

*Autograph compliments
of Henry Clark*

Industrial Research in Canada

BY
PROFESSOR J. C. McLENNAN, Ph.D., F.R.S.,
University of Toronto.



An Address to the Members of the Royal Canadian
Institute, November Fourth, Nineteen Hundred
and Sixteen.

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INDUSTRIAL RESEARCH IN CANADA.

To the Members of the Royal Canadian Institute.

Ladies and Gentlemen:

Before proceeding with the subject which I have chosen for my inaugural address, namely, Industrial Research in Canada, I must first of all express to you my appreciation of the high honour you have conferred upon me in electing me to be your President for the coming year. Owing to limitations imposed upon my time I may not be able to preside at as many of your weekly meetings as a proper fulfilment of my duties demands, but if I fail in this regard, I know that my deficiencies will be met by the kind and generous co-operation of our Vice-Presidents, Mr. J. Murray Clark and Dr. A. C. McKay, Principal of the first Technical Institute of Canada, which has been inaugurated recently with such marked success, and which, with good warrant, is a source of great pride to us all. In the second place I wish to take this opportunity of expressing to our past President, Mr. Frank Arnoldi, K.C., our sincere appreciation of his services in emphasizing the importance of the functions of the Royal Canadian Institute in our midst, in inaugurating a Bureau of Industrial Research in connection with our organisation, and in stimulating and promoting with zeal and patient determination the consideration of matters connected with the subject of Industrial Research.

I also wish on this occasion to give expression to the sense of loss we all feel in the death of Dr. George Kennedy, which took place in June last. For two years he was President of the Royal Canadian Institute, and for thirty years he was the editor of its Transactions. He attended the Saturday evening lectures perhaps more regularly than any other existing member of our organisation and he took an unflinching and helpful interest in everything which had to do with the welfare of the Society. He devoted all his hours of recreation to science and the works of philanthropy, and on passing away made provision for promoting both of these objects, the Institute itself being one of his beneficiaries. The memory of his presence with us is one that we shall always cherish, and the purity of his aims and the single mindedness with which he regulated the conduct of his life will long serve as a model for us all.

I. CONSERVATION OF RESOURCES AND DEVELOPMENT OF INDUSTRIES.

In dealing with the question of Industrial Research in the brief time at my disposal the key note of what I shall have to say will be "The Conservation of our Natural Resources, and the Scientific Development of our National Industries".

AGRICULTURE.

Three of our chief sources of wealth, I may point out, are our agricultural lands, our cheap electrical power, and our mineral deposits. Of these the agricultural industry is by far our greatest national asset. The importance of this industry was early perceived by our Governments and Legislatures, and due provision has been made already for its proper development. Through the agency of the Dominion Experimental Farms inaugurated by the late Dr. William Saunders and through the activities of the Ontario Agricultural College under the Presidential guidance of Dr. Mills, and Professor Creelman, as well as by the laudable work of the late lamented Dr. C. C. James, great advances have been made in the selection of the most suitable seed grains, the best breeds of dairy cattle, horses and other farm animals, and vast improvements have been made in recent years in the preparation, storage and transportation of our dairy products. From what has been accomplished so far we may safely say that our agricultural industry is now on an eminently satisfactory basis, and that it is developing on sound lines. Much can still be done, however, to ameliorate the disabilities of farm life, by improving roads, by increasing facilities for education, by adding to the comfort of farm dwellings and the beauty of their surroundings, and by a more extensive use of electric power in farm operations. Speaking generally, too, I may be permitted to say that our agricultural lands are not as intensely fertilised as they should be, and production is not as much by half as it could easily be by proper treatment of the soil. And we have the remedy at hand if we would but use it. The vast deposits of calcium, potassium, and phosphate bearing minerals in Canada require but to be worked to furnish us with unlimited supplies of mineral fertilising agents. Our electrical power, too, can furnish us with vast supplies of nitrates if we would but apply it. At Niagara Falls, Ontario, already we have in the American Cyanamide Works, an industry of some thirty-thousand horse-power capacity in which thousands of tons of fertilisers made by the extraction of nitrogen from the atmosphere are manufactured each year. But the whole of this output goes to the country to the south of us, and is used to increase the pro-

duction of the cotton fields of the Southern States. This great industry moreover, is owned and controlled by the interests which hold these cotton bearing areas, and the output though manufactured by Canadian developed power is not available for the fertilisation of our own fields.

It is but one example of how a large percentage of the electrical power developed on the Canadian side of the Niagara River is sequestered. Through lack of enterprise on our part and through concessions granted to foreign controlled organisations a large proportion of our electrical power is now diverted from Canada and is being used to develop the industries and increase the production and the wealth of our neighbours to the south of us. This is not as it should be. And I venture to suggest that if we would conserve one of the greatest sources of our national wealth, we should see to it at once that the exportation of electrical power is gradually diminished and that it ultimately ceases. This is the policy I may add that we have so successfully pursued in conserving our supplies of natural gas. We should seek to establish on our own side of the border all forms of industry in which electricity and its power capabilities can be used. Moreover in this electrical power we should never forget that we have at hand especially in what is known technically as the "peak load" a supply of energy which could with proper development be used to replace the coal which we obtain at ever increasing cost from the United States. The time will come, yes, I believe it is near when the export of hard coal from the United States to us will cease. We should be prepared for this eventuality and should systematically proceed to develop to the utmost limit the power capabilities of every fall of water throughout the whole length and breadth of Canada. Along that path lies national safety and national wealth and prosperity. With the example of the successful operation of the central heating plant of the University of Toronto before us we see what a simple engineering problem it is to heat a large group of widely scattered buildings. The whole of the city of Toronto could be readily and easily heated from a number of central heating stations just as it is now supplied with water and illuminating gas. I venture to suggest that steps should be taken immediately to develop this field. We could I believe easily heat our towns and cities with the hydraulic power which at the present time we are either allowing to go to waste or which we are failing properly and efficiently to develop.

MINERALS AND METALS.

On the outbreak of the war it was found that the supply even within our Empire, of such metals as zinc, nickel, mercury, and the rarer metals,

tungsten, molybdenum, and platinum were largely under the control of alien enemies. Vast stocks of these metals had been accumulated in alien countries and the treatment of the ores of these metals had practically slipped into their hands from our own.

As an illustration of what I have referred to I may cite the case of tungsten. This metal as you may know is largely used for metallic filaments of electric lamps and for hardening steel cutting tools. As an example of what was going on previous to the war, I may say that the whole of the output of Burma went to Germany, and the world was dependent on her for a great part of its supply of this metal as well as of the alloy ferro-tungsten. Moreover the monazite sands of Travancore were controlled by her and she also regulated the price and the output of this mineral and the production from it of thorium nitrate, thereby controlling also the gas mantle industry. In regard to tungsten, drastic and immediate action was necessary in order to meet our requirements in carrying on the war but for some extraordinary reason since 1914 there has been a steady drop in the production of tungsten from Burma. In January, 1915, the exports from that country were 232 tons, while in January, 1916, the output diminished to 217 tons. Even when the control was in our own hands the influence of the enemy was still felt. A number of coolies were sent to Tavoy to meet the requirements but still tungsten was not produced in anything like the quantities expected. The Government of Great Britain has now, however, sent mining engineers to supervise production and no doubt the situation will be altered. I mention these things to show you into what a pitiable state we had fallen through our neglect of matters of vital importance in connection with the mineral industries of the Empire. Attention should be drawn here to one particular industry which has been developed in Canada through the prosecution of the war. For some years Professor T. L. Walker and others co-operating with the Geological Survey of Canada have made a special study of the deposits of molybdenum ores in Canada and as a result of this work the Geological Survey was enabled to point out to the metal industries of Great Britain that we had in our midst considerable deposits of molybdenum, and that this metal could be used largely in place of tungsten in the hardening of steels. But the information fell on deaf ears until the outbreak of hostilities when, with the supplies of tungsten largely diminished, a demand arose at once for the molybdenum. I am glad to tell you that the production of this metal has now become a very important and profitable industry in our country.

We have been taught the lesson and at a terrible cost that we must preserve our metals, first of all for our own use. We have vast resources in minerals in Canada, but they will require special treatment. New

processes will have to be devised for treating the ores. For example, I might cite the case of zinc and phosphorus. We have in British Columbia large deposits of zinc ores and of phosphate bearing minerals. It is true, we do not know as yet how to treat them economically, but methods can and will be devised if we set our hearts on it. There is no reason why we should be dependent on other countries such as Germany for our supply of such vital commodities. Norway and Sweden have shown us what can be done by the application of electricity to the solution of such problems and with our extensive waterfalls we have at hand the means of producing electricity at the lowest possible cost. Efforts should be made to conserve it for our own use and research should be directed particularly to the development of its applications in the treatment of ores.

While dealing with the question of metals and minerals it might not be out of place to refer here to a movement which has been recently inaugurated by The Iron and Steel Institute, The Institute of Metals, The Institution of Mining Engineers, and The Institution of Mining and Metallurgy of Great Britain for the formation of a central Department of Mines and Metals in Great Britain to protect and advance the economic interests of British mining and metallurgical industries and to stimulate the development of the mineral resources of the Empire. As is well known there are well organised Departments of Mines in Canada and in some of the other Dominions but up to the present time there has been no Department of Mines in the centre of the Empire. In the plans which are being formulated it is proposed that the duties of the projected Department of Mines and Metals when established should include:

1. The making of arrangements for expediting the completion of mineral surveys of the United Kingdom and of the Crown Colonies and other British Possessions.
2. The systematic collection and co-ordination of information bearing on the occurrence, uses and economic value of minerals. Some of this information should be promptly and widely disseminated in summarised form to those interested in the industries, through the medium of the existing publications of the Institutions directly concerned.
3. The co-ordination and dissemination of information on mining laws, development of mineral areas, output, processes of extraction, plant, capital employed, markets, etc., etc.
4. The stocktaking in a general sense of the mineral resources of the Empire and the review from time to time of the position of each mineral or metal to ensure that the mineral wealth of the Empire is being developed and exploited with due regard to imperial interests.

