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THE ORGANIZATION OF RESEARCH IN CANADA*

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I count it a very high privilege to be with you to-night and to have the honour of speaking to you on the occasion of the celebration of the 75th anniversary of the foundation of your Institute.

I join in the congratulations which you have received on this event, and I bear tribute to your founders for the vision which they displayed and to their successors in office down the long span of intervening years, who have maintained the traditions and given to the scientists of Nova Scotia, and to those interested in science, a forum where papers could be presented and discussed; where friendly personal contacts could be made and information exchanged among workers in allied fields. Experience since the earliest days of the Royal Society of London has shown that such institutes are essential if men of science are to be developed and given a proper opportunity of making their contribution to the great stream of information which year by year adds to the knowledge of mankind and the advancement of science. The City of Halifax and the Province of Nova Scotia are indeed fortunate that this need was early recognized and provided for.

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I am to speak to you tonight about research in Canada: why it is necessary; how it is organized; what it has accomplished; what the future holds. In the course of my remarks, I hope to give you some idea of the tasks which have been assigned by Parliament to the National Research Council; of the organization which has been built up to carry them out; of the progress which has been made; and of our plans for development to meet the ever increasing needs of Canadian industry.

Recently, the secretary of one of our large associations wrote to me that "the stage of convincing the people that industrial research is useful and necessary is pretty well passed." I wish I could agree with him, but I am afraid the situation has not yet developed to that happy state where we can take a recognition of necessity and the provision of adequate facilities and support for granted; and, while I am convinced that there is an increasing understanding of the need for organized industrial research, I have not found it so general that we can obviously count on getting what we need.

For this reason, I welcome this opportunity to go briefly into the general situation, and to stress the urgent need in this country of paying more attention to research in all its various branches.

The civilization in which we live is distinguished from those of the past by its high complexity, by which I mean that no individual or family or even group of families is any longer a unit in producing the things or rendering the services which are required in daily life.

In our grandfather's day, life went on much as it had for the previous thousand years or so. The farmer tilled the field and harvested his grain which he took to the local mill to be turned into flour; the shepherd tended his flocks and the wool was worked into clothing in the homes of the inhabitants; transport depended on the horse, and the village wheelwright produced from local material such simple vehicles as were needed; wood supplied the requirements for fuel;

tallow made candles for light; really about the only thing which had to be imported into any typical community was iron and this was needed only in strictly limited quantities.

During the last hundred years this simple system of life has all been changed, and the change has been the *consequence of specialization.*

When men specialize they acquire not only manual skill through which the product of their labour is greatly increased, but they also acquire knowledge of a particular trade, and this special knowledge in the minds of certain individuals is the mother of invention. Out of this came the marvelous advance in the mechanical arts which has taken place and the far-reaching applications of machinery to ease the task and multiply the power and speed of man. In the result, articles are made available in quantity to all for daily use, which in a previous age would have been luxuries, unattainable even for the wealthy.

We have become accustomed and have adapted ourselves to this higher standard of living and we would not go back. We could not if we would, for populations have developed which could not exist on the basis of a primitive civilization and people would have to die by the thousands and tens of thousands if there were retrogression.

It seems that man can adapt himself without difficulty to an expanding civilization, but in a reverse case, or if he stands still, he perishes. It is the business of research to serve an expanding civilization; to find new and better methods of satisfying old requirements; to open the way to new services needed by the public; and to create the materials and technique by which they may be developed. Nowhere in all the wide range of sciences is any limit in sight—progress continues at an ever increasing rate and the future is beyond conjecture.

In the days of the stage coach the maximum distance which could be traversed in a day did not exceed about 100 miles. Voyages by sail across the oceans were matters of months. Today aircraft cruise at over 250 miles per hour

and telegraph and telephones link the continents in instant communication. Measured on a time scale the earth has shrunk and there would perhaps have been no objection to this if the moral side of civilization had kept pace with the material, so that the nations might have learned to work in co-operation and with mutual consideration and forbearance. Unfortunately, this does not seem possible and the world, as we know it today, has become highly nationalized and competitive.

