraction of the neutrons. To find or produce materials that are suitable is a difficult but essential part of the development of economic nuclear-electric power. The importance of neutron economy leads to the choice of unusual substances such as heavy water instead of light water for transport of heat, to the development of the new alloys such as Zircaloy-2 to be used where otherwise we might have used stainless steel, and to insistence on high purity in materials.

3.6 The ability of the fuel to capture the necessary percentage of the neutrons in competition with the other materials in the reactor depends very greatly on the shape, size and separation of the pieces of the fuel in the reactor core, and on the distribution and quantities of the other materials there as well. The distribution of the fuel elements in the reacting core is called its lattice. A good lattice is one in which the fuel is able to capture a high percentage of the neutrons: we say that this lattice has a high reactivity.

3.7 We predict the reactivity of a lattice design by intricate calculation, but a more accurate evaluation is obtained by putting the lattice together and testing it. We test lattices in the low-power reactor, ZEEP. Tests of this kind in ZEEP enabled us to choose the best lattices for NRX, for NRU and for NPD. Many other possible lattice arrangements have been tested in our ZEEP reactor, from which we may choose designs suitable for future reactors. To avoid unnecessary duplication of effort we exchange results of such experiments with laboratories abroad that do similar experiments - laboratories in Saclay in France, in Sweden, in Harwell in England, and at Savannah River in the United States. This is a good example of the international cooperation that takes place in nuclear technology.

3.8 The ZEEP reactor is too small to permit a satisfactory test of the lattice of some of the more recently proposed designs. Therefore a new low-power reactor, called ZED-II, has been constructed which is larger than ZEEP and better equipped. The first use of ZED-II will be to confirm the lattice of CANDU.

Burn-up

3.9 The tendency of a material to capture neutrons is called its neutron capture cross-section. It is important to know the capture cross sections of materials in order to avoid those that are too wasteful of neutrons. It is particularly important to know the cross-section of the materials which are produced in the fuel while energy is being released from it. They include the different kinds of plutonium and the waste products of the fission reaction - known as fission products. We need this information to predict the burn-up, that is the amount of energy which we can extract from a ton of the fuel. The burn-up depends on the waste of the neutrons in fission products in the fuel because as more fission products accumulate the waste increases until it becomes necessary to replace the burned fuel with fresh fuel. By knowing the cross-section of the fission products, and other information about them, we can predict the burn-up; that is, we can predict how much energy we can extract from a ton of the fuel. Thus we foresee that we will get about 6,000 megawatt days per metric ton from the fuel in NPD, and about 9,000 megawatt days per ton in CANDU. The 9,000 megawatt days of nuclear energy will produce about 60,000,000 kW of electricity. Measurements of neutron capture cross-sections are an important part of the work in our Division.

3.10 We are beginning to determine the deterioration of the fuel with burn-up more directly by tests carried out in the reactor PTR, built and equipped especially for this purpose. For these tests the reactivity of a sample of the fuel is first measured in PTR. The sample will then be put in NRU for several months and a large amount of energy will be extracted from it. Finally it will be returned to PTR to observe the change that has taken place in its reactivity.

3.11 The same equipment in PTR enables us to test other materials that are used in the construction of a reactor. We want to test them because the presence of small quantities of certain impurities can greatly increase their tendency to waste neutrons.

3.12 Since waste of neutrons limits the energy we can get from the nuclear fuel, neutron economy is the most important concern of the reactor physicist. The nuclear engineer has the problem of transferring that energy, in the form of heat, from the reactor to the boiler. What is best for heat transfer is not always best for neutron economy. So the physicist and the engineer must work together and must compromise.

Heat Transfer and Fluid Flow

3.13 Because a nuclear reactor is a very costly plant, it is desirable to get a very large output of heat from it. In NPD, for example, heavy water enters the reactor at 485°F and flows along the Zircaloy-covered pieces of fuel. Heat from the fuel penetrates the Zircaloy cladding and heats the heavy water which leaves the reactor at 530°F. It then passes through the tubes of the boiler, giving up heat to boil ordinary water surrounding the boiler tubes, thereby making steam to drive the turbine. The heavy water, by giving up heat in the boiler is cooled again to 485° and is pumped back to the reactor to repeat the cycle. Many factors limit the rate at which the heat can be transferred: the velocity of flow of the heavy water through the reactor, the size of the passages for the flow, the area of the surface of the fuel cladding in contact with the flow of heavy water, the maximum permissible temperatures of the fuel, the cladding and the heavy water, and other details.

3.14 Striving for high heat output while compromising with the demands of neutron economy leads to design detail and operating conditions that are different from common engineering practice. Much of the information needed for design cannot be found in the standard books on engineering; it must be obtained by experiment or derived by theory.

3.15 The reactor design engineer, faced with new conditions in the problem that cannot be resolved by past experience and calculation, builds a model and reproduces the design conditions. He can then measure directly the transfer of heat from fuel cladding to liquid, he can measure the power required to pump the liquid through the system, he can observe any undesirable vibration caused by the rapid flow, and he can test other features of the design. We do the small-scale experiments of this kind ourselves, but experiments requiring larger equipment are done by contractors under our guidance. For example, Orenda Engines Ltd. has begun a series of experiments related to the use of steam for the transfer of heat from the reactor. Experiments on transfer of heat and the flow of fluids are also done in the Nuclear Power Plant Division in Toronto.

3.16 It is not possible in experiments done away from nuclear reactors to reproduce all of the conditions that exist in a reactor. For example, the intense exposure to radiation, which can alter the properties of some materials, is missing. Also it is very difficult to simulate the release of heat from nuclear fuel by other methods of heating in an experiment outside a reactor. To do experiments so that the fuel and other critical parts are exposed to reactor conditions, use is made of apparatus called an in-pile loop. An in-pile loop has its own fuel, heat-transfer system, pumps, instruments and other important parts but obtains neutrons and radiation from a large reactor. There are eight loops in NRX and NRU and two more are being constructed. Contractors for the United States Atomic Energy Commission, and for the United Kingdom Atomic Energy Authority share in the use of some of these loops. They share the cost of the loops and benefit from the exceptionally good facilities of our reactors for experiments of this kind. We benefit from the results of the experiments. In-pile loop experiments are particularly important for testing the new designs of fuel described in the work of the Chemistry and Metallurgy Division.

Reactor Reliability and Control

3.17 Reliability and control are other important aspects of reactor design. They have received great attention at Chalk River from the beginning. In our older reactors, NRX and NRU, used for such a variety of purposes, there are many more opportunities for failure of equipment and mistakes in operation than in a reactor whose use would be restricted to the production of commercial power. Certainly we have had our share of equipment failures, yet in the 15 years' history of Chalk River there has been only one case where anyone had received an injury that was clearly due to radiation exposure; it was a radiation burn on a man's hand. Nevertheless, our experience of equipment failure has stimulated much attention to the reliability, the control and the safety of reactors. Almost every Division of our organization has participated in the development of new ideas and principles in reactor reliability, but it is particularly the concern of the Reactor Research and Development Division.

3.18 Chalk River has made important contributions to the design and use of automatic control for reactors, which we believe is more dependable and more safe than manual control, and to the reliability of protective equipment for reactors. We have developed automatic control equipment which is continuously self-testing, so that the occurrence of faults is made known immediately and can be corrected without delay. We have also designed protective equipment that can be tested easily and without interrupting operation of the plant. Our experience has given rise to other important new principles in the safety of the design of reactor equipment and in the safety in the operation of reactors.

3.19 The Division has carried out tests to investigate the safety of a number of features in the design of the NPD reactor. For example, we wished to have a better idea of how much damage might be done in a reactor if one of the pressure tubes through the reactor burst. In ordinary industry, of course, bad ruptures of high-pressure steam pipes and equipment are extremely rare and the risk is considered negligible. In a nuclear plant more attention is paid to the risk of such an accident because it might lead to other damage and possibly permit the escape of some radioactive matter. We therefore burst samples of pressure tubes by steam pressure under conditions like those in a reactor to see the extent of the possible damage near the burst tube.

3.20 We have carried out tests to determine how fast the heavy water would escape from the heat-transfer system if one of the large pipes were broken off completely. We did further experiments to learn how quickly water from an emergency supply could be introduced into the system in case of loss of the heavy water to prevent the fuel from melting and thereby permitting the escape of dangerous fission products. We have assisted those engaged in the design of NPD in calculations to determine what steam pressure would develop in the boiler room if piping broke; this has enabled the building to be designed to withstand it.

Association with other Organizations

3.21 An important duty of the Reactor Research and Development Division is to assist other Divisions and outside industry. It has introduced engineers from Canadian industry to nuclear reactor technology.

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It gives assistance on the design of in-pile loops, on problems related to the transfer of heat from the reactor to the boiler and on cost-optimization studies. It has acted as liaison with Canadian industry on a number of development contracts. It has advised the Departments of Transport, of Northern Affairs and of National Defence on the suitability of nuclear reactors for special purposes, and helps our own operating Divisions on some of the technical and scientific problems which arise in connection with the operation of our reactors. It maintains a close cooperation and exchange of technical information with similar departments in National laboratories in a number of other countries.

Comparison of Reactor Concepts

3.22 As has been mentioned before, the first purpose in the power-development program of our Company has been to develop a nuclear reactor that would be suitable for the production of electricity in central power stations in southern Ontario. This purpose is being met by the heavy-water-moderated, natural-uranium-fuelled type of reactor, with NPD as the small demonstration plant, and CANDU as the first full-scale plant. Meanwhile, we have tried to find a competitor of CANDU. We have been looking for a different type of reactor that might also compete economically in large central power stations in southern Ontario because the rivalry of two designs would stimulate improvement of both of them. Enthusiasm would be quickly attracted to a new design if it appeared more promising for the plants that came after CANDU.

3.23 In looking for a possible competitor for CANDU, it is natural to think of the graphite-moderated types of reactors because of their success in the United Kingdom. The United Kingdom, with its Calder Hall reactors moderated with graphite and cooled with carbon dioxide, has been the first to approach closely the goal of competitive nuclear power. They chose this type of reactor because its technology was farthest advanced and could be developed most quickly into a practical power plant. However, on closer examination of the cost of building that type of plant in southern Ontario it becomes evident that it could not compete with the coal-fired electric power station. AECL's present feeling is that present designs of graphite-moderated plants are unlikely ever to be competitive in this province.

3.24 In the United States, reactors that use ordinary water as a moderator are the farthest developed. Reactors of that type also could not compete, at least within the next decade, with the CANDU type of reactor for the production of electricity in large central power stations in southern Ontario.

3.25 The only possible rivals for CANDU in this province seem to be nuclear power plants which also use heavy water as the moderator but differ from CANDU in other respects. They may differ for example, in the kind of liquid or gas that is used to carry the heat from the reactor to the boiler or directly to the turbine.

3.26 A possible alternative is the use of gas, such as carbon dioxide. We spent about a year in looking into the possibilities of this type of reactor. The Harwell Atomic Energy Establishment collaborated in this study because they also were interested in it. In the end, we decided that the best heavy-water-moderated gas-cooled reactor which we could conceive could not compete economically with CANDU.

3.27 During the course of that study we became interested in the possibility of using dry steam for transport of the heat. Dry steam would be raised in a boiler and, passing through the reactor, would become hotter. It would then return to the boiler where its heat would produce more steam which would pass through the reactor and get heated in turn. Finally the steam would pass on to the turbine to drive the motor generators to produce the electricity. For several months we have been engaged in a careful cost analysis of a plant of that type. It appears to be better than the carbon dioxide cooled reactor, but does not seem to be as good as CANDU.

3.28 A new suggestion has now arisen. Why insist on dry steam? Why not wet steam? That is to say, steam which carried with it a fine mist of tiny drops of water? The presence of those water droplets would increase the amount of heat that a given volume flow of the steam could carry away from the reactor. The idea presents some problems, but we think that it is worth looking into, and preliminary calculations are encouraging.

3.29 Our discussion so far has been on the design of a reactor suitable for a large central power station in southern Ontario. We are not forgetting other possible applications of nuclear power production elsewhere in Canada. Because nuclear fuel is so compact, because a little fuel will go such a long way, because it is very costly to transport such bulky fuels as oil or coal to remote places, the possibility of using nuclear power for defence and meteorological stations in the far north suggests itself. Small reactors moderated with ordinary water and using highly enriched fuel might be considered for such purposes. Unfortunately, nuclear power can be produced cheaply only in fairly large plants, and the requirements for power for communities in the far north are relatively small. Thus it turns out that the advantages of nuclear power in the far north are not as great as one might at first imagine. The demand for such plants has not yet been very pressing.

3.30 There are many parts of southern Canada where the need for new power stations will be for plants of medium size with a capability of the order of 20,000 or perhaps 50,000 kW - i.e. plants which are small in comparison with CANDU but large in comparison with those that might be needed in the far north. It will be possible for nuclear power to compete in many of these regions requiring comparatively small plants where the present costs of electric power from coal are rather high -- 8 and 10 mills per kWh and higher. To meet these requirements the CANDU type of reactor is not necessarily the best. Under some circumstances the organic-cooled heavy-water-moderated reactor may be better.

3.31 The Canadian General Electric Co. Ltd. has proposed an outline design of a heavy-water reactor of this type. The advantage of the organic liquid is that it is less costly than heavy water, can carry a greater quantity of heat per unit volume than a gas or steam, and does not need to be confined at high pressure with thick-walled tubing. This type of reactor does not seem to be capable of competing with CANDU for the very large stations but we think it may be suitable for plants of intermediate output capability in some regions. Our Division plans to undertake a careful cost optimizing study of this type of reactor also.

3.32 A nuclear power station is a very complex plant. The designer must make many decisions regarding details in the design, and there are many possible combinations of these details. If one feature in the design is changed, it may lead to other changes in an effort to find the best result. A cost-optimization study is a comparison of these possible variations to determine which combination of design details will lead to the plant with the lowest operating cost. The calculation of these costs by old-fashioned methods is extremely tedious, and months would be required to compare only a few variations in the design. Using high-speed electronic computing equipment many hundreds of variations in the design have been compared in a relatively short time.

3.33 The ability to compare costs rapidly has helped us greatly, for example, in reducing the probable costs of producing power in the CANDU reactor. It permits us to claim that the predictions which we make about the probable costs of producing power with future heavy-water reactors are at least as accurate as the predictions made in favour of some other-types of nuclear power stations, particularly when we are talking about costs in our own country for the type of reactor we understand better than anyone in the world.

3.34 About a dozen very different kinds of nuclear power plants are now being developed throughout the world. For each type a great and costly development effort is required from the first picture in the mind to the achievement of the first economic power plant. None have yet reached that goal. But we are getting close to the goal with fifteen years of heavy-water-reactor development behind us. That is a long head start which puts any very novel and undeveloped concept at a severe disadvantage.

3.35 As we approach our objective, we are very impatient to see NPD coming into operation, demonstrating the technical feasibility of the heavy-water-moderated plant, and to see CANDU operating to prove its economic success. Our impatience to see NPD operating is to be expected. What surprises us is the interest shown in other countries in the promise of NPD. There is hesitation in many countries to invest heavily in nuclear power until the performance of the heavy-water plant, with its advantage of low-cost natural-uranium fuel,has been demonstrated. They respect Canada's leadership in the development of the heavy-water nuclear power station and are looking to us to prove its feasibility and economy. The weight of Canada's voice in international discussion of atomic energy - in political discussion, commercial discussion and technical discussion - derives from our technical reputation in atomic-energy research and development. Its continuing weight will depend much on the success of NPD and CANDU.

Appendix 4 - 4.1 -

CHEMISTRY AND METALLURGY DIVISION

Director	-	Dr. W.M. Campbell	Branches -
Staff	-	Professional 71	Research Chemistry
		Technical Staff 108	Research Metallurgy
		Other Staff 8	Fuel Development
			Chemical Engineering
			Development Chemistry

4.1 The work in this Division can be divided roughly into basic research and applied research or development. The dividing line is difficult to define but in general the basic research supplies the background knowledge on which any successful development program must be based. Nuclear science is relatively young and as a result there is not the extensive background of knowledge in the published literature that there is in some of the other branches of science. Thus at AECL a great emphasis is necessary on basic research.

4.2 In the Chemistry and Metallurgy Division the work centers around the study and development of fuels both for the existing reactors NRX and NRU and for the future power reactors such as NPD-2, CANDU and OCDRE. The fuel for these reactors must be easy to make and must be capable of a long life under reactor conditions. In order to do this it must retain its original shape almost exactly and it must not be corroded by the hot flowing coolant. The fuel program then is concerned with the study of various fuel designs and a comparison of their properties to find the design most suitable for a particular reactor.

4.3 As an example, the fuel for NPD-2 and CANDU is in the form of a bundle of long thin rods. In each bundle there are 19 rods, 0.6 inches in diameter and 19.5 inches long fastened between webbed end plates. The complete bundle is cylindrical, 19.5 inches long by 3.25 inches in diameter. The individual rods are made up of thin-walled zirconium alloy (Zircaloy) tubes filled with uranium dioxide and sealed at each end. The uranium dioxide is in the form of dense cylindrical pellets which can just slide into Zircaloy tubes and which are stacked in the tubes before the second end is sealed. The fuel bundles are loaded one after another into the horizontal pressure tubes in the reactor. Here the fission energy is produced in the uranium dioxide, it is conducted out through the Zircaloy sheath and it is carried away by the heavy-water coolant which flows at a high velocity longitudinally between the individual rods in the bundle.