5. Generally to advise the Imperial Government on all questions bearing on the mining and metallurgical industries. To perform this function efficiently it is essential that complete information should be available and also that the industries concerned should be consulted through their respective organisations.

The institutions to which I have referred have long felt the necessity for such a Department as that proposed but since the outbreak of war and the consequent revelation of the dangerous position into which these vital Imperial interests had been allowed to drift, the necessity has been demonstrated over and over again. It is not too much to assert that if a properly organised and efficiently conducted Department of Mines and Metals had been established in Great Britain much valuable time, many lives and vast sums of money would have been saved to the Nation in the conduct of the war.

DEPARTMENTAL CO-OPERATION.

It is a matter of common knowledge that in the activities of the permanent departments of the Governments of the different states constituting the British Empire there is not the active co-operation that should prevail if efficient progress is to be secured. Perhaps I may be permitted to cite an example or two of a defect of this kind which was recently brought to my attention. The Geological Survey of Great Britain as you all know, has a magnificent record to its credit. Its operations in the British Isles have been most complete and its reports are most voluminous and very exhaustive. It has happened, however, that after its reports have been presented to Parliament they have been carefully filed away and no special attempt has been made to bring their contents in a definite, particularised, and effectively useful manner before the industrial organisations of the country. When the War broke out it happened that one of the largest refining and reduction works in England found their supplies of a particular flux required by them in the treatment of their ores entirely cut off. The firm had been accustomed to import the flux from mines under the control of one of the Central Powers. A representative of the Institution of Mining and Metallurgy happening to call on this firm learned of their dilemma, and to the chagrin of its members pointed out that the Geological Reports mentioned above contained a detailed account of large deposits of this particular flux situated in England within 10 miles of their works. It is needless to tell you that in a very short time a light railway was constructed between the deposits and the works and the firm is now rejoiced to find that it can carry on its operations without let or hindrance and at a greatly reduced cost.

Again, before the war it was customary for the manufacturers of ordinary commercial glass articles to import from Belgium the sand used in their manufacture. The loss of this country to the enemy immediately cut off the supply. Search however was instituted, and it was soon found that sand equally suitable existed in large quantities in the British Isles. We have heard of the folly of carrying coals to Newcastle, but it will be difficult to find examples of economic folly more prodigious than the two which I have cited.

I might also cite an example of the lack of departmental co-operation in our own country. A few years ago it became a matter of considerable interest to ascertain if radium bearing minerals existed in deposits of any extent in one of the Provinces of Canada. The action which was taken in the matter—and I have no doubt that such action was taken in good faith and intended for the best—was to offer a reward of some \$25,000 for the discovery of such minerals in paying quantities. Up to the present, I believe, no part of the reward has been paid. Now in the procedure followed in this case, the Department referred to was quite unaware of the existence of a staff of trained scientists in another Department of the same Government which had gained world wide recognition for its researches on the properties of radium bearing soils and minerals and which, if asked to do so, could have indicated a very simple way of making a complete survey of the Province, which would give such information as would enable one to say whether radium bearing minerals existed in any considerable quantity or not. Moreover, the methods which would be applied in this survey are of such a sensitive nature that if deposits of the minerals sought for did exist it would be possible to locate them with ease and considerable precision.

These are but two or three illustrations of our lack of co-ordination in effort, but they serve to show what can be done if proper machinery be devised to co-ordinate our activities and to work out in detail a broad scheme of scientific co-operation.

II. NATIONAL ORGANISATION FOR INDUSTRIAL RESEARCH.

Coming now more particularly to the subject of my address, namely, the establishment of an organisation for stimulating and fostering research as a basis for our manufactures and industries, we are faced with the problem of how to bring such a project into operation with the greatest efficiency and the least possible friction.

UNIVERSITIES AND INDUSTRIAL RESEARCH.

The view is held in some quarters in Canada that the direction of research work, both industrial and purely scientific, should be placed

under the control of the Universities and that it should be fostered and supported by grants of money from the Dominion Treasury directly to them.

It must be remembered, however, that the functions of the Universities are primarily educational, and that by the British North America Act matters relating to education are not by any means national in their scope, but as to upkeep, control and direction belong particularly to the individual Provinces. The Universities as I have stated are especially concerned with the literary, scientific, technical and artistic training of our young men and women. It is true, generally speaking, that the best and most efficient teachers are those who carry on investigative work or direct researches. Such activities give life and vigour to the teaching and serve as a great inspiration to the students. It is also true, however, that the educational aspect of university work imposes definite limits both as to the time available for research and to the character of the researches, especially the experimental ones, which can be undertaken with reasonable prospects of a successful issue. In Universities the problems attacked are generally speaking of fundamental or academic interest. They are such as can be solved by work carried on at intervals, or such, especially those in which students co-operate, as can through their results be used for the attainment of academic standing or the acquisition of University degrees. Problems of a secret or private nature cannot be conveniently carried out in University Laboratories. In the first place it is difficult to maintain secrecy in such institutions, and in the second place the solution of secret problems in University Laboratories is not desirable on account of the lack of harmony in the staff which it is likely to engender, and on account of the need therein for a high minded and lofty scientific spirit which it would inevitably tend to suppress or at least fail to develop.

Moreover it is doubtful if in a democracy such as our own, public funds should be used either directly or indirectly for work of this character. At the same time there seems to be no reason why the Dominion Government should not subsidise research work by grants made directly to members of the staffs of the Universities for researches which are of a public character and are for the public good. Such researches could, with the approval of the authorities concerned, be carried out in University laboratories, for with the conditions at present existing, these and the apparatus in them, are available for a considerable time each year. It would seem to be desirable and advisable in the interests of efficiency to use them. Research work of a secret nature or for the advantage of individual firms, might possibly be tolerated in University laboratories for a time, until other facilities are provided, but in my opinion it should

not be formally encouraged. Experience has shown that there are other agencies through which such work can be more efficiently and satisfactorily carried out.

INDUSTRIAL AND SCIENTIFIC RESEARCH COMMISSION.

In Great Britain where they are now deeply concerned with this question, they established two years ago a Commission on Industrial and Scientific Research*. It is controlled by a Committee of the Privy Council consisting of three or four members of the Government, and directed by an Advisory Council consisting of a small group of men of distinction in Science and of accomplishment in the industries. In Canada through the initiative action of the Minister of Trade and Commerce, Sir George E. Foster, steps have been taken to set up a Commission† of a similar character. It appears that such a body is the best agency for handling the problem with us. Among its activities it will first of all make a survey of the ground for the purpose of seeing what organisations are at present in operation and engaged in research work. It will be the duty of the Commission to co-ordinate these and to extend and develop their efforts. Cognisance will have to be taken by the Commission not only of the work done by the Universities but also of that done through such agencies as the National and Provincial Governmental Departments, the Royal Society, the Royal Canadian Institute the Society for Chemical Industry and perhaps what is most important of all by private firms in their works. The Commission will be able to give definiteness and direction to the efforts now being put forth in this direction by the Boards of Trade, the Grain Growers Association and the Canadian Manufacturers' Association. Machinery will have to be devised to prevent overlapping. Steps will have to be taken to establish in Ottawa, and probably also in such industrial centres as Montreal, Toronto, and Winnipeg, large and fully equipped technical libraries which will contain all Scientific and Technical Journals, Trade and Industrial Magazines, books, and other publications, and also copies of all patents with their specifications wherever issued. We are sadly lacking in such facilities at the present time in Canada and the Commission should take steps to see that this defect is speedily remedied.

In Great Britain a large number of the industries have shown extraordinary enterprise and resourcefulness since the war broke out and there has appeared a greater disposition among individual manufacturers to co-operate by interchanging ideas, putting their trade secrets into the common stock, and calling in all the available scientific and mechanical resources of the country for the purpose of increasing output and improving organisation. In certain trades the changes which

*See Appendices I and II.

†See Appendix IV.

have already taken place amount to a positive revolution. There is scarcely an industry in the country which has not come out of the ordeal of the war without being stimulated by the special difficulties which had to be surmounted. As has been stated, the history of the war in Great Britain has been a history of grave and threatening difficulties courageously faced and successfully overcome.

When the war broke out the manufacture of optical and chemical glass in France and England was practically insignificant. The steel industry was paralysed at first by the lack of chemical glass for testing purposes, and the porcelain and pottery industries were brought to a standstill through the supply from Germany being cut off of Seger cones used as guides to firing. To-day they have industries which supply all their needs. The compositions of chemical glasses have been ascertained. Methods of manufacture have been devised and have been put into operation, and through the efforts of Dr. Mellor, recently deceased, the composition of Seger cones has been successfully worked out. The manufacturers of porcelain have pooled their knowledge, combinations have been effected and research laboratories have been instituted and manned to help them through the co-operation of the Industrial Research Commission, and with the aid of the financial support of the Government.

I may perhaps be permitted to refer to another phase of the work of the British Commission on Industrial and Scientific Research. In their report which has just been issued they lay emphasis on what are "key" or master industries. Such, they point out, are the magneto industry, and the manufacture of lathes and milling machines, optical glass, porcelain, fine chemicals, dye stuffs, synthetic drugs and high explosives. For such articles the market is a limited one but the articles themselves are vital for numerous other industries. For the development of such industries the Commission takes the view that State support is absolutely necessary, and steps have already been taken by that body to place a number of these industries upon a satisfactory basis. Through the action of the Commission* the University of Leeds has made arrangements whereby the organisation known as "British Dyes" may receive substantial assistance in the matter of scientific research and at the same time special facilities are to be given to private firms and others in the national interest. In dealing with the textile industry, support has also been given for the investigation of the nature and constitution of cellulose fibres at the School of Technology at Manchester. The Commission is also supporting an investigation of the de-gumming of silk at the Imperial Institute of Science in London. At the Royal Technical College, Glasgow, and at the University of Manchester it is carrying on researches on the design of steam nozzles for turbines.