If we fall behind in the struggle we face disaster just as certainly as did the tribal peoples of early history. To them the penalty of failure was mercifully swift; to us it may be long drawn out but none the less unpleasant on that account.

In the past, the conflict between nations was carried out by armies and navies; today the arena of the struggle, except for rare intervals, has shifted to industry and the prize is markets. So predominatingly important has industry become that unless a nation is highly developed in this respect it is no longer possible for it to have effective armed forces for defence, and so it lives precariously at the whim of others.

Thus the efficiency of industry, and I use the term in the broadest sense, is a matter of vital concern to everyone. It is the business of the research organizations of a nation to promote this efficiency in every way; to assist in turning every national resource and facility to account; to improve processes and to cheapen products so as to better the competitive position of their country in the markets of the world, and particularly to be ready to suggest new articles of manufacture when the fashion for the old diminishes or they stand in danger of being displaced. It is to these activities in aid of Canadian industry that the National Research Council is dedicated.

During the last half century or so the industries of the world have been modified and built up on the basis of scientific knowledge. The mechanical industries derive from Newton's laws of motion; the electrical industries are based on the early scientific work of Henry, Faraday, Maxwell, Ampère,

and down the years through Edison and a multitude of others; aviation is the outgrowth of hydrodynamics and aerodynamics; the chemical and metallurgical industries make use of knowledge accumulated since the days of the alchemists.

Most of this fundamental information, which has made modern industry possible, was built up slowly in the universities of the world. It was not acquired for any utilitarian purpose, it came as a by-product in the search for truth. This form of research has in consequence come to be called "pure science", and it continues to hold a most important place in the scheme of things as they are.

Until towards the end of the last century only a relatively small fraction of the fundamental knowledge which had been acquired and stored up by the universities had been assimilated by industry and new knowledge was accumulating perhaps faster than it could be made use of.

In this period all industry had to do was to exploit the existing stores of information, but even for this trained minds were needed, and there was a demand for men who could understand the facts and apply them to the everyday problems with which they were faced.

Experience showed that men who had been trained in the universities in the fundamentals of mathematics, chemistry, physics, etc., were particularly useful, and, first in the larger manufacturing establishments and later extending in ever-widening circles, there began to grow up organizations for what was called "Applied Research".

Applied research was something that most business men of that day could understand. It was immensely profitable. In contrast "Pure Research" was deemed academic and the men who engaged in it were thought of as people who were not practical. Business was then quite content to leave to the universities the pursuit of knowledge for its own sake.

At the beginning of this century some forward-looking leaders of industry recognized that industrial application had nearly overtaken the capacity of the universities to produce

new facts to work on, and out of this idea "Industrial Research" was born.

On this continent the first step was taken in this direction in 1901 by Mr. E. W. Rice of the General Electric, who established under Dr. Whitney the first industrial research laboratory for the purpose of carrying on fundamental industrial research; that is, the acquisition of new scientific knowledge and the discovery of applications for this new knowledge. This new form of research, backed by the large resources of a great company, was to accelerate scientific progress and to extend the frontiers of human understanding.

Dr. Langmuir, who succeeded Dr. Whitney, has rightly observed, "Such research work cannot usually be directed towards definite goals for it involves unknown factors. Success if attained is often reached by wholly unexpected methods and the problem which is finally solved is not the problem which was foreseen."

That the idea of fundamental industrial research was "practical" has been amply proved. In the field of lighting alone three major improvements came out of the organization which Rice created, and these, in their result, decreased the cost of illumination by four-fifths; it has been estimated that on present costs for electrical power and rates of use the saving to the public on this continent, brought about by the modern lamp as compared with the carbon filament, amounts to some 5 million dollars a night. It has been further estimated that for every dollar of profit made for the company by innovations developed in this laboratory, the public has been saved from 10 to 100 dollars.

The example set by the General Electric was quickly followed and many of the larger industrial corporations now maintain departments of considerable size devoted to industrial research; for example, the Bell Laboratories in New York, concerned with solving problems in the sphere of electrical communications, have a staff of some 4,000 persons of whom about one-third are scientists holding graduate and post-graduate degrees.