Fuel Development

(a) Manufacturing Development

4.4 The first step in developing a fuel is to work out an easy, reliable method of fabricating it. This is a joint effort between the AECL fuel development groups at Chalk River and Toronto and two Canadian companies - Canadian General Electric Co. Ltd. and AMF Atomics (Canada) Ltd. First a method for making uranium dioxide powder had to be worked out starting with a uranium nitrate solution, one of the intermediate products of the Eldorado Mining and Refining Co. plant at Port Hope. During the past 2 - 3 years a process for making UO_2 powder has been developed in the laboratory at Chalk River, and the method is now being used at Eldorado's Port Hope plant where several tons are being made for the first NPD-2 fuel charge. Some work is still being carried on at Chalk River both to improve the process and to produce small lots of special uranium oxide for irradiation experiments.

4.5 The next step was to find a means for converting the uranium oxide powder into the dense cylindrical pellets. The process as developed in the Chalk River laboratories consisted of pressing the powder at over 20,000 lb/in^2 in a hydraulic press and then sintering the "green" compacts in an atmosphere of hydrogen for several hours at about 3000°F. The final pellet is glassy and almost completely devoid of pores. The process with a few modifications, is being used in the Carboloy works of Canadian General Electric Co. Ltd. to produce pellets for the first NPD-2 fuel charge. Several tons of pellets have been made already. Meanwhile, the ceramic group at Chalk River has continued work on improving the uranium oxide pellets. For example, in one investigation it was found that the addition of traces of certain other oxides improved some properties of the fuel but the complete assessment has not been finished yet.

4.6 The finished pellets then had to be sheathed in tubes to keep them out of contact with the flowing coolant. The tubes or sheaths are made of Zircaloy, the best available material, and have walls only 0.015 to 0.025 inches thick. Zircaloy is a new alloy, so it has been necessary for the manufacturers to carry out extensive fabrication development and for the users, AECL, CGE and AMF, to work out testing procedures. Trial lots were purchased from several suppliers and these were examined. Some defects were found and manufacturers were asked to modify their processes. The problem of being able to inspect tubing quickly and cheaply on a routine basis still exists but several approaches now being followed show promise and a satisfactory solution is expected shortly.

4.7 Putting the uranium oxide pellets into the tubes and sealing the ends by welding did not require much development at Chalk River although the welding requires a special technique. More work however had to be done at CGE and AMF to convert the laboratory procedures to an assembly-line process. The final operation of assembling the 19 individual rods or elements into bundles has not been studied at Chalk River but it is being worked out by CGE at Peterborough. Routine assembly of the NPD-2 fuel is just beginning.

(b) Irradiation Testing

4.8 The final step in developing a fuel is to study its behaviour when irradiated under reactor conditions. One of the most important parts of the Chalk River program is the irradiation testing of fuel samples in the NRX and NRU loops. These loops are closed circuits, one part of which passes through the reactor core and contains the fuel samples, and around which a high-temperature high-pressure coolant is circulated. Thus the fuel sees essentially the same conditions it would see in an operating power reactor. There are six loops in NRX and two in NRU. When the specimens are removed from the loops they have to be examined to see if any changes have taken place. Two shielded cells with their associated manipulators, viewing equipment, cameras, etc. are in operation and a third is under construction. In addition, a series of small cells is used to examine the microstructure of irradiated metals and other materials.

4.9 One series of irradiation experiments was done to find out how the volume of the uranium oxide changes in a reactor. As it becomes hot it expands and it was found that under certain conditions it may stretch the Zircaloy sheath. From the results recommendations have been made to the designers to provide enough initial free volume between the pellets and sheath to allow for the oxide expansion under operating conditions.

4.10 In another series of experiments small holes were deliberately made in the Zircaloy sheath. This allowed water to get inside the sheath and fission products to get out into the water stream. The results indicate that if a small hole does form in a sheath, say by corrosion, the element will not distort in a serious manner nor will large amounts of uranium oxide or fission products get out into the flowing water. This latter point is important when considering maintenance of the primary water circuit.

4.11 The irradiation of assemblies of several elements has been carried out and this is now progressing into the testing of the normal production bundles being made up by CGE. The objective here is to see whether there is any interaction between elements leading to a distortion of the bundle and causing trouble in the reactor. Any unexpected corrosion is also being looked for. The first test in an NRU loop was successful and more are planned. These tests cannot provide statistical proof of fuel reliability but by carefully planning the irradiations they can give assurance that there are no major faults in the design or assembly.

(c) Advanced Fuels

4.12 While the main effort is on uranium dioxide fuel for the first charges of NPD-2 and CANDU, some work is being done to find out how to make cheaper and better fuels for the later charges. In one series of experiments the making of pellets by high-temperature sintering is eliminated. Instead a certain grade of uranium oxide powder is tamped into the Zircaloy tube, the ends are sealed and the tube is then hammered down, in a process known as swaging, to a smaller diameter, thereby compacting the oxide to a high density. This fabrication method could allow much more freedom in the design of the bundle. The results to date are promising but much more work is required before swaged fuel will be considered for NPD or CANDU.

4.13 Plutonium is a possible fuel for future reactors. It is formed in the uranium oxide in the reactor and it can be recovered from the spent fuel by a chemical reprocessing step. The recovered plutonium can then be made into a fuel element and returned to a reactor to produce more power. Although it will be some years before there will be enough spent uranium fuel to justify building a reprocessing plant in Canada, an acceptable plutonium fuel element will have to be developed before that time. With this objective a number of aluminum-plutonium alloys have been made and tested successfully in NRX. At present the emphasis is shifting to plutonium oxides which might be mixed with uranium oxide. A new laboratory for this work is being constructed and will be ready for occupancy in a few months.

Metallurgical Development

(a) Corrosion and Associated Problems

4.14 Except for the uranium fuel and the heavy water all the rest of the reactor consists of metals. The study and evaluation of the different alloys which might be used is an important function of the Chemistry and Metallurgy Division.

4.15 NPD-2 and CANDU use heavy water at 1100 - 1500 lb/in^2 and 525 - 560°F as the primary fluid to remove the heat from the fuel elements. All the components in the primary system - the fuel bundles, the coolant tubes, etc. - must be resistant to this environment. Zircaloy is the preferred alloy so its corrosion is being studied in the laboratory and in NRX. Much of this work is aimed at giving a better understanding of the corrosion reaction, which in turn might lead to improved performance. The results indicate that the Zircaloy corrosion rate is low and that there will be no problem under normal operation. Abnormal conditions are being examined and at present an investigation is being carried out to see what happens if there is a leak at a certain point along the pressure tube. Under certain conditions the corrosion rate may be excessive so a special type of water treatment is being investigated and it looks promising.

4.16 When Zircaloy corrodes in water it forms hydrogen, and some of this is absorbed into the metal. The absorbed hydrogen may make the metal more brittle so an extensive program on Zircaloy hydriding and its effect on the mechanical properties is being carried on at Chalk River. Other phases of the problem are being studied under contract by the Canadian Westinghouse Co. at Hamilton. Some interesting results have been obtained but there still is a great deal to be learned before hydriding and its effects are fully understood.

(b) Zirconium Alloy Development

4.17 For the past several years there has been an intensive program on Zircaloy in order to establish its behaviour under reactor conditions. Such properties as tensile strength, ductility, impact resistance and creep have been measured. In general, the properties of irradiated Zircaloy are as good as or better than those of the unirradiated alloy. Evidence of the fruits of this research is the fact that the working stress for CANDU has been raised from the NPD value of 13,500 lb/in^2 to 15,000 lb/in^2. This results in an appreciable saving both in initial capital cost and in fuel cost.

4.18 The search for better zirconium alloys not only for the CANDU type of reactor but also for high-temperature steam-cooled reactors is going ahead. The Chalk River laboratories are taking the lead in this and are being assisted by two industrial companies, Orenda Engines Ltd. and Atlas Titanium Co. This latter company is setting up a new laboratory under contract with AECL to be devoted entirely to zirconium alloy work. Several promising leads are being followed but it is still too early to make any predictions on the ultimate success of the programs.

(c) Other Alloys

4.19 Although Zircaloy is very satisfactory for water-cooled reactors it is not satisfactory for those cooled with organic liquids. Certain new aluminum alloys or beryllium look promising but thorough assessments have to be done. These are just beginning. At Chalk River the effect of irradiation on the swelling of beryllium is being studied. At the Canadian Westinghouse Co. in Hamilton beryllium is also being studied, where the emphasis is on trying to determine the reasons for the low ductility. To date they have shown that this property can be improved by a careful heat treatment.

Chemical Engineering Development

(a) Processing of Radioactive Wastes

4.20 The processing of spent uranium fuels has been studied on a laboratory and pilot-plant scale for several years. This work has recently been discontinued since it will be some years before Canada is producing enough spent fuel to justify building a chemical-processing plant. However, in the course of the studies a very promising method for disposing of the fission-product wastes was discovered. The method is to melt the wastes into a glass which can then be buried in the ground. The investigations have progressed through the laboratory into a small pilot plant where some 50 glass blocks of about 4 lb each have been made. Some of these have been buried for a field test and the remainder are being evaluated in the laboratory. A design study has just been completed for a small plant which would complete the development program and at the same time convert all the existing Chalk River wastes into glass blocks. This would provide enough blocks for a thorough field test which would continue for several years.

(b) Insulation of Reactor Pressure Tubes

4.21 Several years ago the reactor designers began considering a modification to the pressure-tube design. The modification involved putting the insulation inside the tube rather than outside as in NPD-2 and CANDU. Since there was no insulation method readily available, a development program was started. Two types have been studied, one consisting of concentric layers of dimpled metal foil and the other a layer of compacted powder. The results have been turned over to the designers for economic assessment and for detailed design study. It is doubtful whether either of these schemes will be useful for CANDU, but they show promise for high-temperature reactors, i.e. reactors cooled with organic liquids or superheated steam.

- 4.7 -

Studies on Reactors cooled with an Organic Liquid

4.22 This is the newest reactor program which has been taken on by AECL and much of the work is at a preliminary stage. The reactor concept is basically similar to NPD-2 and CANDU in that uranium dioxide fuel and a cool heavy-water moderator are used but the heat is removed from the fuel with circulating hot "oil" rather than with heavy water. This overcomes some of the limitations of a heavy-water coolant and allows a higher temperature to be used.

4.23 The development and design work is divided between AECL at Chalk River and CGE at Peterborough. CGE is concentrating on design studies and on the development work that does not require irradiation facilities. AECL is carrying out all the in-reactor work required for the development of fuel, structural materials and the organic liquid coolant.

4.24 One problem is that the organic liquid decomposes slowly under reactor conditions. An extensive chemistry program is underway in which small samples of various possible liquids are heated in the NRX reactor and the decomposition rates are measured. Close collaboration is maintained with both US and UK experimenters. The results are confirming and extending existing data and they indicate that the decomposition rates are not excessive at a reasonable operating temperature. Further facilities are being built in NRX in order to speed up the program.

4.25 Closely associated with the above work is a program to determine whether tars will deposit on the fuel sheath and if they do what conditions have to be used to avoid deposition. Such deposits could "insulate" the fuel elements and allow them to become overheated. The first studies will be done at Chalk River in an out-of-pile rig which has been designed and will be constructed shortly. Later the work will be extended to an in-reactor loop which is just being built in NRX for testing fuel elements.

4.26 The fuel development work at Chalk River for the organic-cooled reactor is mainly irradiation testing and subsequent examination. The planning of the experiments and the preparation of specimens is closely coordinated with CGE and Atomics International Co. in the U.S. (The latter company is operating an organic-cooled test reactor, the OMRE, and has a very large research and development program on this type of reactor). For the irradiation work a small circulating loop was built in NRX in 1958 and used for the first series of experiments. It has been improved to provide higher temperatures and more testing space and it started operating again in May 1960.

4.27 Structural materials and sheathing for the UO_2 presents a problem since Zircaloy cannot be used as in NPD-2 and CANDU. The most promising material is an alloy of aluminum containing a small amount of aluminum oxide. This is quite a new product so it is necessary to work out methods of shaping and welding it. This is being done as a collaborative program with CGE and Atomics International. Beryllium is also being considered but on a longer-term basis. The programs at Chalk River and the Canadian Westinghouse Co. at Hamilton, mentioned previously, are being expanded to meet these long-term requirements. The results to date on both the aluminum alloy and beryllium show that there will be some limitations on the way these materials can be used but that these limitations are not too restrictive.

Basic Research

(a) Fuels

4.28 Several major research programs are being carried out on uranium dioxide. In the reactor many fission products are formed and some of these are gases. If the gases escape from the uranium oxide into the free space around the pellets and within the sheath they might build up enough pressure to bulge the sheath. But all the gas does not escape. Studies are being made to find out how the rate of escape is affected by the way the oxide is made, the temperature it attains in the reactor, etc. Temperature has been found to be an important variable, but as long as the uranium oxide remains below about 2700°F there will be very little escape of gas. Slight changes in the composition of the oxide influence the escape markedly. More recently it has been shown that some of the gas which escapes from the oxide can be driven back into it again. The work to date has brought to light many very interesting properties of uranium oxide fuels and has reassured the designers that there is no cause to worry about excessive gas pressure within the sheath.

4.29 Another research deals with thermal conductivity of the oxide. The oxide has a low conductivity which means that the centre of the element becomes very hot, and will reach about 3500°F in CANDU. At this temperature some fission-product gas is driven out of the oxide, but extensive irradiation tests have shown that the amount is still acceptable. Before the fuel can be modified to reduce this temperature it is necessary to know what basic properties affect the oxide conductivity. This research is proceeding and to date has shown, for example, that the conductivity decreases somewhat when the oxide is irradiated in a reactor. The effect of adding certain constituents is also being studied but there are no conclusions to date.

4.30 In a related research program uranium oxide is being heated in the laboratory under conditions similar to those in a reactor. Recent results have settled an international controversy - that of how voids in the fuel form and move - on certain observations in irradiated elements.

(b) Metallurgy

4.31 The properties of some metals and alloys change markedly when they are irradiated in a reactor. A long-range study is being done to find out why these changes take place. This means irradiating samples under different conditions and then measuring such properties as electrical resistivity, density, mechanical properties, etc. When the irradiations are carried out at room temperature (or even much lower) several overlapping changes take place. One way to eliminate some of the undesirable effects is to do the irradiations at a very low temperature. For this reason an apparatus is being built which will allow samples to be irradiated in NRU at about -450°F.

4.32 In another research a study is being carried out to discover why certain steels become more brittle under irradiation. Another kind of brittleness is that associated with the formation of inert gases in metals, such as helium in beryllium. The behaviour of these inert gases in metals is being investigated in detail. While brittleness is not a major concern with Zircaloy, it is a major disadvantage in certain other materials, so a better understanding of the phenomenon could also have a practical value.

(c) Chemistry

4.33 The many and varied research and development projects demand a great deal of chemical analytical support. Many of the analytical problems require that new and improved methods be worked out. For example the Zircaloy corrosion program requires the determination of hydrogen in the metal. A method had to be worked out and equipment built. In order to satisfy these demands there is a separate analytical group that concentrates on the development of new methods and the more difficult routine work. Instruments that can save manpower or give more accurate results are used wherever possible.

4.34 Many research programs in chemistry are being carried out, some of which are in collaboration with physicists and other scientists. One such research was to determine the nuclear properties of certain fission products which slowly built up in a fuel element. This also has a practical application by allowing the reactor designers to estimate the fuel life more accurately.

4.35 This same requirement of being able to estimate fuel life accurately is the basis for another research problem. Here, samples are cut from a highly irradiated fuel rod and are first examined by the reactor physicists in the PTR reactor. The chemists then take over and analyze the samples. The combined results give a much better understanding of reactor physics. Most of this type of work has been on the current natural uranium fuels, but work is starting on other fuels such as enriched uranium, plutonium and thorium.

4.36 An extensive research program on the chemistry of water under irradiation has been carried on ever since the Chalk River project started. More recently, with the interest in other coolants, the program has turned toward organic liquids. Various liquids are being irradiated under carefully controlled conditions with gamma rays from cobalt-60 and in the Van de Graaff generator. The object is to find out the basic mechanism by which the organic molecules break up, and this in turn might lead to ways of slowing down the decomposition. A number of interesting observations have been made and the work is continuing.

Research and Development Contracts

4.37 In addition to the work carried out at Chalk River, the Chemistry and Metallurgy Division sponsors a number of contracts at certain Canadian universities and industrial companies. The research contracts at the universities are based on a requirement for fundamental information on certain aspects of the development program and on the experience and facilities available at the university. For example a contract was given to the Metallurgy Department at the University of Alberta to study the mutual solubility of oxygen and hydrogen in Zircaloy. These two impurities have an important bearing on the behaviour of Zircaloy in a reactor.

4.38 The industrial contracts cover particular aspects of the development program. The largest of these contracts are with the Canadian General Electric Co. Ltd. and AMF Atomics (Canada) Ltd. for the development of CANDU fuels. The two companies are approaching the design from different directions, thus making it possible to select the best design for the reactor.