*See Appendix III.

As a result of all these activities two tendencies have been emphasised: (1) Trade associations have been formed for common action at home and abroad raising the average standard of production, and (2) recognition has been made of the leeway they had to make up as regards scientific research, the utilisation of its results and its application to technical and industrial purposes.

The Commission to which I have already referred has been a most potent factor in stimulating and promoting all these results. It has encouraged manufacturers of particular lines to combine in their efforts, it has co-operated by supplying them with information as to the technique of their industries and it has furnished a supply of scientific men likely to help them in the solution of their problems.

WORKS RESEARCH LABORATORIES.

In addition to drawing lessons from what has been accomplished in Great Britain, much may be learned also from what is going on to the south of us. In such large organisations as The General Electric Co., of Schenectady, The Westinghouse Electric and Manufacturing Co., of East Pittsburg., The Eastman Kodak Co., of Rochester, The DuPont Powder Co., The American Rolling Mills Co., The National Electric Lamp Association, The General Chemical Co., The U.S. Steel Corporation, The Edison Laboratories, The Pennsylvania R.R., they have as adjuncts large and magnificently equipped research laboratories manned by the ablest scientific men whose services can be secured and hundreds of thousands of dollars are set apart by each of these organisations each year for industrial research.

In a number of these laboratories the activities of the researchers are not confined to the solution of problems of pressing necessity. In the laboratory of the General Electric Co., for example, the workers are encouraged to exploit fields of purely scientific interest, for it is realised that what to-day may be of merely academic interest may to-morrow have the greatest industrial importance. It is to the credit of this policy that to-day we have on the market the metallic filament electric lamp, the gas filled electric lamp, the gas arc electric lamp, gas electric rectifiers, the Coolidge X-ray tube, and the steel alloys of vanadium and other rare metals which have proven themselves so useful in the manufacture of dental and high speed mechanical cutting tools.

In Canada our works are as yet, generally speaking, small and circumscribed in their production. We have, however, industries such as the rubber industry, the agricultural implement industry, the cyanamide works, and the steel industry in which a beginning has been made. All these have now research laboratories attached to their works. The

Canadian Pacific Railway, too, has recently recognised the importance of this subject and has organised in connection with its system a research laboratory under the direction of Messrs. The Arthur D. Little Co., for the purpose of exploiting the natural resources and raw materials with which it is more immediately concerned.

These few illustrations which I have cited to which others might be added will serve to show that steps are being taken in Great Britain and in the United States to conserve their resources and to stimulate and protect the industries of the two countries. Moreover they point out very clearly the path which we must follow if our manufacturing interests are to be so protected and developed that they may be prepared adequately to take their part in the great industrial struggle which must inevitably follow the termination of the war.

In Canada as in Great Britain it will be difficult for an Industrial Commission of the kind I have referred to, to deal with individual firms. Small manufacturers cannot afford to set up research laboratories as adjuncts to their works. It will be necessary for the manufacturers in particular industries to combine for scientific purposes and possibly also for financial reasons. For by such action it will be possible for the Government to subsidise research in particular industries. Generally speaking it will not be found practicable, I venture to think, for such subventions to be given to individual firms for the development of research problems of an exclusive or private nature. This will of course lead to the creation of great trusts as it has already done in the United States, but such a result need not necessarily prove an economic evil if we profit by the lessons they have learned and if due precautions are taken for the protection of the interests of labour on the one hand and also on the other of those of the consumer.

We must encourage in every possible way our manufacturers to call in to their aid the assistance of the trained investigators which we are at present turning out in large numbers in our Universities. We in the Universities are justly proud of the product of our industry and our only regret is that hitherto our industries have failed to avail themselves of the services of the highly trained men and women who graduate from our halls each year. To our regret and to the oft expressed regret of these graduates the lack of openings in our own country has forced them to accept positions in the research laboratories of the United States. There they are assisting in building up great industries, rivals to our own, and in adding to the already stupendous wealth of that great country. This tide is draining us of our most valuable product and we anxiously look forward to the time when the full appreciation of research work and of the application of scientific methods will lead our manu-

facturers to so orientate their industries that an efficient research spirit will prevail. May the time soon come when the mental capabilities of our people as well as the other natural resources of our richly endowed country will be carefully conserved and developed for our own use.

STANDARDISING, TESTING, AND RESEARCH LABORATORIES.

In what has preceded I have dealt with the part which may very well be taken by our Universities in a national scheme of Industrial Research. I have also emphasised what appears to me to be a most important factor in the development of our industries, namely, combination of effort and the establishment of research laboratories in connection with the works of these industries. I have also pointed out in what way it appears to me the National Government may legitimately be asked to give financial aid to these two types of organisation. There is however another phase of the question which demands consideration. In a number of the Departments of Government research work is being carried on continually and entirely for departmental purposes. It is felt by some that there is a danger of overlapping in this work unless some scheme of efficient co-ordination be devised. This matter is now I believe under consideration by those immediately concerned with it, and it is possible that as a result, it may be found necessary to establish in different localities in Canada laboratories in which much of this work can be done under one or more directing bodies, consisting of the permanent officials interested in the matters taken up, and of others whose scientific attainments and qualifications may be such as to make them desirable members of such body or bodies. Departmental activities which might be cited as being preeminently suitable for being carried on by such organisations, are, the standardisation of weights and measures, the calibration and testing of meters and measuring instruments of all kinds, the testing of food-stuffs, the analysis of drugs and chemicals, the development of ceramics, the investigation of marine lighting and signalling, the treatment of ores and the investigation of the properties and treatment of natural products such as fish, oils, natural gases, peats and minerals of all kinds.

The working out of a scheme which will embrace all these different types of activity will be a task which, I think you will agree, will tax the powers and capabilities of the Commission on Industrial Research to which I have alluded. It can however be done and effected very speedily if there be a general recognition of the difficulties involved, and if a general and hearty desire be evinced by those whose co-operation is sought to assist in working it out.

It may be said that much of the research work to which I have referred can be accomplished in the laboratories of our Universities. That some of it can I will readily admit, but I venture to think that if a serious attempt be made to meet the needs of our country in an adequate manner, it will be found that University organisations possess limitations, in the way of space requirements, continuity of effort and administrative machinery which effectually preclude them from assuming the direction of anything more than a minor part of the industrial research work of the country.

What is wanted is in my opinion first of all a consolidation and correlation of the research work now being carried out at Ottawa in different departments and under different Ministers.

In my opinion the magnificent work which is now being done under the Geological Survey and in the Department of Mines at Ottawa, could very well be extended. Increased laboratory accommodation should be provided and additions made to the staff of highly trained technical experts. Sections should also be attached in which problems of a physical and chemical nature can be treated. Problems of this type are now being dealt with by a number of the Governmental Departments at Ottawa, but in my opinion all these activities should be co-ordinated with the work in the Geological Survey referred to above, and the whole placed under the direction of one Board, embracing the highest technical and scientific opinion available in the country. If such consolidation were accomplished it could be done on a basis and in a manner to provide for the most powerful and the most efficient scientific direction.

In the second place I think the facilities afforded by the Universities should be supplemented by the establishment of a few physical and chemical Research Bureaus or Laboratories in the centre of those localities in Canada where the industrial activity is the greatest. For example, under the conditions at present existing it would seem that one of such Bureaus could with advantage be established in the Province of Quebec, either at Montreal or Quebec—preferably at Montreal. Another should be established at Toronto, probably a third at Winnipeg, and later on a fourth in British Columbia, and maybe fifth at some centre in the Eastern Provinces. These Bureaus implementing the facilities offered by the Universities could be made somewhat elastic in their organisation and they could become most efficient institutions for assisting the departments of Provincial Governments in their scientific work, and for co-operating with manufacturers by providing them with scientific information and advice and by investigating for them numerous scientific problems which are pressing for solution.

III. BUREAU OF INDUSTRIAL RESEARCH OF THE ROYAL CANADIAN INSTITUTE.

And now I may be asked what part does the Royal Canadian Institute aim at taking in the scheme of National Industrial Research which I have briefly outlined. In a sentence it aims at providing local effort to meet local needs.

The Royal Canadian Institute was incorporated by a Royal Charter granted on the 4th of November, 1851. Its aims are:

I. To promote scientific research in Canada. For this purpose it encourages all who are workers in Science to present to the public through its meetings the results of their investigations and it offers to them every facility for making these known through the Proceedings and the Transactions which immediately on publication are sent to upwards of five hundred scientific learned societies throughout the world.

II. To form in Canada a library of the publications of all the scientific societies of the world. These publications are given in exchange for the Proceedings and Transactions of the Royal Canadian Institute and as this exchange has been going on for upwards of sixty five years the Institute has in consequence a library of about 10,000 volumes composed of the scientific memoirs and archives of all the important learned societies. This library is the only one of its kind in Canada and it has already proved of very great value to workers in Science.

III. To engage and lead the attention of the people to questions of public interest and utility on which scientific opinion may have an important bearing and

IV. To bring into co-operation all the scientific workers in Canada. The institute endeavours to accomplish this by offering assistance in the way of publication of valuable papers of scientific workers and by placing at their service the library of the Institute. But the aims of the Royal Canadian Institute are higher still for it recognised that from economical and geographical considerations the Western portion of Ontario including the city of Toronto and its associated contributory districts is marked out as a region of intense prospective industrial activity. Its numerous railways, existent and projected, both steam driven and electric, together with its vast available resources in electric power, indicate very clearly that it is peculiarly well suited for the location of numerous and extensive industries. These industries will require scientific guidance and advice, and an organised scientific basis for the economical production and manufacture of their products.