I want now to turn your minds back for a decade or so and to ask you to look at Germany where Research—Pure, Applied and Industrial—had early been recognized as a matter of profound concern, and where its organization and correlation had been taken under the auspices of the government. Under this jealous care every idea and invention was seized upon and subjected to intensive development at the hands of large groups of trained scientists; eager business men stood ready to exploit whatever they produced.

There are many in this room to-night who will remember how this and the neglect of other nations had reacted on German world trade to the point that eminent authorities have said that in 1914 she had no need to embark on war of the older fashion in order to become mistress of this globe. The prize was within her reach and it was only her impatience which eventually caused her to be set back.

You know also of the great difficulties which faced the Allies on the outbreak of hostilities by reason of the German monopolies. The German dye industry, for example, which had taken the invention of a British chemist and turned it into a great commercial undertaking, led directly to efficiency in the production of explosives and of poison gas.

I have often wondered why this menace was suffered to develop without adequate counter measures being taken, and it seems, on looking back, that its very gradualness must have been the answer, men's minds becoming accustomed to it by degrees. It is true that in England before the war they still had the momentum of the earlier industrial development, the individual initiative of their captains of industry and the skill of their workmen as assets which had not yet been overtaken, while we in Canada could think that our boundless natural resources and our virgin wheat lands would provide an inexhaustible treasure for which we could draw tribute from all the world.

The impact of the war shook the complacency of the British peoples, and it was out of that event that our organized research was born, and this was true in the United Kingdom, in Canada, and, also, to some extent, in the U. S. A.

Great as was the contribution made by our manhood on the field of battle, great as were the triumphs of our armed forces, it seems, on sober reading of the histories of those times, that at least an equally essential contribution was made by industry, once scientific and industrial research was organized and brought into play.

To illustrate what was accomplished in Great Britain, I mention a few significant facts.

In 1914 there was no optical glass industry in the United Kingdom. Germany and Austria had a practical monopoly in this field and even the lenses for the sights of British guns were imported. Organization of the scientists in 1916, followed by extensive basic and applied research, corrected this situation. Today, the optical glass produced in England is of the finest quality in the world. They are self-sufficient not only for defence, but in the peaceful arts as well, and under the watchful eye of a committee of the Department of Scientific and Industrial Research there is no danger of a failure in this field.

I mentioned poison gas. Chlorine, a product of the German chemical industry, was used against the French and the left flank of the 1st Canadian Division on 22 April, 1915. The Germans used it because they thought the Allies would not be able to reply in kind—they were contemptuous of our scientific organization—but by the summer of 1918, as a result of organized research, our chemical industries were producing "mustard" by a new process at a rate many times that which had been found possible in Germany.

There are here in this city men who had a hand in organizing Canadian industry for war, and who took part in the great investigations and research which that enterprise demanded. They can be rightly proud of what they accomplished and of the team play and co-operation which marked that undertaking under the leadership of Sir Joseph Flavelle, who continues to this day to take a great interest in the Ontario Research Foundation, which he was instrumental in establishing. To illustrate the magnitude of their achievement I mention one isolated fact alone: for the year 1917 Canada produced over

46 per cent of the field gun ammunition acquired from all sources for the British armies, and, in addition, substantial quantities for our allies, France and Russia.

I have heard it stated that Canadian shells were as low priced as any, so our industry was efficient. I myself and others here can bear witness to the high quality of the product.

Apart from every other advantage, the financial benefits from this industry went a long way to saving Canada from bankruptcy and enabled us to continue with our forces in the field unimpaired until the end.

As I have said, the organization of research in Canada, as a function of Government, dates back to the impact of the war. In 1916, Canada, following the example of the United Kingdom, established an Honorary Advisory Council for Scientific and Industrial Research.

It was not contemplated at that time that this Council should set up laboratories of its own; it was to act as an agency for consultation and co-ordination between those already carrying on research in the established laboratories of the several departments of the Dominion and Provincial Governments, in the universities and in industry.