BIOLOGY AND HEALTH PHYSICS DIVISION

Director	-	Dr. G. C. Butler	Branches -
Staff	-	Professionals: 25	Radiation Hazards Control
		Technical Staff: 77	Radiation Dosimetry
		Other Staff: 14	Environmental Research
		Prevailing Rate: 86	Biology

5.1 The Biology and Health Physics Division has four main functions:

(a) to advise management on all aspects of radiation safety and contamination control;

(b) to carry out applied research and development on improved methods of electronic and chemical dosimetry, warning devices, decontamination, waste management, etc.;

(c) to carry out basic research on the biological effects of ionizing radiations and the use of radioisotopes in biological and environmental studies;

(d) to operate the Project's decontamination and film-dosimetry services.

5.2 Many of the Division's responsibilities are fulfilled through joint effort of members of the different branches; the Division, moreover, works in close co-operation with the Medical Division.

5.3 For many years the chief Canadian source of expert knowledge on the biological effects of radiation and on the control of radiation hazards has been at Chalk River. For this reason, the advice and assistance of the Biology and Health Physics Division has been sought continually by other Government departments, private industries, the armed services and the universities. Although some of this burden is now being assumed by qualified experts in other organizations, the great increase in the use of radioactive isotopes in research and industry, the participation of private industry in reactor development, and the increased public awareness of hazards from fallout, all contribute to demands for services and advice from this Division.

5.4 The educational activities of the Division include:

(i) a one-week course in health physics for industrial physicians and safety engineers (twice a year);

(ii) a similar two-day course for students of the Joint Atomic Biological and Chemical Defensive Warfare School, Department of National Defence (twice a year);

(iii) a one-week course in contamination control and decontamination techniques for NCO's and officers of the RCEME (twice a year);

(iv) lectures and laboratories on Health Physics in the Chalk River Reactor School;

(v) lectures at the Civil Defence College and for other organizations as required;

(vi) training in radiation safety for all Company employees.

5.5 Committee work on a national and international scale is an inevitable result of the need for safe standards of radiation protection and improved methods of detection and measurement. Among the national committees in which members of this Division participate are the following:

(i) Reactor Safety Advisory Committee (Atomic Energy Control Board);
(ii) Radiation Advisory Committee (Department of National Health and Welfare);
(iii) Radiation Protection and Treatment Panel (Defence Research Board);
(iv) Panel on Toxicology (Defence Research Board);
(v) Electronic Components Research and Development Committee (Defence Research Board);
(vi) Subcommittee on Electronic Materials (Defence Research Board);
(vii) Tripartite Cooperation Program Sub-group L, Electronics Materials (Defence Research Board);
(viii) Advisory Committee on Entomological Research (Defence Research Board);
(ix) Committee on Labelling and Marking of Radioactive Shipments (Canadian Standards Association).

5.6 International groups in which the Division is represented are the following:

(i) International Commission on Radiological Protection
  (a) Committee on Radiobiology
  (b) Committee on Waste Disposal;
(ii) World Health Organization Expert Advisory Panel on Radiation;
(iii) International Atomic Energy Agency Panel on Disposal of Radioactive Waste to the Sea;
(iv) United Nations Scientific Committee on the Effects of Atomic Radiation;
(v) USAEC and American Institute of Biological Sciences Committees on Radioepidemiology;
(vi) Committee of Consultants on Genetics, U.S. National Institute on Neurological Diseases and Blindness.

5.7 The Division collaborates closely with national and provincial Departments of Health, the Atomic Energy Control Board and the armed services on all matters relating to radiation safety. It also freely provides advice to Government organizations and universities who are initiating research in radiobiology or with radioisotopes. In return, the Company has benefitted by assistance from various departments in carrying out meteorological, hydrological, geological and land-use surveys in the vicinity of Chalk River and other reactor sites. In addition, The Canadian Broadcasting Corporation and National Film Board frequently seek the Division's advice on the preparation of programs and films dealing with the effects of radiation on man.

5.8 Assistance to industry is provided in various forms. Engineers from the Radiation Hazards Control Branch frequently give advice on ventilation, shielding and contamination control to companies handling radioactive materials. Technicians from this Branch have also been called on to perform contamination and radiation surveys for some of our contractors. When these programs are continuing the Division has given advice on the organization of radiation-safety procedures and the selection of personnel to do it. Companies such as Canadian General Electric and Ontario Hydro which work closely with AECL on reactor development frequently call on this Division for advice on safety features of reactor design and waste management.

Radiation Hazards Control

5.9 Advice on radiation safety and control of contamination in day-to-day operations throughout the Project is provided by the Radiation Hazards Control Branch. In addition to their supervisory duties, the professional group (all fully qualified engineers) advise management on such matters as shielding, ventilation, building layouts and safe operating procedures. Members of the technical staff (Radiation Surveyors) are always present at any potentially hazardous operation and advise the operators on the level of radiation present, safe working times and the necessity for additional shielding, respirators or protective clothing. The non-technical Contamination Monitors do continuous surveys for radioactive contamination and call in trained Decontamination Operators to clean contaminated areas as required.

5.10 The excellent radiation safety record of AECL (no lost-time injury in 15 years) is largely due to the activities of the Radiation Hazards Control Branch and the cooperation it receives from operating personnel throughout the Project.

5.11 The RHC Branch also operates the Project Decontamination Centre, a small "factory" to which all contaminated clothing, equipment, apparatus, machinery, etc. is sent for cleansing to safe levels. During 1959, materials valued at $1,476,000. were decontaminated in the Centre and less than $3,000. worth had to be disposed of as unrecoverable. The annual cost of this operation for materials and labour is approximately $100,000.

5.12 Provision of effective respirators and protective clothing is another function of this Branch. After use, all respirators are decontaminated, checked for faults, re-assembled and returned to the operating areas. Improved respirators have been developed through the cooperation of the Defence Research Chemical Laboratories, and improved protective clothing in cooperation with private industries.

5.13 Experience with major contamination incidents at Chalk River has shown that much still remains to be learned about methods of decontamination. Washing and mopping large areas of floor or walls by hand is both laborious and time-consuming. For this reason the Branch is developing an automatic floor washer which retains the contaminated water for safe disposal. Another recent development is a mobile change room which may be moved to contaminated areas to provide showers and change facilities for contaminated workers.

5.14 Another important function of the Radiation Hazards Control Branch is the provision of a training course in radiation protection for all new employees, and frequent lectures and demonstrations of the principles of radiation hazards control for employees of longer standing.

Radiation Dosimetry

5.15 In any atomic energy establishment, effective control of radiation hazards depends largely on the efficiency of instruments or other devices used to detect and measure radiation or radioactive contamination. Many of the instruments required for this purpose are not commercially available or, if they are, they are unreliable or unsuitable. The Radiation Dosimetry Branch is responsible for recommending suitable instruments for use by the Radiation Hazards Control Branch. Improvement in these instruments and development of more useful models is the chief task of the Dosimetry Branch. The results of this work are made available to organizations cooperating with AECL such as Canadian General Electric and Ontario Hydro. Among the instruments recently developed are:

(i) Ambient Radiation Monitor. To detect and record changes in atmospheric radioactivity at points up to several miles from operating reactors, e. g. the Chalk River reactors and the NPD reactor near Rolphton.

(ii) Personal Warning Dosimeter. This device, worn by the employee, is pre-set to determine when a man has received a specified safe level of radiation. At that time an alarm sounds, warning the wearer to leave the area immediately.

(iii) Portable Contamination Detector. This device is much lighter and more compact than the previous model. It also may be used under conditions of high humidity.

(iv) Doorway Monitor. This instrument is used to detect contaminated persons who are entering a clean area. It is not affected by slow changes in activity (e. g. when active gas from the reactor passes overhead) but sets off an alarm when a person walking by is carrying more activity than that found in luminous dial watches.

(v) Battery-operated Transistorized Pulse-Height Analyser. This instrument is used to determine the nature of radioactive contaminants at points where an electric power supply is not available.

(vi) Total-Body Counter. This Company's total-body counter was built and is operated by the Radiation Dosimetry Branch for the Medical Division. The device consists of a heavily shielded small room in which a subject sits while electronic devices determine the amount and kind of fission products present in his body. An added refinement has been the development of a total-body scanner which locates ingested contaminants within the body.

(vii) Atmospheric-Radon Detector. The radiation hazard in uranium mines depends primarily on the concentration of radon gas and its particulate daughter products. Members of the Dosimetry Branch developed an atmospheric-radon detector for estimation of the hazard. This development has enabled the mining industry to determine when improved ventilation is necessary for the protection of the workers.

5.16 The Radiation Dosimetry Branch is also responsible for the film badges worn by all employees while at work. These films are developed by the film service at weekly or fortnightly intervals and the radiation dose is recorded. During the past year only one employee received more than the maximum permissible annual dose of five roentgens (he received 6.7R)and the average dose for all 2,400 employees was 0.72R. Although overexposures such as the one mentioned above are not serious, any employee receiving more than the permitted maximum is removed from work with radioactivity and given other duties until his average rate of exposure is reduced to 5 roentgens per year.

Enviromental Research

5.17 The major interest of the Environmental Research Branch is to protect the public from any health hazards that might arise from atomic-energy operations. At AECL this responsibility is met by advising the operating branches on the safe management (i.e. containment or controlled dispersal) of solid, liquid and gaseous wastes.

5.18 To ensure that safe standards are maintained and that the results of operations are satisfactory, this Branch conducts extensive surveys of the environment in areas surrounding the Chalk River Project and the NPD reactor site near Rolphton. Samples of soil, water, and plants and animals from the areas for the disposal of solid and liquid wastes are continually monitored for radioactive contamination. Records of disposals to the ground are kept and supplied to the Department of National Health and Welfare. The rate and direction of ground-water movement from such disposals is under continuous study. To date the concentration of radioactive contaminants in the one stream draining the area has never been greater than one-quarter, and on the average one-twentieth, of the maximum permissible level in drinking water for those who work with atomic energy. The concentration of radioactive materials in the process sewer from the Chalk River plant is not permitted to rise above this level. This extremely low concentration (10^{-6} $\mu c/ml$) is then further diluted by the water of the Ottawa River which flows past the Plant at an average rate of ten thousand million gallons per day. Analyses of river water are routinely reported to local officers of health. Additional scrutiny of the river is provided by routine sampling of bottom sediments, fish and other animals at numerous stations as far as twenty miles downstream from the Project. This study has been carried on for many years and thus far it has failed to reveal in bones of pickerel more than one-tenth of the concentration of Strontium-90 permitted in the bones of atomic-energy workers. It has never been possible to detect Strontium-90 in the flesh of these fish.

5.19 In addition to routine monitoring, the Environmental Research Branch carries out an extensive experimental program. Some of this work is described below:

(i) Lately it has recently become evident that the release of radioactive iodine constitutes the greatest hazard from internal contamination during reactor accidents, but little is known of the form in which it is released or of the routes through which it enters the body. Investigations at Chalk River have shown that iodine escapes both in particulate and gaseous form and that it may enter the body through the skin as well as by inhalation. These findings have obvious implications for our respirator and protective-clothing program.

(ii) The detection of trace amounts of many of the rare radioisotopes is not easy. The well-established techniques of analytical chemistry are often not applicable; where they cannot be suitably modified, new methods must be developed. New techniques for the detection of radioactive sulphur and tritium have recently been published by members of this branch.

(iii) The fate of fission products in fresh waters is being investigated in a study of the uptake of radio-strontium by fish. Previous workers have assumed that such uptake would occur through the food chain. Studies at Chalk River have shown that several environmental factors may influence the rate of uptake and that, in waters of low salt content, an appreciable proportion of the strontium may be absorbed directly through the gills.

(iv) Small-scale movements of ground-water are being investigated in connection with present and future experimental disposals of fission products in glass blocks. These movements have proved to be extremely complex, but the simultaneous use of three radioactive tracers (H-3, Si-85 and S-35) and one dye (fluorescein) has greatly facilitated the experimental program.

Biology

5.20 The Biology Branch is chiefly concerned with research on the effects of radiation on living organisms although some work is directed towards the use of radioactive isotopes in biological investigations. Two of the latter studies are carried on in cooperation with the Department of Agriculture (research on life cycles and migrations in insects) and the Department of Northern Affairs and National Resources (research on movement of sap in trees).

5.21 Of major interest is the effect of radiation on the heredity of living organisms and particularly on man. In all organisms so far investigated, increases in radiation have caused genetic changes (mutations), most of which are harmful. In order to assess genetic effects on man we need two basic pieces of information about human populations: we must know what is the natural mutation rate and we must know whether various hereditary defects are maintained in the population by mutation or selection - i. e., whether families with hereditary defects have larger or smaller numbers of children. These problems are being attacked by modern data-processing techniques in collaboration with the Dominion Bureau of Statistics, the Department of National Health and Welfare and the British Columbia Department of Health.

5.22 Since man is not an experimental animal, most of our information on the effects of radiation must come from investigations on lower forms of life. Our studies include the following:

(i) radiation resistance in mouse cells in tissue culture. Occasional resistant cells occur naturally in otherwise sensitive cultures. These tend to survive heavy irradiations, and resistant cultures can be grown from them. They are different from the parent strains in being resistant to ultra-violet light as well, and in having fewer chromosomes. The work may throw some light on the development of resistance to radiation in cancers during radiation therapy;

(ii) genetic effects of radiation in yeast populations. In these experiments millions of rapidly reproducing individuals may be studied in short periods of time. Sexual reproduction in yeast is similar to that of higher organisms;

(iii) reversible and irreversible effects of radiation in insects. The insects under study were selected because the time of cell division can be controlled. Most radiation damage is expressed at that time;

(iv) biochemical effects of radiation in nucleic acids and in the synthesis of enzymes in mammalian cells;

(v) the effect of radiation on learning ability, fertility, etc., in rats over a number of generations. Populations in which the male reproductive tissues are exposed to high doses (400 to 800R) in each generation tend to have reduced learning ability; however, this might perhaps be an effect of the reduced litter size and the resulting difference in prenatal environment, and further experiments are needed to settle the point. In addition, there is a higher proportion of dwarf animals in the irradiated populations;

(vi) protection against radiation effects by the use of parathyroid extract injected before and after irradiation. Treatment with this material doubles the survival rate in rats exposed to high doses of radiation.

5.23 All of the work of this branch is published in the open scientific literature and presented at scientific meetings.

OPERATIONS DIVISION

Manager	-	Mr. D.D. Stewart		Branches -
Staff	-	Professional	88	NRX Reactor
		Technical Staff	19	NRU Reactor
		Other Staff	37	Reactor Technology
		Prevailing Rate	161	Reactor Loops
				Chemical
				Production Planning and Control
				Reactor Training

6.1 The Operations Division has the responsibility of maintaining in continuous service some of the larger experimental facilities at the Chalk River project. These include the larger reactors, NRX and NRU, the two Van de Graaff machines, the chemical-processing plants and related control laboratories, and some of the shielded hot cells. Much of this program requires staff twenty-four hours a day, seven days a week. Although the Division is supported by other Divisions, such as Engineering Design and Engineering Services, it in itself is a service organization to the requirements of the Research groups.

NRX Reactor

6.2 This 40 MW reactor was commissioned in 1947 and has been recognized over the succeeding years as one of the world's finest research reactors, providing large experimental facilities with high intensities of neutrons. Initially the reactor was designed to provide facilities for fundamental research and for isotope production. A chemical-processing plant was provided to recover plutonium from the spent fuel elements. Significant contributions to knowledge have resulted from the numerous and varied experiments carried out using the reactor. The facilities to produce isotopes were extended and improved, and the production of cobalt-60 provided the Commercial Products Division with an excellent product for world-wide sale. The high neutron intensities in the core of NRX enable cobalt-60 with a particularly high specific activity to be made, material of great value for beam-therapy units used in hospitals.

6.3 In the early 1950's development work on nuclear power reactors increased greatly, and resulted in the exploiting of NRX facilities for a purpose never envisaged by the original designers. This involved replacing a fuel rod with a tube that could be connected at both ends to an external system to form a closed circuit or loop. The loop contained pumps and heaters so that water at power-reactor conditions of $500^{\circ}F$ and $2000\ lb/cm^2$

could be circulated through the tube in the reactor. This tube could then be loaded with fuel elements at power-reactor ratings and studies made of the fuel behaviour under power-reactor conditions. At the present time six such loops are in operation in NRX, all containing pressurized water as the coolant. A seventh loop will soon be commissioned and will use an organic liquid as the coolant. These loops are large installations, require considerable operation and maintenance effort, but have provided invaluable information for the power-development program. In most cases the costs of installation and operation are shared by AECL and either the United States Atomic Energy Commission or the United Kingdom Atomic Energy Authority. In like manner the planned programs are agreed to be of mutual interest and the results of the experiments are shared.

6.4 The NRX Reactor supervision is also responsible for the routine operation and maintenance of the two Van de Graaff Generators. The newest of these, a 10 MeV tandem machine, was first operated in 1959. These machines are in constant use by physicists and chemists for various fundamental research programs.

NRU Reactor

6.5 NRU was first operated in November, 1957. It is more complex and much larger than NRX, producing 200 MW rather than 40 MW. The staff required to maintain this unit is therefore considerably larger. NRU is a triple-purpose reactor: it produces plutonium in the irradiated uranium rods which at present are shipped to the USAEC under contract, it provides excellent facilities for research and for loop studies, and in it are produced large quantities of radioactive isotopes. Two water-cooled loops are in operation and a third, steam-cooled, loop is being investigated for possible future installation. Since the neutron intensity is five times than in NRX, it produces cobalt-60 of high specific activity in considerable quantities.