To meet this situation the Royal Canadian Institute, some two years ago, organised a "Bureau of Industrial Research and School of Specific Industries" and with this organisation it aims at promoting in every way available the alliance between science and industry and the advancement of original Scientific and Industrial Research in Canada. It aims at undertaking to report upon the bibliography of any scientific subject or the object of any Scientific and Industrial Research. In a word it aims at taking from Industrialists perplexing manufacturing problems and by the application thereto of contemporary Science, working out practical commercial solutions of these problems.

On the Council of the Bureau we have representatives from the staff of all the Faculties in the University of Toronto, we have representatives from the Technical Institute, the Canadian Manufacturers' Association, the Board of Trade of Toronto and of the Associated Boards of Trade of Ontario. The Society of Chemical Industry also has representatives on the Council. Moreover we are assured, I am told, of the hearty support of practically all of those members of the staff of the University who may not for the time being be members of the Council. I have no doubt, too, that in the course of time the Council will include representatives from the various departments of the Provincial Government and of the Trades and Labour Council. It is gratifying to find that at its inception the Bureau has secured the hearty support of such influential bodies as I have mentioned. It means that many preliminary difficulties have been successfully overcome and that we can now move forward united and confident of the ultimate success of the local movement.

Among other directions in which the Bureau intends to act, it aims as mentioned above, at working out an information department. It is thought that such a department can first of all encourage the manufacturers to apply to the Bureau for information on the technique of specific industries. It is our opinion too that surveys should be made from time to time of our industries by the Bureau with a view to collating information regarding the character and extent of their mechanical equipment. Furnished by them with this information it will be possible to make suggestions for increasing production and for embarking on the manufacture of new products. We have in the Royal Canadian Institute as I have stated the basis of a good technical library. We have, too, the Toronto Public Reference Library, the University Library, and the Provincial Library in close proximity. But the technical side of all these libraries could be greatly extended. I venture to think that this is a direction in which we would be warranted in applying to the Dominion Treasury for financial assistance. An information depart-

ment such as I have referred to and a large fully equipped technical library would soon prove of inestimable value to the manufacturers in the districts I have mentioned, and to the public generally. There should I think, be at least three or four of such libraries established in Canada and it seems to me that for the Western and Central Ontario Districts it should be done by building upon the basis which has been so well laid, *i.e.*, by adding to and extending the library of our Institute.

It seems to me too that the Government of the Province of Ontario might increase its support of the movement inaugurated by the Royal Canadian Institute by coming into closer relation with the Bureau. Many of the problems which are presented to the departments of the local Government for solution can be solved in the laboratories of the Provincial University, but there are others which require continuity of effort and sustained treatment. Numbers of these will require special research apparatus, more space than is available or is likely to be available in University laboratories, and a special staff of researchers. Such problems could with economy and efficiency be investigated in the laboratories of the Bureau of Industrial Research associated with the Institute. I would urge the members of the Provincial Government to give consideration to the suggestion that in the steps I understand they contemplate taking to develop research in connection with their own departments they could possibly accomplish efficiently what they are aiming at by co-ordinating their efforts with those now being put forth by the Institute in a parallel direction.

RESEARCH WORK AND THE INDIVIDUAL MANUFACTURER.

I have now referred to the types of investigations, which according to my judgment can best be carried out in our University Laboratories, in the works of our industries and in laboratories which may very well be established at the different industrial centres in our country. But as yet I have left out of consideration the means of attempting the solution of problems of a private and exclusive or secret nature. These I think belong to a category by themselves. The cost of defraying the expenses incurred in solving such problems should I think be met by the manufacturers themselves, who are to be directly benefitted by their solution. Distinct laboratory equipment will be required for the purpose and this the Bureau of the Royal Canadian Institute aims at providing if it can succeed in securing adequate financial support. I would appeal to our manufacturers for help in this matter. Many of them, through their own energy and resourcefulness, through beneficent tariff arrangements, and through other favourable conditions, have

become prosperous, and even wealthy. Will not some one or some group of them come forward and give their support to the equipment of such an institution? It need not be large, it need not be costly, but one of some kind is required if we are to attempt the work at all. The Mellon Institute which has been founded at Pittsburg by private benefaction is our model in this direction. Through the energy of the late Professor R. K. Duncan, a Canadian, and through that of his successor Dr. Bacon and of his colleagues numerous problems have been solved in the Mellon Institute which have enabled the manufacturers of the United States to increase their output and lower the cost of production.

Among the problems successfully treated in the Mellon Institute are (1) the refining of copper, (2) the process of leaching, (3) cement manufacture, (4) the elimination of the smoke nuisance, (5) glass manufacture, (6) bread making, and (7) paper making.

With these illustrations before us it is clear that we can follow with confidence in the footsteps of those who founded the Mellon Institute for they have marked out a path which has led and will continue to lead to certain success.

I have spoken thus definitely about a sphere of activity which might legitimately be developed by the Bureau of the Royal Canadian Institute. It is a field which as yet has not been preempted by any interests or by any existing scientific organisations. There is no need, however, for the Bureau to confine its attention to the manufacturers in one particular part of Ontario. The Institute is founded on a Royal Charter and its constitution is not by any means limited by Provincial considerations. The whole of Canada is open to it. We must of course, develop slowly, but in the course of time problems of the type I have indicated will be presented for solution in all parts of our country and there is no reason why the Bureau should not co-operate in helping manufacturers no matter in what part of Canada their industries may be located.

As the situation develops, too, problems whose solutions are in the general public interest will multiply, and the Bureau as well as our universities may very well concern itself with the solution of such problems in addition to those of an exclusive or private nature. It will frequently be found, however, I venture to think that our Universities and Technical Institutes will be able to provide experimental equipment and to afford laboratory facilities better suited for work of general interest than the Institute. For the handling of such cases I am assured that our Universities and Technical Institutes will heartily co-operate with the Institute in making such official arrangements as will enable us to

hand over the solution of problems of a public nature to the directors of the laboratories in these institutions either for direct solution by them or for the investigative work to be immediately initiated, directed, supervised, and administered by them.

IV. RESEARCH WORKERS.

I should also like to refer with your permission to one or two other matters which to me appear to merit some attention in the treatment of my subject. One of these has to do with the welfare of the personnel required to actually carry out the investigations of industrial research. We have in the graduates who are being turned out annually from our universities a body of well trained investigators. In the past, as already pointed out, many of these have had to go to the United States for employment. We should, however, retain them in our own country. They could be secured and held, initially and in part at least, by the establishment, in connection with our Bureau, of Fellowships of about \$1500 per annum. This is a modest sum and one which could be easily paid by manufacturers for the solution, either complete or in part, of some of their problems. I hope this matter will be taken up at once, that the manufacturers will immediately take steps to enable us to secure modest but suitable laboratory accommodation, and that they will hasten to bring their difficulties to us and endow Fellowships for their solution. We on our side are waiting to co-operate most heartily. Another point to which I must refer is the treatment of Fellows who succeed in successfully solving problems which may be presented. They should not be treated in a niggardly manner. Many of them are looking to the industries for their future occupation. If they make some new discovery or improve a process, they should receive some adequate financial return. The manufacturers should be prepared to adopt some system of paying royalties to them, or what is better still, they should be given some financial interest in the firm which profits by their discovery or improvement in a process. While this would be only fair it would also tend to put our industries on a higher plane for it would be putting into operation a scheme which would ultimately result in our great industries being directed and managed by a body of men who have received not only the highest training which our Universities and Technical Colleges can furnish, but who have also shown that they possess the power to initiate and carry on original investigations, and at the same time have a deep sympathy with research methods and know how to co-ordinate these with economic values.

V. INDUSTRIAL ACTIVITY AFTER THE WAR.

Another matter to which I wish to draw your attention is the utilisation of our war equipment in the industries after the war. The prosecution of the war has necessitated both in this country and in Great Britain, the establishment of vast and extensive works for the manufacture of munitions and other war equipment. It has necessitated also the installation of enormous additions to the mechanical equipment of existing works. Two years ago for example the manufacture of aeroplanes and aircraft generally was but an insignificant industry in Great Britain. To-day all is changed. At the present time aircraft are being constructed in a dozen centres in England and Scotland, and in addition the Government maintain a factory at Farnborough which covers hundreds of acres and includes on its staff thousands of men and women who are feverishly at work constructing and assembling the parts of aeroplanes which are being turned out in prodigious numbers. Great and enormous works have also been established for the manufacture of chemicals and other materials used in the making of explosives and of artillery. Formerly the guns and ammunition for the army were largely manufactured at Woolwich but to-day there is hardly a town or city in the Kingdom which is not contributing its quota to the armament of the nation. In one part of Scotland alone which came under my notice, the works recently established by the Government for the manufacture and storage of explosives and other munitions covers an area of almost 200 square miles.

On the Clyde, too, the most intense activity prevails. An entirely new fleet is being created. In a visit I paid there recently I counted over two hundred war vessels under construction. There were flotillas of torpedo-destroyers, and destroyer leaders, dozens of submarines, many mine sweepers and monitors, and numbers of battle cruisers and battle ships. Yards in which a war vessel had never been constructed hitherto had their slips filled with these additions to the navy. Firms which were formerly competitors now lend one another engineers, models, drawings and workmen. In addition to the need for this enormous expenditure of strength on the construction of war ships there came an imperative demand for increased merchant tonnage. To this demand the workers on the Clyde, masters and men, responded with alacrity and enthusiasm and the intensity of the effort is most impressive. In addition to the war vessels now being built which I have mentioned I observed large numbers of enormous freight and passenger carrying vessels under construction, some almost completed and others with their keels only just laid. As one passes up the Clyde from the Broomielaw to Greenock

in a small river boat one is deafened with the noise and the rattle of it all. It is simply stupendous and gives one the impression of being in the midst of a gigantic factory where the workers are not men but supermen and the directors are the very gods and titans of mythology. And the intensity of the effort is not confined to the Clyde district alone for if one is to believe what one hears, a similarly intense activity is in evidence in the neighbourhoods of Portsmouth, Chatham, Newcastle, Liverpool and Belfast.