To give you some idea of the very limited facilities then available—a report prepared at the time indicates that the annual expenditure on research in all governmental laboratories, Dominion and provincial, amounted to considerably less than $100,000, and that of some 2,400 leading Canadian firms engaged in manufacturing, who replied to a questionnaire, only 37 had laboratories which even pretended to engage in research. The total annual expenditure of these firms for research and testing, apart from salaries, the figures for which are not available, amounted to some $135,000. That is, and making a liberal estimate for the cost of research in the universities, the total expenditure for all agencies in Canada must have been considerably less than half a million dollars annually.

Looking back at the history of the Honorary Advisory Council for Scientific and Industrial Research, it is remarkable what has been accomplished with the limited facilities at their

disposal, but it is not to be wondered at that men, who were informed on the subject, should have realized the utter inadequacy of the provision which had been made and that they should have pressed for some improvement. As a result of this pressure of public opinion, the matter was repeatedly considered in Parliament and, eventually, the Research Council Act was passed in 1924 under the guidance of the late Honourable James Malcolm, then Minister of Trade and Commerce, and the construction of new laboratories on Sussex Street, in Ottawa, commenced. These laboratories were opened in 1932. As was perhaps to be expected, the appropriations made available during the period of depression were on a substantially lower scale than those planned, and, as a consequence, the organization, both as regards staff and equipment, is far from complete. It is now our business to rectify these deficiencies and the only way in which it can be brought about is to see to it that, with what we have, a service of value is given to the public.

The National Research Council today consists of 15 members selected, for terms of three years, from among men prominent in scientific work in our Canadian universities or in Canadian industry. The Council is required by statute to meet at least four times annually in Ottawa. There is a President, appointed by the Governor-in-Council for a term of years, who reports directly to the Privy Council Committee on Scientific and Industrial Research, of which the Minister of Trade and Commerce is the chairman.

The Council's membership is broadly representative of all parts of Canada and includes persons qualified to speak authoritatively on education, science, industry, business and finance. From Nova Scotia, Dr. A. S. Mackenzie was appointed when the Council was first established in 1917, and I am glad to say he is still a member and that he continues to attend our meetings regularly.

The Council is a body corporate, capable of suing and of being sued, of acquiring and holding money, property, etc. By statute the "Council in addition to certain specific duties

set forth in the Act shall have charge of all matters affecting scientific and industrial research in Canada which may be assigned to it by the Committee of the Privy Council."

Apart from administration, which is organized much on the usual lines of a department of Government, the staff of the Council is grouped in a number of divisions, each under a director: Research Information, concerned with the collection, collation and issue of scientific information and with the general planning of co-operative investigations through committees, etc.; the Divisions of Biology and Agriculture, of Chemistry, of Physics and Electrical Engineering, of Mechanical Engineering, including Hydraulics and Aeronautics, etc., are each responsible for the direction and conduct of technical work in the fields indicated by their designations; provision is made for the closest co-operation and collaboration between all branches concerned in any particular problem. At the present time the staff comprises a total of 163, of whom 67 are graduates or post-graduates. There are also 31 additional research workers, of whom 9 are graduates, employed directly under committees.

In order to bring to bear the knowledge of scientific men and industrialists, and to correlate the work of all research organizations concerned, a number of so-called associate committees have been set up. These meet as the occasion may require, but in this era of limited finances much of their work has necessarily to be done by the less satisfactory method of correspondence.

The function of these committees is to direct co-operative research on the problems assigned to them; to settle the objectives; to indicate the individuals or organizations which should undertake the several component parts of the inquiry; to receive and co-ordinate the resulting information; and to make it available to those who will turn it to advantage.