6.6 NRU uses heavy water for both coolant and moderator, whereas NRX uses it as the moderator only. This results in a much larger inventory of heavy water in NRU, approximately 70 tons, but permits the higher power output and neutron intensities to be achieved. NRU was the first reactor, at least in the western world, to permit satisfactory removal of fuel elements during operation at full power.

Reactor Technology

6.7 This group evolved from one whose principal responsibility was studies in reactor safety. The present duties include safety studies on reactor systems and experimental auxiliaries, but extend to a wide range of technical problems which arise in the day-to-day operation of the two reactors. The engineers in this group are experienced in reactor operation and can undertake various studies that are not so readily handled by those with direct responsibility for regular operation of the reactors.

Chemical Branch

6.8 In 1949 the solvent-extraction plant was commissioned to recover plutonium from spent NRX fuel. This plant is now obsolete since both NRX and NRU fuel are shipped to the USAEC for processing. Chemical laboratories are maintained, however, for routine analyses as required by the reactors, by waste-disposal facilities, etc. Two universal cells or shielded rooms are staffed to provide for the examination of irradiated fuel elements and for the routine recovery of cobalt-60 from reactor rods, with subsequent transfer to smaller capsules after standardization. A "waste farm" disposal system is operated to monitor and control the disposal of liquid wastes containing radio-activity from the entire project.

Reactor Loops Branch

6.9 The group was established in mid-1959 to coordinate various phases of the loop program. This type of development work had by then expanded to such an extent that better coordination of the many facets, from design to operation, appeared essential. The Reactor Loops Branch has responsibility tc act as the agent for the customer, usually the Division which will be the loop's chief user, and to ensure that the design, fabrication, testing, and commissioning stages are followed through as efficiently as possible. This responsibility also extends to ensuring that the finished equipment does in fact provide the facilities required originally by the customer.

6.10 The branch works closely with the Reactor Operating Branches to ensure that existing loops are continually improved and interfere to a minimum with continuous reactor operation. In addition the histories and performance of various components are assessed and resultant data are relayed to the design organizations.

Production Planning and Control Branch

6.11 This group provides the following general services to the entire Operations Division:

(a) Scheduling of experiments going into reactors and universal cells from AECL, UK, USA, and other foreign countries.

(b) Procurement, storage and accounting for fissionable and fertile materials.

(c) Arranging shipment of fuel, isotopes, heavy water, etc., to USA, UK, India, Europe, or wherever required.

(d) Liaison with the Commercial Products Division in Ottawa.

(e) A stenographic pool.

Reactor Training

6.12 One engineer is now employed in this work. Of recent months most of his time has been devoted to the preparation of lectures for the newly established Chalk River School on heavy-water reactors. Previously this branch was responsible for some of the training of new Operations engineers and operators through lecture courses, etc. Most of this training must of necessity be on the job. In 1958 thirty Indian engineers came to Chalk River for a training period of fifteen months. These men were the responsibility of the training supervisor and have since returned to India to be associated with the operating staff of the Canada India Reactor.

ENGINEERING SERVICES DIVISION

Manager	-	Mr. J.W. Davidson	Branches -
Staff	-	Professional 30	Building Maintenance and Construction
		Technical Staff 6	Maintenance & Power
		Other Staff 74	Transport
		Prevailing Rate 725	Workshops Estimating and Planning

7.1 The main function of this Division, to provide essential services to all Project branches, has not changed over the years, but the method of providing this service has altered. In order to service the expanding Project efficiently without a corresponding increase in service personnel, all installation and fabrication that can be handled by outside firms is being contracted out. This change achieves better use of the professional engineers, technicians and craftsmen responsible for installation, modification and repair of Project facilities. At the same time it provides an opportunity for industrial firms to gain experience in nuclear engineering.

7.2 The Engineering Services Division's most important task is to do work where specific knowledge and skills associated with nuclear work are required. It has many other responsibilities: maintenance of buildings, roads and grounds; operation of the power house and all standard plant machinery; transportation of employees to and from the Project; assembly and inspection of reactor fuel elements mainly for the NRX and NRU reactors; the fabrication of prototype equipment and the supervision of service work contracted to outside firms. These diverse functions require the work of the separate branches to be efficiently integrated and call for close co-operation between individuals in the various branches.

7.3 On the staff of this Division are most of the prevailing-rate employees in the Project. The number of these employees has remained fairly constant during the past two years because of the increased use of outside firms for Plant installations. Although the method of organization and operating philosophy is patterned to a large extent on normal industrial practice, the complexity of the Division's work necessitates the use of more professional engineers than one would find in a comparable industry.

Building Maintenance & Construction Branch

7.4 The main functions of this branch are the maintenance of Plant buildings and grounds and the construction or alteration of buildings and facilities. The construction carried out by the branch is limited mainly to those jobs which, due to radiation, contamination or other reasons, the Company does not find feasible or economic to sub-contract to outside firms. In general, large construction projects are let out to contract but are supervised by professional engineers of the branch.

7.5 The value of work undertaken by contractors for the fiscal year 1959-60 was approximately $2,200,000.00 as compared to $900,000.00 done by the branch itself.

7.6 Major construction projects carried out under contract were the ZED-2 reactor and a new building to house all branches of the Biology and Health Physics Division. Typical examples of the work carried by the branch with AECL construction forces are the erection of a shielded dry-box line for handling highly radioactive metallurgical specimens, and the construction of a bay to handle and store rods from the NRX reactor. The latter project involved extensive work on the old contaminated bays, and was carried through without any over-exposure to radiation of the tradesmen concerned.

7.7 The branch is responsible for the upkeep of the roads, the maintenance of fire trails throughout the 17 square miles of surrounding bush country and the supply of all janitor services for the Plant buildings. The branch operates a laundry service for contaminated clothing, and is responsible for the disposal of solid waste products. The disposal of radioactive waste requires the maintenance of large disposal facilities consisting of concrete, wood and sand trenches located well away from the main Plant area.

Maintenance and Power Branch

7.8 This branch provides mechanical, electrical and instrument service. It is responsible for the production and distribution of Plant services such as steam, water, air, electricity and also liquid nitrogen.

7.9 It is divided into three groups - Mechanical, Electrical and Instrumentation - each headed by a professional engineer. The groups are further broken down into specific and very specialized sections to handle the complex service requirements of the research program. Crews consisting of the more skilled craftsmen are maintained in the NRX and NRU Reactors to cope with the day-to-day problems as well as major installations for the reactors and research experimental equipment. Because of the nature of the work, the branch has on its establishment a greater number of professional engineers than would normally be found in a comparable industry. This is more so in the Instrumentation Group because of the complex control circuitry required for the safe operation of the reactors and the numerous and diverse items of electronic equipment used in an establishment doing nuclear research. These latter items in particular call for an efficient and strong maintenance force.

7.10 The installation of all the NRX high-temperature, high-pressure experimental loops used for irradiation experiments is an example of large projects carried out by this branch. In line with AECL policy of interesting outside industry in nuclear installations, the NRU Loops were contracted out but the installations were supervised by branch engineers.

Transport Branch

7.11 The location of the Project makes it necessary for the Company to operate a bus service for its employees living in Deep River, Chalk River, Pembroke and intermediate points. The Transport Branch has a fleet of 40 buses for this purpose. The fleet has operated for 15 years and during that time has travelled approximately 5,000,000 miles with only one accident in which passengers were injured. There have been no fatalities.

7.12 Transport also operates a fleet of 30 trucks and 6 passenger cars to supply trucking and personnel requirements for the Plant. A repair shop is operated to carry out preventive maintenance, repairs and overhaul not only of the buses, cars and trucks but also of the diesel- and gasoline-powered stationary and portable engines located throughout the Project.

Workshops, Estimating and Planning Branch

7.13 The main functions of this branch are to operate two large machine shops as a general plant service and provide estimating and scheduling for construction and fabrication. One of the machine shops is located close to the reactors and deals with jobs and materials directly associated with radiation. The other shop is in the so-called "inactive" area.

7.14 Men skilled in all mechanical trades are trained in the special problems encountered in nuclear work. For example, special attention is given to fabrication of vessels to withstand corrosion, - the welding of new alloys such as Zircaloy-2 is undertaken, - and special tools for the maintenance and repair of the reactors are made.

7.15 Over the last few years the demands on the machine shops have increased considerably. These have been met partly by a small increase in manpower but mainly by contracting more and more work to commercial shops. In the calendar year 1959 work in excess of $250,000 was contracted out.

7.16 The fabrication of complete fuel rods for NRX and NRU is now done by a Canadian supplier, except for nickel-plating and final assembly of NRU rods, which are carried out by the branch. The responsibility for supervision of the supplier and inspection of the finished rods also rests with the branch.

7.17 The Estimating and Planning section prepares detailed estimates on all major work orders and construction projects. For such major items the preparation of an accurate time schedule, involving the different phases of design, procurement, construction, installation and testing is a necessary and important task and is logically associated with the preparation of estimates.

ENGINEERING DESIGN AND APPLIED DEVELOPMENT DIVISION

Manager	- Mr. R. D. Sage		Branches -
Staff	- Professional:	58	Engineering Design
	Technical Staff:	77	Applied Engineering Development
	Other Staff:	18	

8.1 This Division provides engineering assistance - mainly mechanical, electrical and civil - to all other Divisions at the Project. The work is mostly the design of modifications to existing facilities and the design or development of new ones.

8.2 The Division has a staff of engineers, located in a central design office, capable of handling design projects covering a broad field of engineering. They design nearly all the experimental equipment required for basic research associated with the reactors. They are also constantly engaged in the detailed design of new systems and components required to advance reactor technology.

8.3 The Division also has a Mechanical Development Laboratory which houses testing and inspection equipment required throughout the Project. A small amount of development work is carried out, mainly in mechanical and electrical engineering. The majority of the work, however, is associated with testing and proving equipment designs. A small group is employed on inspection and quality control of fabricated equipment and supplies.

8.4 Large design projects are generally carried out by consultant firms and administered by a project engineer, who is responsible for supplying the consultant with the engineering requirements. He also acts in a liaison capacity between the consultant and the division requiring the project. The following are examples of projects in this category that are under way or have been recently completed:

(a) ZED II Reactor - This is a zero-energy experimental research reactor to be used in studying lattice spacings for fuel assembles in large power reactors. Some novel design features include: a very fast dump system which is used to shut down the reactor; a remotely controlled lattice-changing mechanism capable of handling a wide variety of fuel-rod designs; removable graphite reflector sections that can be replaced with other types of reflectors; and an efficient drying system to remove all traces of heavy water quickly and allow easy changing of fuel assemblies.

(b) Plant to Produce Active Glass - A design study has been completed by an engineering firm on the feasibility of constructing a plant to produce glass bricks in which radioactive wastes are incorporated by a process developed by the Chemistry and Metallurgy Division. The study is being evaluated before a decision is made to proceed with the actual plant.

(c) Additional Boiler House Capacity - A firm was retained to do the engineering required to increase the steam-generating capacity of the boiler house. The design called for converting four existing small coal-fired boilers to oil and installing an additional large coal-fired boiler in an extension to the building.

Canada-India Reactor

8.5 The Canada-India reactor is nearing completion at Trombay in India. This Division has been responsible for supplying the design concepts and engineering requirements to the Shawinigan Engineering Company who were retained as the "Engineer". A project engineer of AECL's Design Branch has been responsible for the general administration of this design and particularly for checking and approving all drawings and specifications produced by the Shawinigan Engineering Company to see that they meet reactor requirements. The basic design of CIR is similar to the NRX reactor except that CIR is housed in a steel pressure shell rather than a conventional building, and that it is cooled by recirculated distilled water which in turn is cooled by salt water. These differences have required a great deal of additional design effort. A number of smaller differences exist but these are mainly associated with the technological advances made since NRX was designed. Some additional research facilities have also been included to make CIR even more versatile than NRX.

8.6 The Foundation Company of Canada was retained to supervise the construction of the reactor in India. In the early stages of construction, when the steel shell was being erected, a number of difficulties arose that caused lengthy delays. These difficulties were mainly due to inexperience in building a structure of this type. Equipment and facilities in India were also not up to Canadian standards. Once the building had been erected, the installation of the reactor and associated equipment proceeded at a satisfactory pace.

8.7 This Division has a technical representative in India supervising the testing of the various systems and components. These tests are being carried out by the Shawinigan Engineering Company to check their design.

Engineering Design Branch

8.8 The function of the Engineering Design Branch is to provide design and drafting requirements for the Project. It also gives engineering liaison between other branches and outside engineering organizations. The branch is divided into six main service design groups: nuclear, reactor, chemical, civil and mechanical, electrical and instrumentation, and the drawing office.

8.9 A broad variety of engineering problems - some of them unique - are encountered. A large number of design requests are constantly being undertaken involving alterations to the NRX and NRU reactors. Other types of work concern engineering studies on the high-pressure, high-temperature loops. Research and experimental equipment is designed for use in conjunction with the Tandem Accelerator, Van de Graaff, PTR, ZEEP and other facilities. Design analyses and specifications are produced for the general engineering requirements of electrical power distribution, instrumentation, building heating, ventilation and civil work, etc.

8.10 A drawing office of approximately 70 people is maintained to provide drafting service. Technical illustrators and tracers are also employed to prepare graphs and illustrations for engineering and scientific reports. This section also records and issues all drawings and blueprints for the Plant.

Applied Engineering Development

8.11 The function of the Applied Engineering Development Branch falls into three general categories: inspection and testing facilities required throughout the Project; development of mechanical equipment and the proving of designs by mock-up; and engineering studies establishing development programs for the advancement of engineering techniques pertaining to nuclear reactors and associated equipment. A small electronic computer is used to assist in these studies. The branch is divided into three main groups:

(a) Mechanical Laboratory - This section is responsible for project inspection. It supervises and maintains all mechanical testing facilities including a large hydraulic test rig for flow studies on fuel rods. It is also responsible for assembling and testing equipment as designed by other engineers in the Division.

(b) Development Design - This section is responsible for the engineering assessment of new requirements relating to existing reactors; it carries out engineering studies pointing out the development and design areas most likely to succeed, but does not take them beyond the proposal stage once it is satisfied with feasibility. It has only recently been formed and its first three projects are a new control-rod mechanism for NRU, a new activity-monitoring system for NRU, and a method of disposing of combustible radioactive waste by incineration.

(c) Experimental Development - This group is responsible for the experimental work required to obtain information on which a design can be based. For example, considerable effort is spent on developing equipment and methods of inspecting fuel assemblies accurately and quickly since the operating efficiency of all the Chalk River reactors depends to a high degree on the integrity of the fuel. A number of inspection instruments have been developed to determine such variables as bond strength of fuel sheaths, length of uranium sections after cladding, thickness of sheaths and defects in the sheaths and uranium cores.

REACTOR COMMISSIONING DIVISION

Manager	-	Mr. F. W. Gilbert	
Staff	-	Professional:	3
		Others:	1

9. 1 The Reactor Commissioning Division was established in June, 1959. To date it has handled a number of functions in the Company and works largely through the assistance of members of other Divisions and by the use of borrowed staff.

9. 2 As the name implies, one of the chief functions is the commissioning of reactors. In this regard, it has direct charge of the commissioning and initial operation of the C. I. R. reactor. It has also undertaken to investigate problems that may arise on the operation of the CANDU and NPD-2 reactors.

9. 3 The Division also has the job of organizing the Whiteshell Nuclear Research Establishment.

C. I. R. Reactor

9. 4 As the C. I. R. reactor is nearing completion, more of the work done by AECL is being transferred from the Engineering Design and Applied Development Division to the Reactor Commissioning Division. At present, the Canadian commissioning staff in India consists of one superintendent, four engineers and two operators. These will ultimately be augmented by the addition of eight more operators, one physicist, one control instrument expert, and one additional operating engineer.

9. 5 These men, working with the Indian staff, have started doing performance tests on the reactor components and will ultimately bring the reactor critical and up to power. It will be turned over to the Indians when it is mutually felt that the reactor is performing properly and the Indian staff is competent to operate the reactor. The present schedule calls for bringing the reactor critical sometime in June and it is expected, barring unforeseen difficulties, that it will reach its full power of 40 MW in September.

9. 6 The design of the C. I. R. reactor follows closely the NRX reactor, but has one major difference: it will be cooled with sea water. The sea water cannot, however, be circulated directly through the

reactor and a primary coolant (distilled water) is used for this purpose instead; the sea water then cools the distilled water in heat exchangers. It is expected that there should be very little trouble in bringing the reactor into operation.

9.7 The C.I.R. design has also been altered slightly to make it more useful for performing loop experiments. All the design alterations that have gone into the improvement of the NRX reactor have been incorporated in the C.I.R. reactor.

NPD-2

9.8 There are two agreements covering the NPD-2 reactor. One is a three-party agreement involving The Canadian General Electric Co. Ltd., the Ontario Hydro Electric Power Commission, and Atomic Energy of Canada Limited covering design and construction. It is being administered by the Nuclear Power Plant Division.

9.9 A second agreement covers the operation of the reactor, and the Reactor Commissioning Division is responsible for its administration. As only one man is employed full time on this work, it is necessary that he obtain help from other Divisions.