The changes which have come about in the last two years in the British Isles are beyond expression. Enormously more has been accomplished than could have been believed possible even by the most vivid imagination. We have seen the Empire perform the greatest achievement in history in raising over five million volunteer soldiers within two years and in creating the arms, munitions and equipment necessary for that army. What is more wonderful still is that we have seen great changes wrought in the mental outlook and viewpoint of the British people.

We have seen them when confronted with the grave and threatening difficulties of this tremendous ordeal, suddenly give up their lives of indulgence, luxury and ease and mobilize all their financial, intellectual, and industrial strength for the struggle. We have seen the labour interests assume national responsibilities, to a degree far beyond what previous to the war we had thought possible. The part taken by the women in this movement, too, is beyond all praise. In the British Isles as also in a measure in Canada one to two millions of women have for the first time received the mental and physical development which comes from earning money and from training in work. Millions of men and youths have advanced from unimportant common place labour to skilled work. At the end of the war we shall have in the Empire from four to five millions of trained men, survivors from the battlefields who will have had the tremendous advantage derived from the physical, mental and moral training required of soldiers. Through the efforts of the clergy, our military leaders and our statesmen, the national conscience, too, has been so awakened that a revolution has been accomplished in the attitude of the army and of the manhood of the nation generally, towards questions of temperance, clean living, literature and the drama. I am making but a conservative estimate when I say that as a result of the war from 10 to 15 millions of the British people will have made an enormous mental, moral, and physical advance.

In walking through the different works in the cities of London, Manchester, Liverpool, Birmingham and other places one is struck by a new alertness, a sort of mental and physical exhilaration that gives

one the impression of being in the midst of a gigantic struggle in which the participants have consecrated themselves body and soul, with a lofty cheerfulness and transcendent eagerness to the accomplishment and consummation of one of the noblest and most stupendous tasks to which humanity has ever set its hand.

On the breaking out of the war two years ago, one witnessed the most heart-rending sights when trainloads of soldiers left the great stations in the British Isles for the front. Wives were seen clinging to husbands, mothers to sons, and sweethearts to their lovers. The air was filled with wailing and anguished cries. To-day, under similar circumstances, one still sees women and girls crowding the railway stations to bid good-bye to their soldier sweethearts and relatives. But all is changed. There is still eagerness, yearning, longing, admiration and tenderness in their faces, but practically no tears. The people are beyond tears. The effects of the war are everywhere and are felt equally by all classes. The result is a most remarkable mental, moral and spiritual exultation. I have not had the privilege of visiting France since the war began, but I am told that the changes which have taken place in that wonderful country are equally marked and equally profound. It has been truly said that "Britain and France are not simply renewed—they are reborn. The British Empire and France are the youngest nations in the world".

The changes which have been wrought by the war in the Old World have also been going on in Canada, though to a less degree, and the question naturally arises:—What are we to do with all this enormous quantity of mechanical equipment which has been assembled and what are we to do with the millions of men and women who have received this remarkable stimulation and change of outlook from the stress of war? Assuredly here we have a problem which will tax the resources of Governments and Legislatures let alone that of Industrial Commissions.

We must however remember that the mechanical equipment, and mental energy which has been developed in the process of rescuing the Empire from disaster, can also be used in the arts of peace for maintaining and extending its intellectual and industrial supremacy. Both capital and labour have learned how to respect each other. Capital has learned that the labourer is worthy of his hire, and labour has learned that the promotion of its interests is not incompatible with efforts on the part of capital to increase production. Both have learned the value of the application of scientific principles to industry and have seen more clearly that co-operation and mutual confidence are vital factors in the advancement of national greatness.

With a successful termination to the war fairly well in sight, increasing attention is now being paid both in Canada and in Great Britain to this question and in both portions of the Empire steps have been taken to constitute advisory boards whose function will be to indicate to manufacturers the various industries in which their war equipment can be put to profitable use. France is probably at the present time ahead of us in dealing with this question for in a report which has recently been published in that country some interesting, definite and very helpful suggestions are made. In this report, for example, it is pointed out that the equipment which is now being used for the manufacture of acids, tar products, powder, and explosives, can under peace conditions be used for the manufacture of artificial perfumes, photographic materials, pharmaceutical products and organic and inorganic dyes. It is also shown that engineers and workmen who have been trained in the manufacture of smokeless powder, melinite, and trinitrotoluol can after the war be used in the same works and with the same machinery to manufacture such articles as artificial silk, nitrobenzene, and aniline, etc.

The report also goes on to say that in order to give effect to these suggestions, there has been formed in France the Syndicat National de Matières Colorantes, which is a combination of coal and metallurgical companies, paper makers, dyers, textile manufacturers, etc. This illustration will serve to indicate to you the progress of the movement in France. Thanks to it, it is now clear that hundreds of thousands of workmen in that country will continue to earn their wages and the works which are to-day mobilised for destruction will to-morrow, when peace is declared, make France more powerful than ever.

One hears frequent reference made these days to the transference of enormous reserves of accumulated wealth from the British Empire and the allied countries to neutral nations, especially the United States, and one is apt to be discouraged by the vastness of our debt to that nation incurred through our prosecution of the war. We must realise however that the future is not at all a hopeless one. Our greatest loss is that of the lives of thousands of our bravest and best whom we can ill spare, but who have made the supreme sacrifice gladly, and confident that by so doing they were not contributing to the loss but to the enhancement of the greatness and glory of our Empire. These precious lives can never be restored to us. But the accumulation of vast mechanical equipment, the establishment of enormous works of all kinds, the mobilisation of industry, practice in the successful production of all types of manufacture in enormous quantities, tremendous advances in the manipulative and mechanical skill of millions of our people, and a recognition of the vital

necessity of co-operation between science, industry, labour, finance, and government—these, together with the wider outlook, the intensity of effort, the moral uplifting and the spiritual exaltation which the war has brought to us in its train are all assets which in themselves connote national greatness. If we conserve and cherish these, if we stimulate and foster the scientific spirit in our midst, if our industries more and more continue to look to science for direction, information and advice, national indebtedness will gradually pass away and with the memory of the sacrifices we have made and the efforts we have put forth, for the liberation, peace and happiness of humanity ever before us, our Empire will rise purified and ennobled to an enhanced glory far beyond that which, in the past, with good reason, has been its chief pride and most cherished possession.

FINANCIAL AND GOVERNMENTAL SUPPORT OF KEY INDUSTRIES.

Had time permitted I could have referred here at some length to a part banking interests might play in developing certain types of manufacture in this country which are at present lacking. I refer to the lack of manufacturers of such articles as glass tubing, thermometers, chemical glass ware, porcelain ware, meters of all kinds, certain types of technical apparatus, certain chemicals, gauges, dies, and machine tools. In the industries these articles are of a fundamental nature and are of vital necessity. In the past our supply was largely drawn from the United States, Great Britain, France or Germany. This means that much of the manufacturing and many of the researches in the works, in the Universities, and the Colleges, are frequently held up for months at a time. Such articles would in Canada at first be manufactured in a small way, at least until types were developed which would command the market in foreign countries. Those who engage in the manufacture of articles having a limited market would probably find it difficult to get proper financial support from our banking institutions. It is quite easy in Canada apparently for railroads, electric development companies, steel corporations, milling and other large and politically powerful interests to have very large advances made to them by the banks under legislative or governmental guarantees, but it is not so easy for the manufacturers of such articles as I have mentioned to get it. It is of great national interest however to have these industries in our midst, and it appears to me that if a Dominion Commission on Industrial Research would emphasize the necessity of developing these fundamental industries in our country that the Government would soon take such

legislative action as would induce our banking and financial institutions to single out these vital industries as being for the common good, worthy of very special support and encouragement. It seems to me that if it be necessary to continue a policy of protection in this country—and I may add that it seems to be both desirable and necessary—we should see to it that it is first of all applied to those industries which are basic and of vital importance to the community rather than to those for example which have to do with the preparation of foodstuffs and clothing material, and the production of books, periodicals and printed matter generally. In the past the application of the principle of "protection" has in some cases worked out as the imposition of a special tax upon the consumer for the benefit of the manufacturer without producing any compensating general advantages in the way of a commensurate or even substantial contribution to the wealth of the nation. I venture to present a special plea at this time, for a scientific revision of our tariffs. Let us take stock of our economic position in a broad way, and adopt such measures as will tend to lower the cost of living and as will ensure the production and manufacture in our own country of such articles as are of vital and fundamental importance to the nation. We are frequently told that the manufacture of machine tools and other articles belonging to the category I have mentioned will require a class of skilled labour which has not in the past been available. In the future this argument cannot be put forward for as a result of the war we shall have hundreds and thousands of men and women in the empire who have had a training not only in machine and tool work of the highest precision but also in machine construction and machine design. The higher positions in such manufacturing industries will afford openings for the trained technical experts being turned out by our Universities. Let us see to it that in Canada we are ready to use to the full the magnificent contribution to our national capabilities which the stress of war has made.

THE HOUSING PROBLEM.

One more point and then I have done. In a previous part of the paper I have referred to the prospective development of the Western part of Ontario and particularly the Niagara Peninsula into a region of intense industrial activity. This means that unless care is taken in advance we shall have in this district a repetition of the wretched conditions which prevail in the neighbourhood of such places as Sheffield, Leeds, Glasgow, and other manufacturing cities in the Old Country. In fact the evil is to a certain extent already with us for if one visits certain towns in Ontario and other parts of Canada at the present time one will find that the workmen are housed in buildings entirely lacking

in architectural beauty, situated often on low-lying and otherwise most unsuitable ground areas. Too often no serious attempt is made to lay out the streets with taste or to erect the houses with due provision for a reasonable amount of comfort and sanitary safeguards. They often seem to be erected at haphazard in close proximity to the works, and in the midst of an atmosphere contaminated with grime and smoke. Very little provision is made for open spaces, garden facilities and park areas. The matter is left entirely to the whim of the manufacturer and the machinations of the land speculator.