I would, by way of illustration as to the procedure, like to tell you something of the Associate Committee on Forestry Research, which has just recently been established, because I think this example will indicate the manner in which all

available information can be assembled and brought into correlation, and through which the necessities of the situation can be determined and action promoted. The Associate Committee on Forestry Research had its genesis at the Petawawa Research Station in a joint meeting of the Canadian Society of Forest Engineers and the Woodlands Section of the Canadian Pulp and Paper Association. There, the field was canvassed, and it was brought forcibly to attention that while there were a number of organizations at work in matters connected with forestry research yet it did not seem that the information was being properly brought together and harmonized. The meeting passed a formal resolution asking the National Research Council to undertake this task. I may say that we very gladly undertook to do so, and as a first step a conference was called of all organizations concerned, federal and provincial, public and private, including a number of industrial concerns. The whole field was traversed and definite conclusions reached, and as a result the Council set up the Associate Committee on Forestry Research, which comprehensively represents the whole industry and to which all concerned can look for correlation in their efforts, and for a national plan into which they can fit their own particular lines of research. It is astonishing what can be done by goodwill and co-operation, and it is a most happy augury for the future when one sees, as I see in that committee, all who are concerned in Canada coming together for a definite common purpose.

In order to make use of the facilities for research which exist in a number of our Canadian universities, the Council in the early years of its existence, developed a system of "Assisted Researches" so that projects of importance, which otherwise could not be undertaken, would proceed under the competent direction of members of a university staff. An application for any particular investigation, setting forth the proposal in detail, its objective, the facilities available, the assistance required and the estimated cost, is submitted by the professor in charge through the head of his faculty

to the National Research Council where it is reviewed. Any grants which are made are restricted to the provision of needed apparatus, hire of labour, travelling expenses, etc., and no contribution whatever to the salary of the applicant is made. Through these grants much useful work has been accomplished and it is hoped that as more funds become available they may be given in larger numbers.

In order to provide for the advanced training of selected young Canadian scientists, the Council each year grants a number of scholarships, which may be held at Canadian universities or in exceptional circumstances at selected educational institutions abroad. For the current year awards have been made to 30 students. These were selected from some 87 promising applicants so it would appear that this branch of our activities could be increased with advantage. I would say that the Council's Scholarship Committee, of which Dr. A. S. Mackenzie is the Chairman, are deeply sensible of this need and that, in accordance with their recommendation, the Government has seen fit to nearly double for the next year the provision which was previously made. Half of the additional funds will be devoted to increasing the number of ordinary scholarships which the Council awards, and half will be devoted to new classes of scholarships which have been instituted at the instance of some of our Canadian universities, and which are designed to open the special facilities which are available in the laboratories of the Council to selected post-graduate students who, otherwise, might have to go out of Canada to pursue their chosen lines of research. The National Research Council is not a university and has no intention of entering this field except by way of assistance and on request.

No student will be accepted for these special scholarships unless one of our universities so requests, and gives assurance that his work with us will count towards the higher degree to which he is proceeding. We have made limited provision also to receive some post-Ph.D. students to bridge the gap between their academic training at their university and their absorption in some specific Canadian industry.

I would like now to direct your attention for a few minutes to certain aspects of industrial research in Canada which merit consideration. The truth of the matter is that we are not doing nearly enough work of this character; that we are allowing ourselves to remain in a position of dependence upon other countries; that for this we are paying tribute on an enormous scale; and, worse, we are not obtaining and passing on to the Canadian people the benefits which they have every right to expect. As is well known, most of our principal industrial companies have affiliations with larger organizations abroad to whom there has been a natural tendency to refer any research problems that arise from time to time. It is often very difficult to examine these problems completely, apart from the special environment in which they have come to attention and the solutions proposed are often, therefore, inadequate, and, both on this ground and on account of delays, very heavy losses are involved. A more serious loss is due to the fact that without a corps of trained investigators on the spot, the needs of the situation are not fully appreciated and many opportunities for useful inventions and developments are missed or unduly delayed.

One of the things about organized industrial research, which has been impressed upon me in many discussions which I have had on this subject, is the curious difficulty there seems to exist in getting people to think about it in terms of economics, and this is true even with engineers and business executives who are accustomed to applying the well known principle of "least costs" in their everyday decisions.