9.10 In addition, this man has been studying the NPD-2 design very carefully from an operating standpoint in an effort to discover where possible troubles might arise during the commissioning and start-up. Design and construction are now near completion and it is not expected the study will lead to any design changes. However, it is hoped that it may help in the early detection of causes of any troubles should these arise during commissioning. It is also hoped that it will show some of the places to be investigated in order to prevent future troubles or increases in the cost of operation.

CANDU

9.11 Very little work has been performed by the Division on CANDU. Personnel in the Division are keeping themselves informed on the design so that they may give assistance when requested.

Whiteshell Nuclear Research Establishment

9.12 The Division is coordinating all the work at present in progress towards the development of this new reactor research establishment. A site has been chosen in Manitoba, chiefly on the right bank of the Winnipeg River just below Seven Sisters Falls. It occupies approximately 11,000 acres, most of which are owned by the Manitoba Government.

9.13 It will be necessary to provide residences for the employees. At present Central Mortgage and Housing Corporation are investigating the problem and two approaches are being considered. One is to attach the new housing to existing towns in Manitoba: Beauséjour and Lac du Bonnet are possibilities. The other approach is to establish a new town, and several sites are being investigated. Central Mortgage and Housing will submit a report when their studies are complete.

9.14 A consulting engineering firm has been retained for the development of the plant site. It in turn has employed other engineering firms from Winnipeg. Site surveys, including drilling and seismographic studies, are in progress.

Review Committee on Reactor Safety

9.15 As part of the program to ensure that there will be no reactor accidents causing damage to people or property, a committee has been established within the Company to study reactors not investigated by the Reactor Safety Advisory Committee of the Atomic Energy Control Board. This committee reports to the President. It is made up of experts who are not closely concerned with the design and operation of the reactors, and to date it has reviewed and made recommendations on the PTR and the ZED-2 reactors. It will, in the near future, undertake to review the safety of the ZEEP and C.I.R. reactors. Some idea of the magnitude of this type of job may be gauged from the fact that the C.I.R. Hazards Report in its draft form consists of about 400 pages not including charts and reference reports.

- 10.1 -

NUCLEAR POWER PLANT DIVISION

Manager -	Mr. H.A. Smith	Manager, Douglas Point Project -	
	Professional 49*		Mr. J.S. Foster
	Technical Staff 22	Manager, NPD-2 and Advanced Projects -	
	Other Staff 33		Mr. C.A. Grinyer

* Including 15 contributed by Ontario Hydro and 7 by Canadian industry.

Formation of the Division

10.1 After completing a feasibility study on a nuclear power demonstration plant at the end of 1954, the Nuclear Power Group, a team of engineers from the power industry who were stationed at Chalk River and who functioned as a branch of AECL, made preliminary studies of the application of natural-uranium-fuelled, heavy-water-moderated reactors for large nuclear power stations. In the spring of 1957 the group produced a report NPG-10 - "Report on a Study of a Full Scale Uranium Heavy Water Nuclear Power Plant" - which described a 200-megawatt station using a pressure-tube reactor. The report forecast the economic application of "post-development" versions of such a plant to a system such as Ontario Hydro's.

10.2 Based on this report, AECL decided to undertake the design and development of a full-scale nuclear power station of this type provided at least one Canadian electric utility had sufficient interest to participate and share in the cost of the work. Of all Canadian utilities, Ontario Hydro has conditions most favourable for the economic application of a nuclear plant. It has requirements for units of large capacity, a high rate of load growth, low rates of fixed charge on capital, diminishing hydraulic resources, lack of indigenous fossil fuels and extensive capacity for uranium production within the province. Ontario Hydro was one of several companies participating in the studies at Chalk River, and it was one of the partners in the NPD-2 project, which had developed from the feasibility study completed in 1954.

10.3 Ontario Hydro decided to extend its activities in developing nuclear power by offering to collaborate in this next phase under the AECL program. Based on the assumption that AECL would establish a new division in Toronto, Ontario Hydro offered to assist in management of the division, to provide up to fifteen engineers at no cost to AECL, to provide suitable office accommodation, and to make the services of its engineering organization available to the division at cost. This offer was accepted by AECL, and on February 1, 1958 the Nuclear Power Plant Division was formed and located in Toronto to carry out the work.

10.4 The new division was made responsible for all of AECL's specific project work directed towards development of economic nuclear power. In this capacity, in addition to performing and directing the design and development work for the full-scale plant, it assumed responsibility (formerly borne by other divisions of AECL) for the administration of the NPD-2 project and technical liaison for it. It is now also responsible for the direction of the organic-cooled heavy-water-moderated reactor concept (OCDRE).

Staffing the Division

10.5 To disseminate knowledge of nuclear power as widely as practicable throughout Canadian industry, AECL solicited professional staff for the division from utilities, manufacturers, and consulting engineering organizations. This staff was to be contributed at no cost to AECL or, if more than one person were provided by a firm, on the basis of reimbursement for one employee for each one contributed.

10.6 Experts from other countries have also been attached to the Nuclear Power Plant Division. Since May 1959 the UK Atomic Energy Authority has had a representative working as a member of the Division, and the Division has had two members working on advanced reactor projects at the UKAEA Industrial Group Headquarters at Risley. Throughout 1959 the Swedish State Power Board had an employee attached to the Division's staff and will be sending a second man to replace him. The United States Atomic Energy Commission has posted a liaison officer with the Division, and the du Pont Company has seconded a man under the auspices of the US-Canadian agreement for co-operation on heavy-water reactors. In the near future Euratom is sending two representatives to work in the Division.

Douglas Point Project

10.7 Initial work by the Nuclear Power Plant Division consisted of studies of plant and reactor arrangement, of steam cycles, and of computations for selection of optimum major plant parameters such as reactor dimensions, the primary heat-transport system and the steam-cycle conditions. This optimization entails the solution of many involved simultaneous equations and is best performed numerically using an electronic digital computer. This work was done on the Datatron Computer at Chalk River using programs developed by the Reactor Research and Development Division. It was carried out under the guidance of the Nuclear Power Plant Division and with input data provided by this Division. Considerable assistance in treatment of the reactor physics was given by the Chalk River staff.

10.8 It was originally intended that the Nuclear Power Plant Division should complete the design and development phase of the full-scale station (known as CANDU) so that fixed-price bids could be obtained on all components and an accurate total cost of the station and the estimated cost of power could be given before a decision was taken on whether or not the station should be built. It was estimated that this design and development phase would take about three or four years to complete. However, in July 1959 the government decided to authorize construction of CANDU to begin immediately in order to gain experience with a full-scale plant. AECL will pay for the cost of the station except for staff and services provided by Ontario Hydro. Ontario Hydro will operate the plant at maximum practical capacity factor and will purchase the power from the station at the appropriate rates at which it would otherwise have to pay to obtain the equivalent power from other sources. After the station has demonstrated its performance, Ontario Hydro will purchase the station from AECL for a sum calculated to represent the worth of the station to Ontario Hydro taking into account its performance, the cost of fuel, the capital charge rates, the cost of alternative coal-fired energy sources and other similar factors.

10.9 A suitable site for the station was chosen by Ontario Hydro with AECL concurrence at Douglas Point on the eastern shore of Lake Huron between Port Elgin and Kincardine in Bruce County, Ontario. Purchase of the 2300-acre site was completed by February 1960, and clearing of the site began in the same month. Because of its location, the station has now been called Douglas Point.

10.10 Engineering work has continued in the Nuclear Power Plant Division and, since September 1959, in the Ontario Hydro engineering division as well. In January 1960, an order was placed for the turbo-generator set, the first and largest single item of equipment for the station. The design and development of the major components for Douglas Point are being worked out in close collaboration with Canadian manufacturers, but it is the policy to order these components, where possible, by competitive tender with fixed-price bids. We hope to have the site cleared, roads built and the construction plant ready by the end of 1960. Civil construction can then start in January 1961, and we hope it will be finished by December 1962. Equipment will start being installed in June 1962, and be all in place by February 1964. Commercial operation is planned by 1965.

- 10. 4 -

The Cost of Douglas Point (as of January 1960)

Site costs, Land and Improvements	$ 877,000	
Building, Structures & Shielding	5,009,000	
Reactor Boiler and Auxiliaries	11,196,000	
Turbine-Generator and Auxiliaries	7,145,000	
Electrical and Instruments	6,100,000	
Common Processes	3,330,000	
Construction Plant and Indirect Charges	3,284,000	
Heavy Water, Helium and Organic fluids	11,677,000	
Purchasing, Inspection, Accounting and Insurance	1,561,000	
Sub-total		$ 50,179,000
Contingency (see Note 1)	$ 8,567,000	
Sub-total Plant and Equipment (1960 dollars)		$ 58,746,000
Escalation (based on 3% price increase per annum)	$ 4,163,000	
Sub-total Plant and Equipment		$ 62,909,000
Engineering	$ 8,150,000	
Commissioning, including training	1,250,000	
Interest during construction (see Note 2)	$ 9,198,000	$ 18,598,000
Total Cost of Plant (see Note 3)		$ 81,507,000
Initial Fuel - including Contingency and Interest	$ 4,605,000	

- 10. 5 -

Unit Energy Cost

10. 11 Assuming that the plant is built for the estimated cost of $81, 507, 000 and the initial fuel charge costs $4, 605, 000, it is estimated that at 80% load factor the net unit energy cost from this plant in the Ontario Hydro system will be in the range of 6 to 7 mills per kilowatt hour. The final energy costs are dependent upon the actual interest rate experienced during construction and the lifetime interest rate in effect when the plant commences operation.

10. 12 The above estimate relates to a one-reactor station (200 MWe) The savings that would result from duplicating this reactor (of the same design) on this site would be substantial in unit capital cost and in unit operation and maintenance costs and would show significant reductions (12% to 15%) in unit energy costs.

10. 13 In estimating unit energy costs, the following factors have been used:

Computation Factors

Asset Lives (see Note 4)

Reactor Components and Fuelling Equipment	15 years
Heavy Water	40 years
Other Plant, including 1/2 fuel charge	30 years

Fuel inventory bears interest charges only.

One-half initial fuel charge is capitalized.

Unit Fuel Cost

Fuel Cost (see Note 5)	$30/lb.
Poison Limit Burnup	9750 MWd/tonne
Station Efficiency	29. 1%
Unit Fuel Cost	1. 11 mills/kWh.

Unit Operation and Maintenance

Annual Operation and Maintenance Cost

100 operators at $10, 000/yr. (including overhead)	$ 1, 000, 000
Outside services	100, 000
Heavy-water replacement and upgrading	200, 000
Supplies	98, 000
Interest on fuel inventory	32, 000
Total Annual Operation and Maintenance Costs	$ 1, 430, 000
Unit Operation and Maintenance Cost at 0. 8 Load Factor	1. 02 mills/kWh.

- 10.6 -

10.14 Notes to tables on the preceding pages:

1. The large contingency item of over $8 million may be taken as an indication of the uncertainties of equipment costs. A considerable portion of this will be for manufacturing development work.

2. Interest during construction calculated, for the purposes of this estimate, at 5-3/4% on escalated values, assuming money is supplied as required.

3. Research and development expense is planned in addition to the above estimate. This research and development cost will be met partly from AECL's regular development program at Chalk River and partly as a direct charge against the Nuclear Power Plant Division. This total program may amount to $9 million in the four-year period from January 1960.

4. This plant is specifically designed for replacement of reactor components. Thus, the 15-year life for the reactor is consistent with a 30-year life for Other Plant.

5. This estimate applies to initial fuel (exclusive of development costs); subsequent fuel price should fall to the region of $24/lb.

- 10.7 -

Effect of Varying the Interest

10.15 The effect of varying the average lifetime and construction-period interest rates, treating the latter on both the Ontario Hydro basis and the AECL basis and relating these variables to a one-unit and a two-unit station is shown in the following table:

Average Lifetime Interest % per annum	Interest during construction % per annum	Unit Energy Cost	
		One-unit station mills/kWh	Two-unit station mills/kWh
4-1/2	4*	5.81	5.00
	5-1/4**	5.96	5.14
5	4	6.02	5.18
	5-1/4	6.18	5.32
6	4	6.46	5.56
	5-1/4	6.63	5.72

* The 4% interest rate is believed to be the rate which Ontario Hydro are currently using for interest during construction. The amount of interest during construction associated with this rate is derived according to the Ontario Hydro practice of assuming funding simultaneous with expenditure.

** The 5-1/4% interest rate is the rate recommended by the government; the amount of interest during construction associated with this rate is derived on the basis of funds being allocated semi-annually to meet expected expenditures in the ensuing six-month period.

NPD-2 Project

10. 16 This Nuclear Power Demonstration project is being built at Rolphton, some 20 miles west of Chalk River on the Ottawa River. It is a joint project of AECL, Ontario Hydro and Canadian General Electric Co. Ltd. AECL is providing research and development data and is paying for the nuclear portion of the plant. Ontario Hydro is providing data for the conventional portion of the plant and is paying for that part of the station; CGE is responsible for the design, development and construction of the station and is making a $2 million contribution towards the cost. Ontario Hydro will operate the station when it is completed and will pay AECL for the power produced.

10. 17 In November 1957, a major design change was agreed as desirable by all parties concerned. The original design (NPD-1) incorporated a pressure vessel for the pressure system. The study of a full-scale plant had meantime shown that pressure tubes were better for large reactors. The demonstration reactor was therefore changed to pressure tubes (NPD-2) to make it a better prototype of the full-scale plant. The delay in completion and the increase in cost were considered fully warranted.

10. 18 NPD-2 is cooled and moderated with heavy water, and fuelled with natural uranium. It produces 20, 000 kilowatts of electricity and incorporates many of the features that AECL, over the years, has established as necessary to a successful competitive design of power reactor. This will be the first time that all these features have been incorporated in one design and therefore its importance to the Canadian atomic energy program cannot be over-emphasized. Whilst the technical aspects, reliability of operation and safety will be domonstrated, the unit cost of electricity produced will be high because the size of a reactor plant plays a very important role in the economy achieved.

10. 19 The pressure tubes of the reactor are horizontal and the fuel will be uranium oxide rather than metal as is used in NRX and NRU. There is an arrangement by which fuel can be changed whilst the reactor is on full power thus eliminating shutdowns and the costs inherent to such operation.

10. 20 The revised construction schedule for NPD-2 estimated a completion date of December 1960 with the first full-power test by mid-1961. Present forecasts indicate site construction progress close to schedule with some delays on equipment manufacture but with full expectation of operation by the summer of 1961.

10. 21 The number of people employed directly as of January 31st, 1960

on the NPD-2 project by contractors are as follows: -

CGE Management and professional	127
CGE technical and workmen	133
Contractors staff and workmen on site	125
Total	385

It is not possible to give the number of people engaged by subcontractors on material and equipment supply but CGE have estimated that over 400 Canadian companies will have contributed in some way to the project.

10. 22 The estimated total cost of the NPD station including the money spent on the earlier NPD-1 version is $32, 250, 000, of which $13, 535, 772 had been disbursed at the end of January 1960. The breakdown of the estimated cost is as follows:-

AECL	- $ 21, 652, 000
Ontario Hydro	- $ 8, 598, 000
CGE	- $ 2, 000, 000
Total	$ 32, 250, 000

OCDRE

10. 23 For stations smaller than 200, 000 kilowatts electric, a heavy-water-moderated reactor using natural uranium as fuel but cooled with an organic liquid looks promising. The capital cost per kilowatt of the station should be substantially reduced. Besides saving the cost of the heavy-water coolant, the use of an organic coolant enables higher temperatures in the reactor to be reached at lower pressures so that the pressure system is materially simplified. The neutron economy for this system is, however, not as good as for a heavy-water-cooled reactor and the fuelling costs are therefore somewhat higher. On balance, acceptable power costs from a developed station are likely to be achieved.

10. 24 A number of technical aspects of an organic-cooled reactor are not yet well known. For example, the effects of the chemical breakdown of organic coolants under the intense radiation and high temperatures are

not fully determined. The formation of by-products and the possibility of deposits on the metal surfaces need to be better understood before full confidence can be placed in this type of reactor system. In addition to research and development studies being carried out at Chalk River, a preliminary design and development contract has been placed with Canadian General Electric to study the technical aspects of a heavy-water-moderated organic-cooled reactor system. A preliminary report will be available by August 1960 which will include a cost estimate for an experimental reactor of this type. This report will assist in the decision as to when such an experimental reactor should be built.

10. 25 A co-operative program has been arranged with the United States Atomic Energy Commission and Atomics International (a subsidiary of North American Aviation) the main contractor for the USAEC in the work on organic-cooled reactors.

Advanced Projects

10. 26 This group in NPPD is assembling staff and will carry out the investigation of improvements to existing reactor concepts of interest to Canada and the engineering investigation of new reactors in collaboration with the Nuclear Engineering branch at Chalk River. In addition, it will direct contracts of a development nature involving investigation and experiment in areas not of immediate application to existing designs.

International Engineering Co-Operation

10. 27 With the development of nuclear power programs in Canada and other countries, the international interchange of engineering information is expanding. The NPP Division has been given the responsibility for co-ordinating this exchange of information on the engineering side. In this way, engineering experience gained in other countries and of value to the Canadian program is obtained and at the same time the promise of the Canadian type of reactor system is made known to technical experts in other countries. Specific programs are under way with the U.S., the U.K. and Euratom.