The proper housing of workmen should, I venture to say, be as much the concern of Boards of Health as the disposal of sewage or the provision of a supply of pure water. If due care be taken now by adequate legislative action we can easily see to it that at a very small additional cost homes can be provided for our workmen pleasing in design, artistically located in healthy locations, and with properly laid out areas for garden and recreation purposes which will give the moral and aesthetic natures of our working people a legitimate chance of development.

Our water supplies in Western Ontario will also have to be looked after. At the present time these are drawn for practically all the towns in this district from sources which in the near future cannot fail to become contaminated. In the Georgian Bay and Lake Huron we have an inexhaustible supply of pure water. With this as a source it would seem to be quite a simple engineering problem to erect reservoirs on the height of land in the counties of Perth and Waterloo, Wellington, or Dufferin, which would supply the whole of Western Ontario. If this were done the pumping plants in all the cities and towns in the district could be dispensed with, and one plant of suitable dimensions, if properly located, would suffice for all. We have seen how in England and Scotland vast sums of money have been expended and how great physical difficulties have been overcome to furnish the cities of Glasgow, Liverpool, Manchester, Sheffield, Birmingham and London with a plentiful supply of pure water. In Western Ontario the problem would I venture to think, be a comparatively simple one to solve. It would however require to be dealt with in a broad way, but with the example of the successful development of the Provincial Hydro-electric scheme before us, it is a problem which our different municipalities, towns and cities might readily undertake to consider, confident that a satisfactory and yet simple solution can readily be found.

But I must close my remarks.

In what has preceded I have endeavoured to present a few aspects of the question of industrial research as they appear to me. My treatment must necessarily be inadequate and defective. I have not had the

opportunity, except to a very limited extent, of becoming familiar either with the financial, the mechanical, or the economic side of manufacturing. My calling, however, leads me continually to the consideration of scientific problems and scientific methods. I have in a measure become familiar with the steps taken in Great Britain and other countries in developing schemes of industrial research and in dealing with allied matters. These I have endeavoured to apply to what appears to me to be the special needs of our own country, a country which we all agree is full of potentiality and promise.

In closing may I be permitted to remind you that the terrible War which is now being waged is but one aspect of a tremendous struggle for Truth and Righteousness. Let us not forget that it is a struggle in which Science is one of the combatants. Are we to be the Allies of Science or must Science look in another direction for support? The words recently penned by the English Poet, William Watson, are not without interest at this time. They are entitled:

WHAT SCIENCE SAYS TO TRUTH.

As the mainland to the sea
Thou art to me.
Thou standest stable, while against thy feet
I beat, I beat!

Yet from the cliffs so sheer, so tall,
Sands crumble and fall;
And golden grains of thee my tides each day
Carry away.

APPENDIX I.

ORDER IN COUNCIL CONSTITUTING A COMMITTEE OF THE PRIVY
COUNCIL OF GREAT BRITAIN AND IRELAND AND AN
ADVISORY COUNCIL FOR SCIENTIFIC AND INDUS-
TRIAL RESEARCH.

AT THE COURT AT BUCKINGHAM PALACE,

The 28th day of July, 1915.

PRESENT:

THE KING'S MOST EXCELLENT MAJESTY IN COUNCIL.

It is this day ordered by His Majesty in Council that the Lord President of the Council, the Chancellor of the Exchequer, the Secretary for Scotland, the President of the Board of Trade, the President of the Board of Education, and the Chief Secretary for Ireland, respectively, for the time being, the Right Honourable Viscount Haldane of Cloan, K.T., O.M., F.R.S., the Right Honourable Arthur Herbert Dyke Acland, and the Right Honourable Joseph Albert Pease, M.P., be, and they are, hereby appointed a Committee to direct, subject to such conditions as the Treasury may from time to time prescribe, the application of any sums of money provided by Parliament for the organisation and development of scientific and industrial research.*

It is further ordered that during His Majesty's pleasure the President of the Board of Education shall preside over the said Committee in the absence of the Lord President:

Moreover, it is further ordered that, for the purposes aforesaid, there shall be an Advisory Council (consisting of such number of persons holding office for such term as the Committee shall from time to time determine) to which shall stand referred, for their report and recommendation, proposals—

- (i) for instituting specific researches;
- (ii) for establishing or developing special institutions or departments of existing institutions for the scientific study of problems affecting particular industries and trades; and
- (iii) for the establishment and award of Research Studentships and Fellowships.

The said Council may itself initiate such proposals and may advise the Committee on such matters, whether general or particular, relating to the advancement of trade and industry by means of scientific research as the Committee from time to time determine.

And it is ordered that the following shall be among the first Members of the Advisory Council:—

Sir William Symington McCormick, LL.D. (Administrative Chairman);
The Right Honourable Lord Rayleigh, O.M., D.C.L., LL.D., F.R.S.;
George Thomas Beilby, Esquire, LL.D., F.R.S.,
William Duddell, Esquire, F.R.S.;
Professor Bertram Hopkinson, F.R.S.;
Professor John Alexander McClelland, F.R.S.;
Professor Raphael Meldola, F.R.S.; and
Richard Threlfall, Esquire, F.R.S.

* By supplemental Order in Council of 23rd May 1916 the Secretary of State for the Colonies for the time being was appointed a member of the Committee.

And it is ordered that the Committee may, out of funds provided by Parliament or otherwise available for the purpose, pay such remuneration to the Members of the Advisory Council and such salary to the Administrative Chairman thereof as the Treasury authorise, and defray to such an amount as may be sanctioned by the Treasury any other expenses incurred by the Council in or in connexion with the performance of its duties, and may enter into any contracts incidental thereto.

And it is ordered that the Committee shall in every year cause to be laid before both Houses of Parliament a Report of their proceedings and of the proceedings of the Advisory Council, during the preceding year.

ALMERIC FITZROY.

APPENDIX II.

SCHEME FOR THE ORGANISATION AND DEVELOPMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH IN GREAT BRITAIN AND IRELAND.

1. There is a strong consensus of opinion among persons engaged both in science and in industry that a special need exists at the present time for new machinery and for additional State assistance in order to promote and organise scientific research with a view especially to its application to trade and industry. It is well known that many of our industries have since the outbreak of war suffered through our inability to produce at home, certain articles and materials required in trade processes, the manufacture of which has become localised abroad, and particularly in Germany, because science has there been more thoroughly and effectively applied to the solution of scientific problems bearing on trade and industry and to the elaboration of economical and improved processes of manufacture. It is impossible to contemplate without considerable apprehension the situation which will arise at the end of the war unless our scientific resources have previously been enlarged and organised to meet it. It appears incontrovertible that if we are to advance or even maintain our industrial position we must as a nation aim at such a development of scientific and industrial research as will place us in a position to expand and strengthen our industries and to compete successfully with the most highly organised of our rivals. The difficulties of advancing on these lines during the war are obvious and are not under-estimated, but we cannot hope to improvise an effective system at the moment when hostilities cease, and unless during the present period we are able to make a substantial advance we shall certainly be unable to do what is necessary in the equally difficult period of reconstruction which will follow the war.

2. The present scheme is designed to establish a permanent organisation for the promotion of industrial and scientific research.

It is in no way intended that it should replace or interfere with the arrangements which have been or may be made by the War Office or Admiralty or Minister of Munitions to obtain scientific advice and investigation in connection with the provision of munitions or war. It is, of course, obvious that at the present moment it is essential that the War Office, the Admiralty, and the Ministry of Munitions should continue to make their own direct arrangements with scientific men and institutions with the least possible delay.

3. It is clearly desirable that the scheme should operate over the Kingdom as a whole with as little regard as possible to the Tweed and the Irish Channel. The research done should be for the Kingdom as a whole, and there should be complete liberty to utilise the most effective institutions and investigators available, irrespective of their location in England, Wales, Scotland or Ireland. There must therefore be a single fund for the assistance of research, under a single responsible body.

4. The scheme accordingly provides for the establishment of—

- (a) A Committee of the Privy Council responsible for the expenditure of any new moneys provided by Parliament for scientific and industrial research;
- (b) A small Advisory Council responsible to the Committee of Council and composed mainly of eminent scientific men and men actually engaged in industries dependent upon scientific research.

5. The Committee of Council will consist of the Lord President, the Chancellor of the Exchequer, the Secretary for Scotland, the President of the Board of Trade, the President of the Board of Education (who will be Vice-President of the Committee), the Chief Secretary for Ireland, together with such other Ministers and individual Members of the Council as it may be thought desirable to add.

The first non-official Members of the Committee will be—

- The Right Hon. Viscount Haldane of Cloan, O.M., K.T., F.R.S.,
- The Right Hon. Arthur H. D. Acland, and
- The Right Hon. Joseph A. Pease, M.P.

The President of the Board of Education will answer in the House of Commons for the sub-head on the Vote, which will be accounted for by the Treasury under Class IV., Vote 7, "Scientific Investigations, &c."

It is obvious that the organisation and development of research is a matter which greatly affects the public educational systems of the Kingdom. A great part of all research will necessarily be done in Universities and Colleges which are already aided by the State, and the supply and training of a sufficient number of young persons competent to undertake research can only be secured through the public system of education.

6. The primary functions of the Advisory Council will be to advise the Committee of Council on—

- (i) proposals for instituting specific researches;
- (ii) proposals for establishing or developing special institutions or departments of existing institutions for the scientific study of problems affecting particular industries and trades;
- (iii) the establishment and award of Research Studentships and Fellowships.

The Advisory Council will also be available, if requested, to advise the several Education Departments as to the steps which should be taken for increasing the supply of workers competent to undertake scientific research.

Arrangements will be made by which the Council will keep in close touch with all Government Departments concerned with or interested in scientific research and by which the Council will have regard to the research work which is being done or may be done by the National Physical Laboratory.