When it comes to research, in place of balancing resulting savings against their cost you meet with this sort of statement, and I am quoting from responsible authorities: It has been publicly stated in England that electrical research which cost some £80,000 is now estimated to be saving that industry not less than £1,000,000 per annum. Also in the iron and steel industry co-operative research led to a saving of £400,000 per annum in coke alone, and of £1,500,000 in finished steel; and one small project in flax development

put an extra £60,000 into the pockets of the growers last year.

These results are no doubt gratifying to the men engaged in the researches in question, but the analysis of the figures shows that an annual benefit has been derived perhaps a hundred times greater than the total expenditure on the research which brought it about. Does this not indicate and prove that not nearly enough research has been done?

I believe the best way to obtain a view of our position in respect to the adequacy, or otherwise, of our attention to research is to take the situation which exists in some other country and to measure our own facilities against it. For the purpose of this comparison I have chosen Russia, partly because we happen to have very complete information available as to what they are doing there in the realm of scientific research, and partly because of the similarity of their conditions and natural resources to those which we have in Canada. On account of this similarity we have to foresee their production of the same things as ourselves for sale in the markets of the world.

The annual expenditure on the Russian Academy of Science, which is only one of their many agencies for research, mounted from about four million roubles in 1928 to 17 million in 1933 and to over 44 million in 1934; that is an eleven-fold increase in a period of six years. Altogether in Russia there are in existence 840 institutes engaged in research, which is twice as many as in 1930, and in these, in 1934, 47,900 persons were engaged in research work. Their annual expenditure on research is reported to be now in excess of 500 million dollars and is planned by the end of 1937 to have a capital investment of some 2,000 million dollars. These are large figures. The latest information we have shows that the budget for Russian research continues to increase just as fast as they are able to produce new trained workers through their modernized educational system and it is clear that no limit has yet been set. We know—and it is significant—that the leaders of their defence forces are attaching the greatest importance to the

pressing forward of these various organizations for research. Russia has a population of 186,000,000, which is some 20 times ours. If you divide their figures by 20 it will give you an idea of what we would have to spend and what effort we would have to devote in Canada to this problem if we were to raise the intensity of our effort to the level of what is actually being done in Russia at this present time.

If you divide the Russian research workers by 20 it gives 2,500. If you divide their current expenditure by the same figure it will give $25,000,000 per annum. We have in our own National Research Council employed at the present time a total of 194 scientific workers and assistants, and we have an annual budget, apart from what we receive from industry, of $621,500. This does not tell the whole story, because there are other departments of the Federal Government which have responsibilities for research from the national point of view, and there are a few other organizations, such as the Ontario Research Foundation under Dr. Speakman, which are taking an interest in certain national aspects of research. But nevertheless this comparison indicates that our provision has been very far short.

Again, I would remind you that in the principal industries of this country we are dependent for our research on our friends from across the border, and in Europe, and, while we appreciate that assistance and service, I do think that, in our own interests, it is wrong to continue to depend on it.

It is wrong from many points of view, not the least of which is that the young research workers whom we are training in our university courses and scholarship schemes are leaving us. They have to go abroad for employment. It has been my business to try to bring some of them back, but when we have one position available for a research worker I find anything up to 70 fully qualified applicants, any one of whom I would have been glad to have working on our staff.

Compare this with Russia where they are pouncing on every qualified man and turning his brains to service on national account to improve their position. On the other hand,

we are dissipating our resources and not using the brains that have been given to this country. Our men are making a contribution in foreign lands but they ought to be making it in Canada. We are willing to share the fruit of their labours with other countries but we would like to see them doing their work where Canada would get some credit and where it would redound to our national advantage.

In Russia, we have the case of a country which was formerly one of the most backward in the world in industrial development. Leaders of great vision have grasped the opportunities presented by organized research and are dealing with the matter on an adequate scale. Their progressive development is acquiring momentum which bids fair to carry them to a leading and possibly to a predominant position in the world. Considering this can we afford to rest content with our own limited facilities?