Appendix 11 - 11.1 -

COMMERCIAL PRODUCTS DIVISION

Manager	- Mr. R.F. Errington		Branches -
Staff	- Professional	53	Works
	Technical Staff	41	Production - Development
	Other Staff	70	Special Assignments
	Prevailing Rate	76	Sales
			Administration & Finance

11.1 This Division, located in Ottawa, is responsible for the production, processing, and marketing of radioisotopes produced in the Company's nuclear reactors. Requirements for these products are at present small in Canada, so a major part of the Division's sales is to foreign markets. In the case of almost every product handled, volume is very important. The Division therefore must maintain a high export volume if prices charged Canadian users are to be reasonable, and this we have managed with some success to do. In order to carry out the program effectively, it has been necessary for the Division to develop processes and equipment accessory to the use of radioisotopes. This has enabled us to provide assistance to customers, and to increase the actual and potential market for radioisotopes.

11.2 It should be noted that, because of the nature of the business and the low volume of Canadian requirements, little or no competition exists between the activities of the Division and Canadian private enterprise.

Origins of the Division

11.3 The Commercial Products Division was originally a part of Eldorado Mining and 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 NRX reactor 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.

11.4 At the time of transfer of the Division it was recognized that circumstances did not permit an operation that 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.

11.5 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.

What Are Isotopes?

11.6 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. Isotopes of the same element have different numbers of neutrons in the nucleus. The term "isotope" was derived from the Greek words for "same place" since isotopes of an element occupy the same place in the periodic table of elements.

11.7 The isotopes the Commercial Products Division offers are virtually all radioactive. They are generally produced either by fission of uranium 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 (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 the radiography of metals and tracing of stoppages in pipelines. Radiation is absorbed by various substances. This property leads to its application in therapy, where energy is absorbed in tissue and breaks down the cell structure. Fortunately, cancerous tissue is more radio-sensitive 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.

Implications of Half-Life

11.8 Some isotopes decay slowly and thus have a long "half-life".

These can be 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 offered by the Division are classified in a 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, if 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 its adequate detection without introducing expensive radiation-protection problems.

Uses of Radioisotopes

11.9 Radioisotopes have a multitude of uses. The cigarettes we smoke have almost certainly been packaged with the help of radioactive density gauges. Weekly newspapers have probably been printed with the help of radioactive static eliminators. Luminous compounds help us to see watches or clocks at night. Experiments on fertilizer up-take improves the economics of agricultural products. Food and other packaged goods are checked for fullness and uniformity of packaging. Loading of tooth-paste into tubes is checked by radioactivity. Pulp and paper mills employ radioactivity to improve mill operation. Oil and natural-gas wells are logged with portable sources of neutrons, and pipeline stoppages are located by radioactive tracers. Castings and weldments are checked for flaws by use of radioactive sources. Automobile engines, tires, and lubricants are improved following wear tests using radioactive tracers. Insect pests are eliminated by radioactive techniques, notably the screw worm in southern United States. Radioactive batteries, with long life and small size, find special uses in satellites.

Where the Division's Products Go

11.10 Business is obtained in Canada and the United States primarily by mail, personal contact, and some advertising. Some non-exclusive commission agents are also used in the United States. In other countries similar methods are used but, in general, sales are made via local agents operating with a commission. Selling problems arise from USAEC and UKAEA offering similar radioactive products and from commercial firms in all major foreign markets offering similar accessory equipment. Customs duties, availability of dollar exchange, and the premium of the Canadian dollar must be dealt with in essentially all foreign sales. On the whole, AECL prices are slightly higher than those of our competitors; however, the high specific activity, purity and service offered by CPD seem to more than compensate for this in the minds of our customers.

- 11.4 -

11.11 Products have been sold to 50 countries and major products to 32 countries. The Table below indicates the relative amounts of revenues obtained in Canada, the United States, and other countries.

Year	Canada %	United States %	Other Countries %
1952-53	42.8	52	5.2
53-54	34.5	49.6	15.9
54-55	30.7	43.5	25.8
55-56	33.1	42.3	24.6
56-57	15	35	50
57-58	14	37	49
58-59	18	46	36
59-60 *	8	47	45

* Estimated for full year to March 31, 1960

The proportion sold to particular areas in the "Other Countries" group varies from time to time. Selling efforts must be adjusted currently to local conditions, having in mind the probability of results.

11.12 Cobalt therapy machines for the treatment of cancer are notable examples of accessory equipment specially developed to use radioisotopes. This development was purely Canadian at the outset although it has since become worldwide. It has directly and indirectly accounted for the principal amount of the Division's revenue and, in fact, has accounted for more than half of all the curies of radioactivity sold by Canada and the United States since radioisotopes were offered for sale. Atomic Energy of Canada Limited has sold and delivered about 180 therapy machines to 28 countries. On these machines it may be conservatively estimated that hundreds of thousands of patients have been treated, no doubt with a fair percentage of cures or palliative effect. It should be noted that there are now more than twenty industrial firms throughout the world manufacturing beam-therapy units, and that the high volume of the Division's business has been obtained against stiff competition from both public and private enterprise.

11.13 A later example of market development via design and manufacture of equipment is the Atomic Energy of Canada Limited Gammacell 220, first offered in 1959. At present 12 of these are in service in 8 countries, thus promoting a market for substantial amounts of cobalt-60 of low specific activity.

11.14 There is at present a surplus of cobalt-60 in the world although combined annual shipments by Canada and the United States have grown from about 16,000 curies in 1953 to nearly 500,000 curies in 1959.

Finances

11.15 It has been considered desirable for the Division to carry on its activities as close to a commercial basis as possible. Generally, programs are not undertaken unless they appear to have a definite benefit to Canada or unless they can be expected to yield adequate revenue from foreign sales, thus providing employment and experience for Canadians. The Division therefore operates as a financial entity within the Company. The system provides for cost accounting and pricing on a commercial basis. In order to achieve results in the face of foreign competitors, it is necessary to have an active sales force capable of achieving results.

11.16 The Commercial Products Division includes Administration, Sales, Development and Production departments. It operates on a basis of advance of money from the Company's main office for capital and operating requirements. Revenues from the sale of products constitute the primary source of income. Products and services obtained at Chalk River are paid for by the Division. Some general data covering the operation of the Division since it became a part of AECL in August 1952 are listed below.

	Revenues	Costs	Profit
1952-53*	$ 418,000	$ 428,000	($10,000)
53-54	868,000	928,000	(60,000)
54-55	1,180,000	1,176,000	4,000
55-56	1,556,000	1,499,000	57,000
56-57	2,075,000	2,119,000	(44,000)
57-58	2,424,000	2,425,000	(1,000)
58-59	2,384,000	2,657,000	(273,000)
59-60**	3,150,000	2,750,000	400,000
Total	$14,055,000	$13,982,000	$73,000

* 8 months
** Estimated to end of March, 1960

11.17 The position as of January 31, 1960 was as follows:

- 11.6 -

Capital Assets at Cost	$ 2,675,000	
Less Depreciation	852,000	
Net (book value)	1,823,000	$ 1,823,000
Other Assets (cash, receivables & inventory)		3,204,000
Total Assets		$ 5,027,000
Total money advanced from main office August, 1952 to January 31, 1960		$ 4,993,000

Inventories are considered to be conservatively evaluated.

The over-all position since August, 1952 has thus been to show a small profit.

Savings from Using Radioisotopes

11.18 The real value of isotopes to the economy of a country is by no means in the production and sale of them. As a rule, only a small amount of radioactive material is used. To the cost of this will be added the cost of measuring and similar equipment which is usually several times the cost of the isotope. In various applications, they provide for enormous cost saving to the user.

11.19 No data are available to show savings to the Canadian economy resulting from the use of isotopes. Estimates of dollar savings annually in the United States have been made by several organizations. As early as April, 1956, Commissioner Willard Libby of the USAEC stated: "Isotopes have already proven to be of great benefit to mankind and by them alone it is clear enough that we will be repaid for all of the effort and expenditures made to date on our gigantic atomic energy project. Even if atomic power and the other peaceful uses were never to materialize, and even if there were no use in armaments, we could still calculate our benefits from isotopes to be a fair return on the dollar investment made." Annual dollar savings to the economy in the United States run to $1 billion at present and the USAEC has estimated possible savings annually by 1962 of up to $5 billion. If we scale down the current United States estimate, we get an indicated annual saving for Canada of some $65,000,000. Even if these figures are optimistic by a wide margin, it is apparent that isotopes are doing a job far beyond the indications from the volume of business in them. In the above, no account has been taken of the values resulting from the treatment and detection of diseases.

Significance of Commercial Products Division

11.20 The Division is valuable to Canada because it provides a service to Canadian users of isotopes both in respect of supplying material and also by way of advice on what materials will be useful in particular applications. Its export activities bring in revenue and provide employment for most of its 240 employees. Export of such items as cobalt therapy machines has also provided much favourable international advertising for Canada and has emphasized Canada's role in peaceful applications of atomic energy.

11.21 The far-sighted approach to the radioisotopes program by AECL management has had the result that, in each year since 1954, commercial revenues of the Division have exceeded revenues from commercial sales as published by the USAEC for the Oak Ridge National Laboratory. 1959-60 revenues for the current fiscal year are likely to exceed those of ORNL by well over 50%.

Appendix 12

MEDICAL DIVISION

Director -	Dr. C. G. Stewart	Branches -
Staff -	Professionals: 3	Village Hospital
	Part-time Professionals: 2	Plant Hospital
	Technical Staff: 35	Medical Research
	Other Staff: 11	
	Prevailing Rate: 9	

12.1 The Division is primarily responsible for the provision of medical care to the employees of the Company at the Project and for the provision of hospital services to the population of the village of Deep River. The Division, working closely with the Biology and Health Physics Division, advises management on matters pertaining to the protection of personnel from exposure to ionizing radiation. It is responsible for the assessment of the degree of internal contamination with radioactive materials of all individuals working in the project. It collaborates with other departments of government and with industry, assessing human internal contamination with radioactive materials for many of them.

12.2 The main source in Canada of expert knowledge on the biological effects of radiation and on the practical control of radiation hazards has been at Chalk River. This Division and the Division of Biology and Health Physics continually act as advisors to other departments of government, private industry, and armed services and universities. The educational activities of the Division include contribution to:

(1) A one-week course in health physics for industrial physicians and safety engineers given twice a year.

(2) A similar two-day course for students of the Joint Atomic Biological and Chemical Defensive Warfare school of the Department of National Defense, given twice a year.

(3) Lectures given to the Chalk River Reactor School.

(4) Lectures on radiation hazards, their origin and assessment, given to senior technical and trades personnel of the Company.

12.3 The Division is represented on and contributes to national and international committees concerned with radiation safety. Among the national bodies on which the Division is represented are:

(1) Reactor Safety Advisory Committee (Atomic Energy Control Board).

(2) Radiation Advisory Committee (Department of National Health and Welfare).

(3) Panel on Radiation Protection and Treatment (Defence Research Board).

(4) Committee on Atomic Warfare (Defense Research Board).

12.4 The International bodies on which the Division is represented include:

(1) Committee II of the International Commission on Radiological Protection on Permissible Dose for Internal Radiation.

(2) World Health Organization Expert Advisory Panel on Radiation.

(3) Joint World Health Organization - Food and Agriculture Organization Expert Committee on Radiochemical Methods of Analysis in Health Studies.

(4) World Health Organization Expert Committee on Medical Supervision of Radiation Work.

12.5 The Division, in conjunction with the Biology and Health Physics Division and with some employees of Rio Tinto Ltd. and Eldorado Mining and Refining, has undertaken to do radiation surveys in some of the large uranium mines operated by Eldorado Mining and Refining Ltd., and to advise the National Department of Health and Welfare and the Ontario Department of Mines on methods, procedures, and standards for control of the radiation hazard in uranium mines.

Deep River Hospital

12.6 This is a private hospital, operated by Atomic Energy of Canada Limited, to provide medical care for the population of the village of Deep River. In actual fact it serves as the general hospital for the larger population living along Highway 17 in the 60 miles from Petawawa to Bisset's Creek. The Medical staff consists of five full-time practising doctors, including a fully trained general surgeon and an internist. In addition the hospital has the part-time services of a fully qualified radiologist. Until October 1st, 1959 these doctors were all employees of Atomic Energy of Canada Limited. At that time, the five full-time physicians elected to go into private practice, and rent office space and services from the Company. One of the five physicians now in private practice continues to act as Medical Superintendent of the Hospital on a part-time basis.

12. 7 The standard of care in the hospital is very high; this is evidenced by the fact it is the only private hospital in Canada that has received full accreditation by the Joint Commission on Accreditation of Hospitals. In fact the Deep River hospital is the only fully accredited hospital between Ottawa and North Bay. Contributing to this recognition are not only the standard of training of the medical staff, but also the fact that only graduate nurses are employed, and that the facilities for surgical, X-ray, and laboratory procedures available in this hospital are considerably greater than those usually associated with hospitals of this size in Canada.

12. 8 The magnitude of the operation in the Village during the past four years may be assessed with the aid of the following table:

TABLE I

DEEP RIVER HOSPITAL OPERATION 1956-1959

	1957	1958	1959
IN-PATIENTS			
Number of Admissions - Adults and Children	857	951	1089
Newborn	204	202	252
Average Occupancy(1) - Adults and Children	50.3%	50.5%	70.8%
Newborn	34.5%	32.5%	41.5%
Procedures carried out in hospital departments			
Operating Room	570	680	867
Laboratory	7748	9256	11,483
X-Ray Department (including B. M. R.(2), E.C.G.(3) and Diathermy)	1678	1787	1926
Source classification of ALL patients (Adults, children and newborn)			
AECL employees and their dependents	63.9%	60.8%	56.8%
Construction workers and their dependents	4.9%	1.7%	5.3%
Others (CPR, Hydro, Army, CGE(4), etc. and their dependents)	31.2%	37.5%	37.9%
OUT-PATIENTS			
Visits to Doctors' Offices (including house calls)	13,948	15,193	17,000(5)

Notes to Table I

(1) Percent of total accommodation in the hospital occupied, averaged over the year.

(2) Basal Metabolic Rate measurements.

(3) Electrocardiograms.

(4) Canadian General Electric employees.

(5) Records for 1959 are available to October 1st only. To that date (9 months of 1959) actual visits totalled 12,708. The figure given in the table (17,000) is the expected value for the 12 months.

12.9 It is apparent from the table that the work load in all departments of the Village Hospital is increasing. The single parameter most indicative is average occupancy for adults and children. The 70.8% figure for 1959's average occupancy implies the hospital frequently operated above its rated capacity, and on many occasions there was not a bed available for admission.

The Plant Hospital

12.10 The main function of the Plant Hospital is supervision of the health of personnel employed at the Project. The branch advises management and labour on matters related to the medical care of employees and on the medical supervision of those who work with radiation. It maintains liaison with professional medical societies, health and welfare agencies, private medical practitioners locally, and with specialist practitioners in universities and in the larger medical centres in Canada, in the interests of employees and management of the Company.

12.11 Pre-employment medical examinations, including blood and urine analysis and chest X-rays, are carried out on all employees. The Laboratory analyses are normally carried out at regular intervals on all employees; in the event of an accident, or any medical indication, specific examinations and analyses are carried out on any employee at any time.

12.12 In addition to employees of the Company, a relatively large number of construction workers, scientists, engineers, and research fellows from other organizations, together with nationals of other countries working in the Project are examined and treated for on-the-job accidents and illnesses. 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 make use of it; serious injuries or illnesses are referred to the Deep River Hospital or to Pembroke hospitals for further care. The Plant doctor is available to all workers in the Project during the working day for special consultations.

12.13 This branch of the Division has certain responsibilities and opportunities peculiar to the operation of an atomic-energy project. In spite of all precautions, accidents occur that lead to contamination by radioactive materials of the body surfaces and internal organs of workers. In most instances these contaminations are minor and can be dealt with by the wash-up facilities provided in each laboratory building. If these simple measures prove inadequate, the Plant Hospital is responsible for the execution of further decontamination. For this purpose a separate, self-contained personnel-decontamination unit is incorporated into the Plant Hospital building. The basic design features of this unit have now been incorporated into the construction of a number of similar personnel decontamination units in hospitals in several other countries.

12.14 The branch has devised and instituted within the Project an emergency-man-power pool. Utilizing an extension of the Pulhems rating system used by the Canadian Army in World War II, an IBM card has been prepared for each male employee on which is entered information from his personnel, medical, bioassay and film-badge records. Within minutes it is possible to obtain a list of workers at any hour of the day or night suitable for use in various types of emergency, together with the data necessary to contact them.

12.15 The magnitude of the operation at the Plant Hospital during the past four years may be assessed with the aid of Table II.

12.16 It may be seen that the total number of hospital visits and total number of haematological procedures have increased appreciably in the past year. The larger number of days lost in 1957, 1958, 1959 as a result of occupational accident is largely attributable to three employees who suffered severe fractures.