7. It is essential that the Advisory Council should act in intimate cooperation with the Royal Society and the existing scientific or professional associations, societies and institutes, as well as with the Universities, Technical Institutions and other institutions in which research is or can be efficiently conducted.

It is proposed to ask the Royal Society and the principal scientific and professional associations, societies and institutes to undertake the function of initiating proposals for the consideration of the Advisory Council, and a regular procedure for inviting and collecting proposals will be established. The Advisory Council will also be at liberty to receive proposals from individuals and themselves to initiate proposals.

All possible means will be used to enlist the interest and secure the co-operation of persons directly engaged in trade and industry.

8. It is contemplated that the Advisory Council will work largely through Sub-Committees reinforced by suitable experts in the particular branch of science or industry concerned. On these Sub-Committees it would be desirable as far as possible to enlist the services of persons actually engaged in scientific trades and manufactures dependent on science.

9. As regards the use or profits of discoveries, the general principle on which grants will be made by the Committee of Council is that discoveries made by institutions, associations, bodies, or individuals in the course of researches aided by public money shall be made available under proper conditions for the public advantage.

10. It is important in order to secure effective working that the Advisory Council should be a small body, but it is recognised that even if full use is made by the Council of its power to work through reinforced Sub-Committees, its membership may be found inadequate to do justice to all the branches of industry in which proposals for research may be made or to the requests of other Government Departments for assistance. It is therefore probable that it will be found necessary to strengthen the Council by appointing additional Members.

The first Members of the Council will be—

The Right Hon. Lord Rayleigh, O.M., F.R.S., LL.D.

Mr. G. T. Beilby, F.R.S., LL.D.

Mr. W. Duddell, F.R.S.

Prof. B. Hopkinson, F.R.S.

Prof. J. A. McClelland, F.R.S.

Prof. R. Meldola, F.R.S.

Mr. R. Threlfall, F.R.S.

With Sir William S. McCormick, LL.D., as *administrative Chairman*.

11. The Advisory Council will proceed to frame a scheme or programme for their own guidance in recommending proposals for research and for the guidance of the Committee of Council in allocating such State funds as may be available. This scheme will naturally be designed to operate over some years in advance, and in framing it the Council must necessarily have due regard to the relative urgency of the problems requiring solution, the supply of trained researchers available for particular pieces of research, and the material facilities in the form of laboratories and equipment which are available or can be provided for specific researches. Such a scheme will naturally be elastic and will require modification from year to year; but it is obviously undesirable that the Council should live "from hand to mouth" or work on the principle of "first come first served," and the recommendations (which for the purpose of estimating they will have to make annually to the Committee of Council) should represent progressive instalments of a considered programme and policy. A large part of their work will be that of examining, selecting, combining, and co-ordinating rather than that of originating. One of their chief functions will be the prevention of overlapping between

institutions or individuals engaged in research. They will, on the other hand, be at liberty to initiate proposals and to institute inquiries preliminary to preparing or eliciting proposals for useful research, and in this way they may help to concentrate on problems requiring solution the interest of all persons concerned in the development of all branches of scientific industry.

12. An Annual Report embodying the Report of the Advisory Council will be made to His Majesty by the Committee of Council and laid before Parliament.

13. Office accommodation and staff will be provided for the Committee and Council by the Board of Education.

ARTHUR HENDERSON.

23rd July 1915.

APPENDIX III.

LIST OF RESEARCHES AIDED DURING THE YEAR 1915-16 BY THE COMMITTEE OF THE PRIVY COUNCIL OF GREAT BRITAIN AND IRELAND ON SCIENTIFIC AND INDUSTRIAL RESEARCH.

Research.	Institution or Body responsible for the Research.	Institutions, Laboratories, &c., at which the Research is, or will be, conducted.
(i) RESEARCHES WHICH WERE ALREADY IN PROCESS.		
Laboratory Glass - -	Institute of Chemistry.	Laboratory of the Institute of Chemistry, King's College, London, and Professor Jackson's private laboratory.
Optical Glass - -	Do. Do.	Do. do.
Refractory Materials	Institution of Gas Engineers.	Stoke-on-Trent Central School of Science and Technology.
Hardness Test for Journals and Pins.	Institution of Mechanical Engineers.	National Physical Laboratory. Certain firms are co-operating.
Properties and Composition of Alloys.	Do. do.	National Physical Laboratory.
Flow of Steam through Nozzles. <i>u</i>	Do. do.	University of Manchester and Glasgow Royal Technical College. Certain firms are co-operating.
Heating of Buried Cables.	Institute of Electrical Engineers.	National Physical Laboratory and University of Liverpool. Certain firms and public electricity supply undertakings are co-operating.
Properties of Insulating Oils.	Do. do.	Manchester Municipal School of Technology. Certain firms are co-operating.
Tool Steel Experiments	Manchester Association of Engineers.	Manchester Municipal School of Technology.
Methods of Notched Bar Impact Testing.	Engineering Standards Committee.	National Physical Laboratory.

Research.	Institution or Body responsible for the Research.	Institutions, Laboratories, &c., at which the Research is, or will be, conducted.
Corrosion of Nonferrous Metals.	Institute of Metals -	University of Liverpool. From 1st October 1916, the research will be transferred to the Royal School of Mines (Imperial College of Science and Technology), and the Brighton Corporation Electric Power Station.

(ii) NEW RESEARCHES.

Optical Glass - -	National Physical Laboratory.	National Physical Laboratory.
Glass Technology - -	Sheffield University Delegation for Glass Research.	Research Institute attached to the University of Sheffield.
Hard Porcelain - -	Joint Research Committee of the Stoke Central School of Science and Technology and the Staffordshire Potteries Manufacturers' Association.	Research Institute attached to the Central School of Science and Technology, Stoke-on-Trent.
Setting and Disintegration of Salts and Crystalline Substances.	Faraday Society - -	Guy's Hospital Medical School and Mr. Bousfield's private laboratory.
De-gumming of Silk - -	Silk Association - -	Imperial College of Science and Technology. Certain firms are co-operating.
Tin and Tungsten - -	Institution of Mining and Metallurgy.	Royal School of Mines (Imperial College of Science and Technology), privately owned laboratories and concentration works of certain companies owning mines in Cornwall.
Statistical Work in preparation of field for research in Iron and Steel	Iron and Steel Institute	Offices of the Institute.

Research.	Institution or Body responsible for the Research.	Institutions, Laboratories, &c., at which the Research is, or will be, conducted.
Rate of Heat Transmission from Hot Surfaces to Fluids over them.	National Physical Laboratory.	National Physical Laboratory.
Deterioration of Structures of Timber, Metal, and Concrete in Sea Water.	Institution of Civil Engineers.	Various Ports throughout the Empire, and laboratories (for special investigations) as may be required.

APPENDIX IV.

REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL OF THE
DOMINION OF CANADA APPROVED BY HIS ROYAL
HIGHNESS THE GOVERNOR GENERAL ON THE
6th JUNE 1916

The Committee of the Privy Council have before them a report, dated 23rd May 1916, from the Minister of Trade and Commerce, to whom was referred a despatch from the Right Hon. A. Bonar Law, Secretary of State for the Colonies, calling attention to a scheme of scientific and industrial research for the United Kingdom, as embodied in Parliamentary Paper Cd. 8005, attached hereto, and a copy of the Order in Council approving of the same.

The Minister observes that this scheme, proposed by Mr. Arthur Henderson, contemplated the appointment of a Committee of the Privy Council which should be responsible for the carrying out of the same, and a small Advisory Council responsible to the Committee to be composed mainly of scientific men and men actually engaged in industries dependent upon scientific research. By Order in Council, 28th July 1915, effect was given to this scheme, and the Committee and Council proposed therein were appointed and their respective duties set out. The scheme was to be applied to the United Kingdom as a whole and was not intended in any way to interfere with the arrangements already made by the War Office and the Admiralty in respect to obtaining scientific assistance for the improvement of munitions of war, but was designed to establish a permanent organisation for the promotion of scientific and industrial research.

The Minister observes that after this scheme had gone into operation, suggestions were made from various sources that it should be extended and made applicable to the Overseas Dominions or even to the Empire as a whole. These suggestions were approved in principle by the Committee of Council, and a memorandum was prepared intimating certain preliminary steps that might be taken to bring about gradually co-operation of effort and co-ordination of research throughout the Empire.

On the 20th January 1916 the Minister of Munitions caused to be distributed to educational institutions in the United Kingdom a circular letter inviting co-operation in the improvement and invention of appliances for the prosecution of warfare, and copies of the same were sent to certain universities in Canada. As a result these universities have given full information on the facilities they possess for carrying on research work in respect to the specific purpose of the Minister of Munitions. They express willingness also to co-operate and assist in the work of industrial research, and are of the opinion that some department of the Government of Canada should undertake to co-ordinate and supervise this work and act as a medium of communication.

The Minister desires to point out the urgent necessity of organising, mobilising and encouraging the existing resources of industrial and scientific research in Canada with the purpose of utilising waste products, discovering new processes—mechanical, chemical and metallurgical—and developing into useful adjuncts to industry and commerce the unused natural resources of Canada. At no period has the importance of such united and thorough action been so evident as since the conditions brought about by the war, when the scarcity of certain compounds and processes has caused confusion and paralysis in industries and greatly added to cost of living. Canada has educational and scientific institutions more or less well equipped for conducting this research, which have already done much along their several lines and are willing and anxious to equip

themselves for doing more. There are also private, corporate and Government laboratories, more or less engaged in research work. The Manufacturers' Associations are alive to the importance and absolute necessity of such work in relation to the industries of the country and are anxious to co-operate in and support it.

What seems to be immediately urgent is to have some method of co-ordination and direction which shall combine the efforts of all, along the lines for which each is best adapted and which would tend to avoid duplication and promote efficiency of action. To this end the Minister has been more or less in continuous communication and conference with representatives of the Universities, the Canadian Manufacturers' Association and the scientific institutions. The consideration thus given has resulted in a practical unanimous agreement both as to the necessity of immediate action and as to the lines along which it should be taken.