I have probably said enough to show that we can by no manner of means afford to regard the situation in Canada with complacency, but on the contrary we should use every endeavour to interest those concerned, and particularly our manufacturers, so that we may conserve what we have in the way of trade in our own markets and in the markets of the world in the face of the ever intensifying competition from new, improved, and cheapened products of other lands.

It seems to me that one of the most important aspects in respect to the organization of our industrial research which must receive consideration is the cost of not doing it. There is no use in resisting the natural trends of development for that is an impossible task. We must put trained investigators to work to find other uses for our products in danger of being displaced, and they must find new products which can be made from available raw materials in order that stability of employment and of capital investment may be maintained, and particularly that the appalling waste and misery which come in the trail of any decadent industry may be avoided.

The nucleus of the organization required to do this work for Canada exists in the National Research Council, which,

as I have said before, is dedicated to help Canadian industry, and I can assure you that our staff stands ready and willing to bring our resources to bear on the study of problems whenever required.

From your own experience you are no doubt aware of the great importance of making a close study of the literature before embarking on any research or investigation, for it may be that what you require to know has already been found out and reported, and if not you will at least have the result of other peoples' thought on the matter as a guide to you in your work. Like other forms of research, a study of the literature is a matter for experts specially skilled and experienced in the art and for this reason the Council has established a Division of Research Information which is charged with the duty of doing this work for our other scientific divisions, for our Associate Committees and, within the limitations of staff, for Canadian industry as well.

The Division of Research Information is responsible for the Council's Library, which now contains upwards of 20,000 volumes of reference works and receives annually some 800 scientific periodicals and 300 other serial publications. The aim has been to develop it as a complement to other scientific and reference libraries in the Dominion so that through a loan and photostat service inquirers from anywhere in Canada may be given promptly the information of which they are in need.

The Division of Research Information is also responsible for the editing and publication of the Canadian Journal of Research, which now supplies a medium through which the work of all Canadian scientists can, if they wish, be reported. The Journal now goes to most of the principal libraries and scientific institutions in the world. During my visits to a number of research centres in Great Britain last summer, I was gratified to find well thumbed copies on the tables of a number of workers, and, in discussion, repeated and favourable reference was made to the papers which had been published in it. I, therefore, feel that the Journal is helping in a sub-

stantial measure to secure that recognition for Canadian science which is due to the class and quality of our workers. Without the Journal, Canadians would be forced to publish abroad, and the identity of their work would, to a large extent, be lost.

I referred earlier this evening to the progress being made in the United Kingdom in the organization of research. Under the policy of the Department of Scientific and Industrial Research, research associations have been created in the principal British trades and industries. Among others are the electrical and allied industries, iron and steel, non-ferrous metals, refractories, cotton, linen, wool, leather, paint and varnish, automobiles, etc. These associations which are very active in research in their respective fields are open to representatives from the Dominions, and the National Research Council has taken membership in a number of them so that copies of their reports may be available in Canada for reference purposes and such of these reports as are not confidential constitute an important source from which the Division of Research Information compiles answers to inquiries.

I have outlined very briefly the functions of the National Research Council, and I would now like to tell you of some of the work which is in progress in our own laboratories.

The Division of Physics and Electrical Engineering carries the responsibility for the maintenance of the ultimate standards of electrical units, etc., and equipment has been provided so that precise calibration of measuring instruments for industry can be carried out. By statute, the Council's staff are responsible for type approval listing of all meters used for the measurement of electricity for sale; we are now equipped to discharge that duty.

We have a heat laboratory where tests of new types of building material are carried out to determine their thermal conductivities. It is very important that accurate information on insulation should be available to architects and designers so that appropriate steps may be taken to cut down the heat losses.

We have a sound laboratory which is studying questions of acoustics so as to aid in developing new materials and the methods of using them with a view to improving public rooms and even private houses from the point of view of sound absorption.

We have laboratories which do the testing of radio receivers, standardization of sets so as to make sure that the minimum requirements from the point of view of safety, fire hazard and so on have been met. All that work is very detailed and laborious.