- 12.6 -

TABLE II

PLANT HOSPITAL OPERATION 1956-1959

		1957	1958	1959
Hospital Visits -	New visits - occupational	809	754	854
	New visits - non-occupational	2992	3462	3524
	Re-visits - occupational	807	626	960
	Re-visits - non-occupational	2680	2117	2644
	Total Hospital Visits	7288	6959	7982
Laboratory Examinations -	X-ray	2226	2240	2202
	Haematology	3063	2680	3204
Workmen's Compensation Board -				
Cases reported to W. C. B.		134	134	144
Cases off work one day or more due to occupational accident or illness		29	15	12
Days lost due to occupational accident or illness		416-1/2	440-1/2	434-1/2
Skin Contaminations		63	52	54

Medical Research Branch

12.17 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 degree of internal contamination of humans exposed to radioactivity free in the environment were just beginning to be used. It is therefore natural that this branch of the Division evolved into an organization whose major preoccupations are the assessment of the degree and the control of internal contamination. Until recently research has been directed mainly at devising and improving methods for the measurement of an ever-increasing number of radioelements in human material, particularly urine, and in setting rates of excretion of various radionuclides that are indicative of maximum exposures that may be tolerated with safety. Chemical methods used for the determination of tritium, the radionuclides of cesium, strontium, barium, radium, cobalt, iron and iodine in biological materials have been devised in the laboratory, as well as methods for the determination of the chemically toxic elements beryllium and lead. In collaboration with the Electronics Branch of the

Physics Division, an automatic fluorimeter for the rapid determination of natural uranium in solution has been designed and built.

12.18 The Division has been responsible for there being built in Deep River in 1958 a whole-body counter suitable for the quantitative measurement in humans of minute amounts of γ-emitting radionuclides. The Radiation Dosimetry Branch of the Biology and Health Physics Division has been responsible for much of the design and installation of the instrumentation associated with the counter, and for its day-to-day operation for the medical division.

12.19 In addition to its usefulness in assessing the degree of internal contamination resulting from accidents with radioactive materials, the whole-body counter is presently being used as a research instrument to learn more about the intermediary metabolism of certain of the more important fission products administered in very small quantities to normal human volunteers.

TABLE III

TABLE OF BIOASSAY ANALYSES

Analysis		1957			1958			1959		
		Total Tests	Positive (1)		Total Tests	Positive (1)		Total Tests	Positive (1)	
			Number	%		Number	%		Number	%
Fission (2) Products	Tests	1409	28	2.0	3082	91	3.0	3629	164	4.5
	Cases		21			86			126	
Tritium (3)	Tests	195	2	1.0	799	1	0.1	1633	7	0.4
	Cases		1			1			5	
Iodine (4)	Tests	124	14	11.3	1080	129	11.9	990	155	15.7
	Cases		8			116			117	
Cesium	Tests	65	0	0	44	0	0	20	0	0
	Cases		-			-			-	
Cobalt-60	Tests	70	0	0	32	0	0	17	0	0
	Cases		-			-			-	
Natural and enriched uranium	Tests	162	1	0.6	57	0	0	33	0	0
	Cases		1			-			-	
Plutonium (5)	Tests	524	4	0.8	179	0	0	48	0	0
	Cases		2			-			-	
Radium	Tests	69	1	1.4	20	0	0	42	1	2.4
	Cases		1			-			1	
Polonium	Tests	5	0	0	0	0	0	41	0	0
	Cases		-			-			-	
Misc. β (6)	Tests	29	0	0	32	0	0	29	0	0
	Cases		-			-			-	
TOTALS	Tests	2652	50	1.9	5325	221	4.2	6482	327	5.0
	Cases	161 (7)	34		433 (7)	203		580 (7)	249	

Notes to Table

(1) The term 'positive' indicates samples that contained a significant amount of a particular radioactive isotope. An individual positive at a particular time is removed from exposure to radioactive materials until subsequent analyses show excretion has fallen to negligible levels. Radiation protection procedures in force at the Project have thus far prevented any individual from acquiring even initially a potentially dangerous body burden of radioactive material.

(2) 'Fission Products' analysis measures total radioactive alkaline earths.

(3) Tritium contamination occurs and is measured as the oxide.

(4) Iodine analyses include all the iodine radionuclides in fission products.

(5) Plutonium analyses include thorium, americium, curium, as well as actinium.

(6) Miscellaneous β analyses include RaD + E, Ru-103, 106, Fe-59, S-35 and P-32, as well as gross β-activity determinations.

(7) Total number of cases in a particular year showing a clearly measurable amount of abnormal radioactivity in the urine.

12.20 Whole-body counting for the presence of gamma-emitting internal contaminants began in November 1958. In that year negligible amounts of abnormal radioactivity were found in nine counts carried out on six cases suspected of internal contamination. In 1959, 124 whole-body counts were carried out on 90 cases. The only significant findings are shown in the following table, where the term body burden means the maximum permissible body content of radionuclide (assumed to be all in the critical organ), permitted for continuous exposure by the International Commission on Radiological Protection. Each of the cases in which one body burden was exceeded represented a single dose of Iodine-131 rather than continuous exposure to the radionuclide; the total radiation dose received by the thyroids of these two individuals during the period of decay of the iodine in the gland is considered insignificant.

- 12.9 -

TABLE IV

WHOLE-BODY COUNTS FOR
GAMMA-EMITTING RADIONUCLIDES 1959

Radionuclide		0.1 - 0.5 Body Burden	0.5 - 1.0 Body Burden	1. + Body Burden
I-131	counts	18	2	5
	cases	9	2	2
I-133	counts	-	1	-
	cases	-	1	-
Ru-106[(1)]	counts	8	-	-
	cases	8	-	-

(1) The body burden of Ru-106 was determined by measuring the γ-emission of its Rh-106 daughter, and assuming parent and daughter to be in equilibrium.

ADMINISTRATION DIVISION

Manager	- Mr. T. W. Morison		Branches -
Staff	- Professional	17	Personnel & Office Services
	Other Staff	156	Industrial Assistance
	Prevailing Rate	122	Purchasing
			Security
			Deep River Administration
			Library
			Public Relations

13. 1 The Administration Division provides services of various kinds to the other divisions of the Company. It provides personnel, employee relations and office services, does the purchasing for the Chalk River and Toronto projects, and administers security, fire protection and prevention, and the Library. It is responsible for the operation of Company properties in Deep River including single and married quarters. It also coordinates the Company's industrial and international assistance program, including the Reactor School, and public relations.

Personnel and Office Services

13. 2 The functions of this branch include employment, wage and salary administration, management-union relations, administration of employee welfare and benefit plans, industrial safety, employee and supervisory training, and general office services.

13. 3 The Employment Office is responsible for recruiting new employees. This office also handles much of the administrative details concerning promotions, transfers, reclassifications, employee ratings and terminations. Employees are recruited through visits to educational institutions, newspaper advertisements, the National Employment Service, and direct mail enquiries. A wage and salary administration office assists other divisions in the application of Company wage and salary policies, studies problems and develops procedures. Salary and wage surveys are made, and information on rates and working conditions exchanged with government organizations and private industry.

Unions

13. 4 Contracts between unions and management are in existence covering
- (a) all hourly-paid employees at Chalk River except Security Guards,
- (b) hourly-paid shop employees of the Commercial Products Division in Ottawa,
- (c) salaried technicians, radiation surveyors and inspectors at Chalk River, and
- (d) salaried draftsmen at Chalk River.

The hourly-paid employees at Chalk River are represented by ten separate craft-type local unions who negotiate jointly and are covered by a single collective agreement. Separate negotiations and contracts are required for the other three unions. The Personnel Office is responsible for preparing background information for negotiations and for the day-to-day operations of the contracts.

Employee Welfare

13.5 The Personnel Office also operates the various welfare plans available to employees. Salaried staff receive generally all of the plans available to the members of the Civil Service, including those provided under the Superannuation Act. Hourly-paid employees are covered under separate plans to cover pensions, insurance, accidents, and sickness. All employees are covered by the Ontario Hospital Insurance plus a Blue Cross supplementary contract to give hospital patients semi-private accommodation and a medical and surgical insurance plan administered by the Mutual Life Insurance Company. In all of these plans the employees contribute part of the cost.

13.6 An apprenticeship-training program for drafting and the skilled trades is operated, and on-the-job training is given to many other classes of employees. A supervisory development program, some of which is conducted outside normal working hours, is also maintained and currently includes case studies of problem situations and related training.

Safety at Chalk River

13.7 A Safety Office, under the direction of a safety engineer, is responsible for an accident-prevention program. The safety engineer acts in an advisory capacity to plant supervision to assist in detecting and eliminating hazards to safety. In addition, he carries out inspections and investigations of radiation, fire, transport and industrial accidents, and handles cases that are to be reported to the Workmen's Compensation Board. A Central Safety Committee made up of senior Company personnel meets monthly to define safety policy and review progress. Safety consciousness is promoted among the employees by safety meetings and through general publicity. All actual and potential lost-time accidents are investigated and the results publicized in order to eliminate accident hazards.

13.8 Generally speaking, the Company has maintained an excellent safety record. There have been two fatalities since the Plant began operation in 1945. With the exception of those years in which there were fatalities, our safety record has been better than average for similar industry on the North American continent. There has not been a lost-time accident due to radiation.

AECL Publications

13.9 The Office Services function of the branch includes the operation of registries for correspondence and documents, a printing section, photographic laboratory, telephone and switchboard, and stenographic services.

13.10 The Scientific Documents Distribution Office sends Chalk River publications to technical libraries throughout the world. Canada, the United Kingdom and the United States co-operate very closely in the technology of heavy-water reactors and a spirit of free exchange is particularly noticeable among the three countries; almost all our reports are available to the US and the UK and, in turn, we receive their documents on exchange. In 1959 Chalk River sent out 25,000 copies of reports describing AECL's work. There were, in addition, 100 articles printed in major scientific journals with a world wide circulation, and close to 500 other reports which, though primarily for internal use, are freely available on request to laboratories whose work parallels our own.

Industrial Assistance and International Co-operation

13.11 The Office of Industrial Assistance was established in 1956 to assist Canadian industry to secure atomic-energy information. Requests for information and assistance from foreign industry and agencies have also been channeled through this office.

13.12 Assistance in addition to the dissemination of information in printed form is extended in the following ways:

(a) Visits - Technical representatives of industries and agencies are encouraged to visit Chalk River and to discuss their problems with experts first hand. There were over 300 such visitors in 1959.

(b) Symposia - Meetings for representatives of industries, government departments and agencies are held from time to time, at which papers are presented by Company and other qualified staff. Last year symposia outlining the Company's atomic-power program were held for Canadian industry, electric utilities and government representatives. A technical symposium took place this year in which some of the special problems involved in fabricating materials and supplies for atomic-energy projects were outlined.

(c) Staff Training - Industries and utilities have been encouraged to send technical representatives to Chalk River and other Company offices for training. Such representatives work directly with Company engineers and scientists and thus gain first-hand knowledge of the theory and application of atomic energy. Since 1956, 78 representatives from 17 Canadian industries and utilities have undergone training at Chalk River.

13. 13 The Company continues to take an active part in the development of international co-operation in atomic energy. Close co-operation with the UK and US continues and there are at present 14 technical representatives from the US and 11 from the UK working at Chalk River and Toronto. Co-operation is also being maintained with many other countries; there have been stationed at Chalk River during the past year representatives from Argentina, Australia, Belgium, Brazil, India, Italy, Japan, New Zealand, Sweden, Switzerland, Turkey and West Germany.

The Reactor School

13. 14 To assist in meeting a world-wide need for training in nuclear science and engineering, a Reactor School was opened in February of this year at Chalk River. Sessions will be of three months' duration and enrolment will be limited to 20 students, with applications accepted only from university graduates. The object of the School is to provide courses that will enable the student to understand the design, construction and operation of nuclear reactors with special attention being given to the natural-uranium heavy-water type. Students attending the first session have come from Canada, Austria, Japan, West Germany and the Philippines. Two of the students are sponsored by the International Atomic Energy Agency.

Purchasing

13. 15 The Chalk River Purchasing Office is responsible for purchasing materials and supplies for all divisions of the Company except the Commercial Products Division in Ottawa. Firm prices are secured in advance on all orders estimated to be in excess of $200 and, whenever there is more than one known supplier, competitive prices are secured. When competitive prices are received, the lowest price is accepted provided that the specifications and delivery time are met. Tenders are called on all construction work being done by other than plant forces, and the contract is placed with the contractor offering the lowest price

provided that the tendering conditions are met. The office is also responsible for customs clearance and recovery of tax rebates where applicable.

13.16 During the fiscal year 1958-59, 22,349 purchase orders were placed. Of these, approximately 20% were for amounts in excess of $200 and represented 90% of the total value of all orders. 12,850 requests for price quotations were sent to suppliers, and approximately 3800 items were cleared through customs. Over 90% of the total requirements of the Project are purchased from Canadian suppliers.

Security at Chalk River

13.17 The Atomic Energy Control Act and the regulations pursuant to it 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 Atomic Energy Control Board has assigned to the Company responsibility for establishing the necessary regulations and procedures and for their enforcement in Company operation. The Security Standards followed 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.

13.18 At Chalk River almost all the work is now unclassified and, therefore, very few classified reports are initiated by the Company, although classified reports are still received from the UK and the USA. As a result, the working areas of the Chalk River Project are now open to any person who requires access in the course of his duties, and the emphasis is on document and information security. Classified documents at Chalk River and elsewhere in the Company are held in special areas to which access is limited

13.19 The Chalk River plant property consists of approximately 8500 acres which is 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 on permanent duty to control entrance to the Project, to prevent theft of Company property, to assist in fire protection and prevention, and to carry out related security duties. Entrance to the Project is controlled by a system of passes and identification. The pass carries a radiation film that provides a continuous record of exposure to radiation.

Fire Fighting

13. 20 A fire-fighting force is maintained 24 hours a day. Since the inception of the Project in 1945, there has been only one serious fire which took place in 1956 when a Health Radiation laboratory burned. Following this fire, building standards and fire-protection measures were reviewed with the Dominion Fire Commissioner of the Department of Public Works. It was recommended that all future buildings should be of fire-proof construction, sprinklers should be installed in present buildings not of fire-proof construction, a separate water-supply system for fire-fighting should be constructed, and a supervisory fire-alarm system installed. With the exception of the sprinkler systems, whose installation is being given a high priority, all other measures have now been taken. Greater emphasis has also been placed on fire prevention. As a result of this and the installations mentioned above, the Company received the Grand Award given by the National Fire Protection Association for Government Agencies in Canada and the United States in 1957, the first prize for Government Agencies in Canada in 1958, as well as the second prize for Government Agencies in Canada and the United States for that year. For the year 1959 the Company was awarded the third prize for Government Agencies in Canada and the United States.

The AECL Library

13. 21 It is extremely desirable that research workers keep informed of work similar to their own that is being done elsewhere. It is the function of the Library to obtain all new publications relevant to the research being done at Chalk River, and to make these readily available to the staff. The most up-to-date sources of recent information are periodicals and short technical reports usually on a single subject. The Library subscribes to 562 scientific periodicals, and now has 6000 annual volumes of back numbers. The Library has 68, 000 technical reports including 27, 000 reports that are produced in microprint. About 17, 000 titles of reports and microcards are added to the collection each year. The Library now holds 30, 000 books, adding about 2500 yearly. The 1960 budget for books and periodicals is about $30, 000; the technical reports are sent free in exchange for similar reports written by AECL staff.

13. 22 As well as serving the needs of AECL staff, the Library fills many requests from Canadian industry that is engaged in atomic-energy programs, and in general acts as Canada's main source of literature on nuclear science. A committee of senior representatives of all

divisions of the Chalk River Project meets monthly to give general guidance to Library operations.

The Town of Deep River

13.23 Deep River was originally developed by the Company to house personnel employed in or associated with the Chalk River plant. It was operated as a Company town from its inception in 1945 until April 1956, when it was incorporated as an Improvement District under Provincial legislation. In January 1959, it was incorporated as a full municipality as the town of Deep River. Following its incorporation as an Improvement District, AECL transferred to the municipality all municipal services including streets, roads, water and sewer facilities, schools and parks. In December 1956, the Company started to sell the houses and as of March 4 of this year a total of 617 units out of 945 had been sold.

13.24 The Company initiated the change in the status of Deep River from a Company town to that of a municipal corporation for the following reasons:

(a) It had been found that where the employer is also the landlord, certain undesirable personnel problems arise.

(b) The residents were denied the usual right of democratic control over their own affairs.

(c) Many employees were anxious to own their own houses and it was not possible under the Company-town arrangement to grant full ownership.

(d) A Company-town arrangement tends to inhibit the normal development of the community and it had been found difficult to encourage private capital to build houses and other facilities. It was believed that if the town was on a full municipal basis the future needs of the residents for housing and other facilities could be met by private capital.

13.25 A review of the results indicates that the change has been successful. The municipality is operating satisfactorily and the residents have shown a great interest in municipal and school affairs. New commercial premises have been forthcoming, but the extent of private building of houses has not been as great as anticipated. There continues to be an acute shortage of houses in the area and, although in the past year considerable private house building has taken place, a larger amount will be required before all local needs will be met.

Housing AECL Employees

13.26 The town has grown by approximately 2000 to a population of 5000 during the last four years. This has produced some acute problems in land development, as much of the land immediately adjacent to the town is not suitable for houses. The development has been orderly and through the existence of building and zoning bylaws the pleasant atmosphere of the town has remained. Provided sufficient private building takes place, it seems clear that the needs of the Project will be better met under the municipal organization than was possible under the Company-town arrangement.

13.27 The Company through its hotel system continues to provide almost all of the accommodation for single persons in the community. In 1959 the Company completed a new 6-storey 200-room residence to replace the temporary dormitories which had been in use since 1945, and to provide more transient accommodation.

13.28 The Company now owns and operates the following properties in and immediately adjacent to Deep River: 328 family dwellings, 3 hotel buildings with a total of 450 rooms and a dining room, a heating plant, a 32-bed hospital, a community centre and associated buildings, 3 bus garages, 3 laboratories, a maintenance shop, part of the original shopping centre consisting of approximately 1200 ft^2, 46 multiple-car garages and approximately 800 acres of vacant land adjacent to Deep River much of which is not suitable for residential development.

Public Relations Office

13.29 The function of the Public Relations Office is to keep the Canadian public informed of the activities of the atomic-energy program. This is done through press releases, assistance to newspapers and magazines, tours of the Chalk River establishment, exhibits at schools, universities, public meetings and exhibitions, descriptive booklets, assistance to radio, television and movie producers, and public addresses. Canada's atomic-energy program is made known to the public in foreign countries through distribution of information to many publications and through exhibits.

Visitors to Chalk River

13.30 During 1959 a total of 4,733 people visited the Chalk River establishment. The visitors come from many parts of Canada and from many countries. A special effort is made to assist high schools and universities, either by providing educational tours of a general nature or by arranging visits to particular parts of the Plant where work related to certain school courses is being carried out. A total of 781 high-school and university students and teachers visited Chalk River during 1959. 690 guests and relatives of employees toured the Plant during the annual Open House. During the summer months, four university students are employed to conduct visitors through the laboratories and reactors.

Exhibits of AECL's Work

13.31 Exhibits of a wide variety are presented, ranging in size from small displays prepared for high schools to larger exhibits such as that shown at the Canadian National Exhibition (2,900 square feet of floor space), which was visited by half a million people. The large exhibits contain realistic, cutaway models of the research and power reactors. There are sections of actual uranium fuel rods, demonstrations of radioactivity, and models of equipment used in the application of radioactive isotopes in medicine and industry. On occasion there have been actual units such as an eight-ton cancer-treatment machine. A display of uranium ores, photographs of the mines, and maps provide information on the Canadian uranium industry.

13.32 While most of the exhibits concentrate on the "ABC's" of atomic energy, presentations of a more technical nature are given at scientific and engineering meetings. Examples of the latter are exhibits at the Annual Meeting of the Engineering Institute of Canada, Toronto, 1959, and at the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958.

13.33 The major exhibits presented during the past 12 months were:
First Canadian Conference on Uranium and Atomic Energy, Toronto;
Atomic Energy Junior Symposium, McGill University, Montreal;
Annual Meeting of the Engineering Institute of Canada, Toronto;
Central Canada Exhibition, Ottawa;
Participation in "Atoms at Your Service", Royal Ontario Museum, Toronto;
Canadian Institute of Mining and Metallurgy, Elliot Lake, Ontario;
Regional Technical Meetings, Engineering Institute of Canada, Ottawa.

13.34 A model of the NPD-2 reactor, together with descriptive panels and photographs, were shown at the Toronto Metropolitan Science Fair, the Sarnia Jaycee Fair, the Champlain Trail Museum in Pembroke, the General Conference of the International Atomic Energy Agency in Vienna, Ontario House in London, the Provincial Science Convention and Fair in Vancouver, Atomic Exhibition in Essen, and in a travelling exhibit in the United Kingdom.

13.35 From 1956 to 1959 an NRX model and a display of photographs of research at Chalk River were shown in a travelling exhibit sponsored by the United Nations Educational, Scientific and Cultural Organization. The exhibit was shown in various cities in France, India, Malaya, Thailand, Vietnam, the Philippines and New Zealand. A large exhibit (5,400 square feet of floor space) will be shown August 20 to September 5, 1960, at the Pacific National Exhibition, Vancouver, B. C.

Broadcasts, Films, Addresses

13.36 Considerable assistance has been given to producers of radio and television feature programs, and the major new developments at Chalk River have been broadcast on radio and television news programs. A 30-minute color film, "Atomic Energy in Canada", was produced in 1958 for AECL by a private company. This film shows the reactors and laboratories at Chalk River, the Canada-India Reactor, the production of uranium metal and fuel rods, and some of the applications of radioactive isotopes. The principles of operation of research and power reactors are presented with the aid of animation and models. The film has been widely shown in Canada and foreign countries. AECL is now co-operating with Ontario Hydro and the Canadian General Electric Company Limited in the production of a film on NPD-2.

13.37 In addition to giving radio and television interviews, AECL scientists and engineers address service clubs, schools and other groups. As an example, five members of the staff gave lectures at the three-day Atomic Energy Junior Symposium at McGill University in January 1960.

Newspapers and Magazines

13.38 Editors and writers are encouraged to visit Chalk River, and a considerable number of them have been given assistance in writing news stories and feature articles. A Power Symposium for Editors and Writers was held at Chalk River May 13 to 15, 1959. Semi-technical and business publications frequently request articles, and the Public Relations Office either writes them or arranges for other members of the AECL staff to do so.

FINANCE DIVISION

Treasurer	- Mr. G.H. Sprague		Branches - Cost Accounting
Staff	- Professional	- 6	General Accounting
	- Clerical and Other	- 63	Internal Audit
	- Prevailing Rate	- 20	Machine and Payroll Accounting
			Stores

14. 1 The Finance Division is responsible for the conduct and control of the Financial activities of the Company. In addition to performing the main accounting functions, the division makes its services available to all branches of the Company where the financial aspects of their operations are involved. Such services may take the form of expense analyses, development of systems and procedures, and special financial studies and investigations.

14. 2 The Division's activities include financial planning and procurement of funds, control of expenditures, and financial reporting. The Company's financial requirements are provided principally from parliamentary appropriations. Each year the company prepares estimates of its cash requirements for the following fiscal year. The requirements for research operations and for research capital purposes are developed separately and are drawn up initially by the individual branches and divisions. The Finance Division reviews and consolidates these estimates. It also develops estimates of the requirements for fundable and working capital. Calculations are also made of the amount of revenue to be earned through Company operations, and this revenue is applied to reduce the requirements from the parliamentary appropriations.

14. 3 After the estimates have been reviewed by management and the Board of Directors, they are reviewed by the Minister, who in turn submits them to Treasury Board. The estimates are later reviewed by parliament and authorized, as in the case of Government departments. As required by the Financial Administration Act, capital budgets are submitted before the first of the year through the Minister to Treasury Board for approval. As an additional control on the capital program, the Company's Board of Directors approves all individual capital projects estimated to cost over $5, 000. When the estimates and budgets have been given Government approval, the Finance Division proceeds to allot branch budgets, to develop forecasts of monthly cash requirements, and to request advances from the Comptroller of the Treasury.

- 14. 2 -

Cost Accounting

14. 4 The Cost Accounting branch was established in 1951 to set up a costing procedure for reactor operations. Since that time a modified process-costing system has been developed along the lines used in the chemical industry. Costs are developed for the various materials produced in the NRX and NRU reactors, including plutonium and isotopes. Costs are also developed for fuel fabrication and for inventories of essential materials. This branch is also responsible for costing certain specialized services such as those provided by the power house, Transport Branch, Deep River Townsite and the Deep River Hospital.

General Accounting

14. 5 The General Accounting branch's responsibilities fall into three main categories. It performs functions connected with the submission of estimates and control of budgets, it maintains controls over expenditures, and it performs the accounting functions applicable to revenue.

14. 6 The preparation of estimates consists of procedures such as consolidation of branch and division submissions, review and scrutiny of the items requested, comparisons with previous years' results, and summarizations for review by management, Board of Directors, and Treasury Board. The control of budgets involves allotment of funds to branches, and analyses of differences between budgeted and actual results.

14. 7 This branch performs a pre-audit of expenditure documents such as contractors' progress claims, suppliers' invoices, and stores issue vouchers. It certified that expenditures are approved by authorized personnel, e. g. , branch heads with signing authority for $300, division heads for $1, 000, Vice-President for $5, 000 and the President for larger amounts. Although the Company's sales are not large in an industrial sense, the revenue and accounts receivable functions are extensive due principally to the Company's housing, hotel and hospital activities.

14. 8 This branch records the results of the financial transactions, and reports and interprets those results through the issue of various financial statements.

- 14. 3 -

Internal Audit

14. 9 Although the accounts of Atomic Energy of Canada Limited are reviewed by the Auditor General who reports thereon annually to parliament through the Minister, the Company maintains an Internal Audit branch as an important phase of its internal control structure. The branch audits all Company transactions, including the project at Chalk River, the Commercial Products Division in Ottawa, the Nuclear Power Plant Division in Toronto, and certain outside contractors. The audit involves an examination of the accounting records and verification that the established procedures are being followed. Insofar as wages and supplies are concerned, the audit is on a continuing daily basis. The audit on wages involves examination of all employment, income tax, pension and other deduction documents as well as verification of leave records and checking the distribution of expense. With regard to material and supplies, the audit is concerned with daily stores receipts and issues and the verification of the stock inventory and expense distribution.

Machine and Payroll Accounting

14. 10 The Machine Accounting operation utilizes punched-card equipment. Source documents covering wages, purchases of materials, receipt of services and other financial transactions are received by the branch, and cards are key-punched therefrom. These cards are used in the preparation of cheques, expense distributions, statistical reports and financial statements.

14. 11 This branch renders a service to other divisions by providing personnel history and seniority data, recording health and medical information, and maintaining records for cosmic-ray and wind-velocity studies.

14. 12 The Payroll Accounting function covers the recording of time worked for salaried and prevailing-rate employees, and computation of earnings. Controls are maintained for gross earnings and for the various payroll deductions for statutory and employee welfare purposes.

Stores

14. 13 The primary function of this branch is to have available sufficient quantities of the many regular items of materials and supplies required for the normal day-to-day operations of the Company. For this purpose the branch maintains a warehouse in which 12, 000 items are

stocked and from which issues are made to branches of the project upon receipt of approved requisitions. In a research organization such as this, a great many specialized items are required. Such items are procured from suppliers, as required; the Stores branch accounts for all receipts. The branch is responsible for all shipments from the project, such as essential materials, returnable containers, laundry and display materials.

14. 14 The Stores branch performs several additional functions pertaining to plantwide operations. These include maintenance of salvage and spare-parts stores, developing procedures for material control for branches throughout the project, and disposal of surplus or obsolete materials and equipment through Crown Assets Disposal Corporation.

Financial Position

14. 15 The Company's research program is financed through appropriations made by parliament. Such appropriations cover the financial requirements for research operating and maintenance, and for the acquisition of new research facilities. The expenditures on the research program from inception to March 31, 1960, totalling $219 million, are shown, by years, in Table 1.

14. 16 New facilities, the capital cost of which may be recovered through their operation, are financed from Government of Canada advances. Advances are also obtained to meet working capital requirements. These advances are covered by the issue of shares or other obligations of the Company as approved by the Governor-in-Council. Advances from the Government for which capital stock has been issued total $54 million. These advances were used to finance construction of the NRU reactor to the extent of $36. 5 million and to provide working capital amounting to $17. 5 million; the major item in working capital is reactor fuel. Advances have also been received from the Government for the construction of housing in Deep River. These advances, totalling $6. 9 million, are repayable with interest in monthly instalments over thirty years. The balance outstanding at March 31, 1960 is $5. 4 million.

14. 17 A statement of the Company's financial position as at March 31, 1960 is shown in Table 2.

- 14.5 -

TABLE I

SUMMARY OF EXPENDITURE FROM PARLIAMENTARY APPROPRIATIONS

FROM INCEPTION TO MARCH 31, 1960

Year	Research Operating $	Research Capital $	Total $
1945-47	2,783,059	22,232,354	25,015,413
1947-48	3,642,139	1,929,464	5,571,603
1948-49	3,929,723	1,817,678	5,747,401
1949-50	5,302,662	1,315,255	6,617,917
1950-51	6,113,247	1,062,802	7,176,049
1951-52	6,624,704	2,607,280	9,231,984
1952-53	7,425,735	5,213,229	12,638,964
1953-54	8,739,112	3,658,946	12,398,058
1954-55	8,733,584	6,166,223	14,899,807
1955-56	10,964,046	7,662,009	18,626,055
1956-57	12,909,531	8,635,422	21,544,953
1957-58	14,073,663	7,110,596	21,184,259
1958-59	17,404,481	10,140,871	27,545,352
1959-60 Estimated	19,582,800	11,546,700	31,129,500
Total	128,228,486	91,098,829	219,327,315

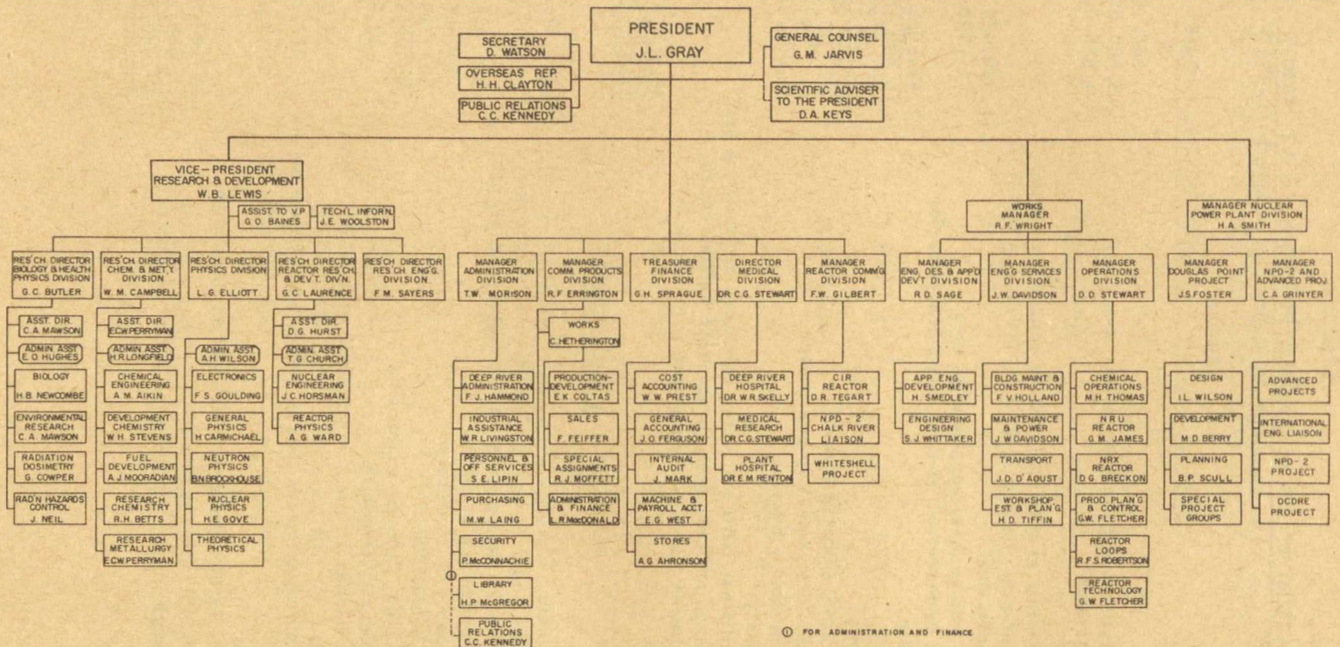
TABLE II

STATEMENT OF FINANCIAL POSITION AS AT MARCH 31, 1960
(with comparative figures as at March 31, 1959)

ASSETS	1960	1959
Current:	$	$
Cash	648,102	854,585
Short-term deposits and treasury bills	5,000,000	6,000,000
Accounts receivable	4,586,043	1,254,400
Inventories:		
Nuclear materials at lower of cost or realizable value, exluding materials valued at $3,746,700 in use for research purposes	11,598,429	8,822,873
Maintenance and general supplies, at cost	791,540	781,523
Commercial inventories, at cost, less provision for obsolescence	2,484,658	2,675,630
	14,874,627	12,280,026
Prepaid expenses	14,835	17,542
Total Current Assets	25,123,607	20,406,553
Contractors' Security Deposits, per contra	47,834	239,208
Mortgages Receivable - housing	4,008,624	2,885,860
Plant and Property:		
Research facilities, NRU reactor, commercial facilities and village housing, at cost, less (i) amounts written off as research expense and (ii) accumulated provisions for depreciation	36,460,330	39,801,197
	65,640,395	63,332,818

LIABILITIES	1960	1959
Current:		
Accounts payable	2,484,673	2,196,845
Government of Canada - unexpended balance of amounts provided under Parliamentary appropriations in respect of research operating program	971,760	-
Advance payments by customers	52,685	38,631
Contractors' holdbacks	261,389	194,415
Total Current Liabilities	3,770,507	2,429,891
Contractors' Security Deposits	47,834	239,208
Government of Canada Loans (for housing) secured by notes due 1984-89	5,373,606	5,886,559
Unrealized profit on property sold on deferred-payment terms	753,207	-
Capital:		
Capital stock:		
Authorized - 75,000 common shares of no par value		
Issued - 54,000 common shares	54,000,000	52,902,360
Retained Earnings	1,695,241	1,874,800
	65,640,395	63,332,818

ATOMIC ENERGY OF CANADA LIMITED



① FOR ADMINISTRATION AND FINANCE

APRIL 7, 1960

NOTE: THE COMPANY'S HEAD OFFICE AND THE COMMERCIAL PRODUCTS DIVISION ARE LOCATED IN OTTAWA.
THE NUCLEAR POWER PLANT DIVISION IS IN TORONTO.
ALL OTHER DIVISIONS ARE AT CHALK RIVER.