Chemistry, since the days of the alchemist, has developed into a very broad subject, and so in our Division of Chemistry we have had to specialize on the problems of first importance. The problems assigned are those concerned with Canadian resources available, if properly used and exploited, to take the place of something which is imported as a finished product. I will mention one or two out of a score of subjects under investigation. Western colloidal clays have been processed to yield a bleaching clay, suitable for use in refining gasoline, lubricating oil and vegetable oils, equal to if not superior to foreign clays which are being imported to the extent of over $300,000 a year. This sum might very well go into the pockets of our own producers and help develop our own industries.

Then there is the question of carbon black. We are vitally interested because we have a great rubber industry and carbon black is used to mix in with rubber to increase its wear resistance. Motor car tires require a considerable quantity and we imported 14,000,000 pounds last year. In the natural gas in the Turner Valley oil fields, we have a material which is going to waste from which our requirements could be met. Our chemists have worked out a process by which that gas can be turned into carbon black with extraordinary efficiency—in fact with some fourfold greater yield than anything achieved in the past. With an efficiency of that sort available, surely we can look to some Canadian industrialist to take hold of these patents and apply them so that we may obtain some value out of that gas which is at present being blown off in the atmosphere at the rate of millions of cubic feet a day.

We use a very large quantity of starch in this country, and that starch is made from material which is imported. We are an agricultural country and it does seem most extraordinary that we should import corn in order to make starch for industrial and culinary purposes. We had a glut of potatoes in the Maritime Provinces a couple of years ago, and the suggestion was made that potato starch might very well be developed to the point that it could take the place of the foreign starch. Comprehensive investigations have been carried out and we now have starches which are quite satisfactory for the textile industry, for plywood manufacture, in the finishing of paper, and recently a process for modifying this potato starch has been worked out so that there is now no technical difficulty in using it both for culinary starch and also for other industries.

As examples of other activities in our laboratories, I would mention: Industrial standardization; safety codes; the discovery of new chemicals which have an amazing effect in promoting the development of root formation in plants and young trees; the new cathode ray compass and direction finder, which promises to have an important place among the radio aids to air navigation, particularly on the trans-Canada airway in the mountainous regions of the west where other methods have proved unsuitable; the Council's work in connection with the establishment of the radium industry in Canada, which was gracefully recognized a few weeks ago by the presentation of a magnificent commemorative plaque of silver; aeronautical research and the testing of aircraft and engines, and the development of new instruments and accessories to meet our special conditions; malting research directed to the testing of new barleys which are being developed to meet the requirements of an important possible market abroad, and of the allied work on hybrid grains through which varieties previously sterile have been endowed with fertility so that their desirable characteristics are now heritable.

The list of work in progress is very long and diverse, and as all projects possess possibilities of economic importance

I would like to have told you about them in detail, but this is not possible as each one is a subject for a full lecture in itself.

There is just one further thought about industrial research which I would like to give you before I bring these remarks to a close and that is, it must be *patient*. I have just been going through the work of one of our co-operative investigations commenced by the Council in 1924, that is twelve years ago. This particular investigation has now at last proved eminently successful and, while the company with which we have co-operated has not yet paid any dividends, I hope the rewards of faith will now not be long delayed. However, what is probably more important than immediate dividends is that the result of this research has changed Canada from the status of importer to exporter of certain key materials vital to the steel industry. It has given a steadily increasing volume of employment and wages have been paid without interruption. The returns to the Council by way of royalties on the product are fully financing the further research in hand, and I have every reason to hope that in due course all our former expenditures will be repaid.

To give an idea of the relative magnitude of other benefits which have resulted, I would mention the fact that the additional freight revenue to one of our railroads which carried the products of this industry now amounts annually to the equivalent of the total of our investment in the investigation to date. Looked at from the point of view of the national balance sheet, the amount of money which now comes into Canada annually, as a result of this one piece of work alone, is in excess of the total being spent on the National Research Council for all purposes.

The requirement of patience and a long-time view is another reason why the leaders of industry should see to it that there is no avoidable delay in placing Canadian research on an adequate and proper basis.