The Minister, therefore, recommends the appointment of a Committee of Council to consist of the Minister of Trade and Commerce, the Minister of the Interior, the Minister of Mines, the Minister of Inland Revenue, the Minister of Labour, and the Minister of Agriculture, which shall be charged with, and responsible for, the expenditure of any moneys provided by Parliament for scientific and industrial research, and also an Honorary Advisory Committee, responsible to the Committee of Council, to be composed of nine members, representative of the scientific and industrial interests of Canada, who shall be charged with the following duties —

- (a) To consult with all responsible bodies and persons carrying on scientific and industrial research work in Canada with a view to bringing about united effort and mutual co-operation in solving the various problems of scientific and industrial research which from time to time present themselves;
- (b) To co-ordinate as far as possible the work so carried on so as to avoid overlapping of effort, and to direct the various problems requiring solution into the hands of those whose equipment and ability are best adapted thereto;
- (c) To select the most practical and pressing problems indicated by industrial necessities and present them when approved by the Committee to the research bodies for earliest possible solution.
- (d) To report from time to time the progress and results of their work to the Minister of Trade and Commerce as Chairman of the Committee of Council.

That a competent Secretary be appointed on the nomination of the Committee and paid by the Department of Trade and Commerce.

That the travelling expenses of the Committee shall be paid by the Department of Trade and Commerce.

The Committee concur in the foregoing and submit the same for approval.

RODOLPH BOURDEAU,

Clerk of the Privy Council.

APPENDIX V.

MEMORANDUM ON THE SUGGESTIONS MADE BY THE GOVERNMENTS OF VICTORIA AND NEW SOUTH WALES FOR MAKING THE SCHEME FOR THE ORGANIZATION AND DEVELOPMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH APPLICABLE TO THE WHOLE EMPIRE.

1. The Committee of the Privy Council for Scientific and Industrial Research have considered the papers communicated to them by the Secretary of State for the Colonies on the 23rd November 1915 and the 3rd January 1916, including memoranda by the Minister of Public Works of Victoria, and by the Honourable Premier for New South Wales. It is suggested in these memoranda that the scheme described in the White Paper issued by Mr. Arthur Henderson on the 23rd July 1915 [C.d. 8005], and subsequently embodied in the order in Council of the 28th July 1915 (which is reprinted as an appendix to this memorandum), should be extended and made applicable to the Overseas Dominions, or even to the Empire as a whole.

2. In the memorandum by the Minister of Public Works of Victoria, special stress is laid on the statement made in paragraph 3 of the White Paper that—

“it is clearly desirable that the scheme should operate over the Kingdom as a whole with as little regard as possible to the Tweed and the Irish Channel. The research done should be for the Kingdom as a whole, and there should be complete liberty to utilise the most effective institutions and investigators as available, irrespective of their location in England, Wales, Scotland, or Ireland.”

The Committee of the Council have no hesitation in expressing their concurrence in the view that the principle of the passage above cited is capable of a much wider application, and so far as in them lies, they are prepared to co-operate cordially with the Secretary of State in promoting such an arrangement between the Mother Country and the Overseas Dominions as would secure the effective application of the principle throughout the Empire. A complete and effective system of research implies the power to carry out each piece of work in the place where the conditions are most favourable and where it can be performed most thoroughly, quickly, and economically. It is obvious that a reciprocal arrangement by which the scientific and industrial resources of the Mother Country in men, material, and equipment could be made available for a research in which any of the Dominions was primarily interested, and which conversely would place the resources of the Overseas Dominions at the disposal of the Mother Country and of each other, would greatly augment the aggregate research capacity of the Empire and enhance the productivity of its industries.

3. The simplest form of Imperial co-operation would be an arrangement by which one Government (or some administrative body acting under its authority) would act as the agent of another Government for the purpose of arranging, carrying out, and supervising a specific research, the entire cost being borne by the Government initiating the research. It is not outside the existing powers of the Committee of the Privy Council to aid a research intended to benefit a British industry, even though the research may be conducted beyond the borders of the United Kingdom. For instance, the best means of recovering a metal found in one of the Overseas Dominions and needed for the production of some new alloy required by the British Metallurgical or Engineering Industry, might form the subject of a research conducted in that Dominion at the instance and at the cost of the Committee of Council. For this purpose their Advisory

Council would naturally try to find some body or institution in the Dominion willing, as the Committee's agent, to arrange for and supervise the actual execution of the research. Conversely, there is no reason why the Committee of Council or their Advisory Council should not act as the agent for an Overseas Government (or for any body or institution acting under the authority of the Government), for the purpose of arranging and carrying out on its behalf and at its cost any research which could more conveniently or effectively be conducted in the Mother Country. For instance, it may be worth while for an Overseas Dominion to defray the cost of a research in the Mother Country into the best method of utilising an earth or metal which is found in the Dominion but for which there is not at present a sufficient market in the Mother Country, with a view to creating such a market.

4. If, however, an effective agency arrangement were established between different parts of the Empire, it is highly probable that this relation would quickly develop into a more intimate and a more highly organised relation. The scope and methods of modern scientific research, especially when it is directed to the solution of the practical problems of trade and industry, are such as often to require the combined efforts of many workers in many places, involving a co-ordinated division of labour, and a series of investigations into problems arising at many points in the process between the raw material and the finished product. When the raw material is produced, and especially where it is grown, in one part of the world and manufactured in another, a satisfactory solution of the series of problems with which the industry is confronted will often require concurrent and concerted investigation in both countries. For instance, wheat, cotton, silk, rubber, and wool offer a number of distinct though related problems which intimately affect more than one of the constituent parts of the Empire, and which can be most effectively dealt with by simultaneous and co-ordinated investigation in different parts of the world. In such cases, moreover, it is not at all likely that the commercial interests of the two countries in the results of the different parts of the research will be so distinct as to admit of separate valuation of and separate payment for the work actually done for each country. The character of modern organized research, and the character of modern commerce and industry, are in fact such as to render it almost inevitable that a relation which starts as one of reciprocal agency between different parts of the Empire should lead to a more definitely co-operative relation of "joint venture" or "limited partnership." Under such an arrangement two or more parts of the Empire would combine to frame a scheme for the investigation of a specific problem in which they were all jointly interested, would contribute in agreed proportion to the cost of the whole work, and would arrange between themselves for the distribution of the work among the laboratories, factories, & c., at the disposal of the contributors for the supervision of the work and for the collection, statement, and use of the results achieved.

5. It is not inconceivable that in the future the relations of agency or "joint venture" may lead to a still more extensive and comprehensive partnership or union of interests. The White Paper already referred to declares, at the end of paragraph 3, with reference to the United Kingdom, that "there must be a single fund for the assistance of research under a single responsible body." The question whether it would be practicable to extend this principle to the whole Empire by the constitution of a Central Body for the purpose of administering a common fund supported by contributions from the United Kingdom and Overseas Dominions, raises issues with which the Committee of Council are not competent to deal. The "pooling" or consolidation of the resources of the Empire for the purposes of scientific research is a stimulating ideal, but though pure science is cosmopolitan and disinterested, it is in its application to trade and industry inevitably

effected by the divergent commercial interests of individuals and Governments, and the wide separation in space and the great diversity of the components of the British Empire, are still material considerations of which full account must be taken in thinking of any scheme for unified administration.

6. The Committee of Council, however, believe that even at the present time, when the energies of the Empire are so pre-occupied by the war, it is not only possible but very desirable to make an advance in the direction suggested by the Governments of Victoria and New South Wales.

It may not be possible during the war to undertake, either at home or in the Overseas Dominions, any researches involving the concerted work of a large number of trained researchers, or the provision of extensive plant and equipment. On the other hand, the Committee of Council are more than ever convinced that during the war it is essential to prepare and test, if only on a relatively small scale, an organisation by which the scientific resources of the Empire can be mobilised on a large scale immediately the war is over. The success of anything like an Imperial Scheme of Research must ultimately depend at least as much upon the skill, foresight, and care with which it is managed as upon the zeal and goodwill of the Governments, universities, and industries which co-operate in it; and it would be very imprudent to wait until the demand has become heavy and urgent in the hope of then improvising a satisfactory system of management.

7. The Committee, therefore, suggest that if the general proposal commends itself, each Overseas Government which is willing to enter into a co-operative arrangement should, as a first step and at an early date, constitute some body or agency having functions analogous to those of the Advisory Council which acts for the United Kingdom.

The Committee of Council have, of course, no intention of suggesting that the particular arrangement adopted for the United Kingdom should be taken as a model by other parts of the Empire. The Committee of Council as originally constituted consists of six Ministers *ex-officio* and three ex-Ministers. This body is ultimately responsible for asking Parliament to furnish the necessary funds and for approving their expenditure. It is an essential part of the scheme that all proposals for research shall stand referred to an Advisory Council which is a relatively small body, mainly consisting of eminent scientific men and men actually engaged in industries dependent upon scientific research, and that this Council shall take full responsibility for the scientific and technical soundness of all research proposals recommended by them for State assistance.

In the case of the Overseas Dominions the precise relation of any new body or agency to the Central or the State or Provincial Government, or to a particular Ministry, must obviously depend on local conditions and local preferences. It is, of course, assumed that it would be supported by the resources and influence of the Ministry of Commerce, as in the United Kingdom the resources and influence of the Board of Trade are available for working the scheme of research in its commercial and industrial relations.

The Committee of Council, however, venture to lay stress upon two points. First, any bodies or agencies instituted for the purpose should, under their respective Governments, have really responsible functions and substantial authority. The several bodies, moreover, should be at liberty to communicate freely with one another, and should within the limits of the funds placed at their disposal, be empowered to negotiate with one another for the formation and execution of schemes of research. Secondly, a close connection should be maintained between these bodies and the public educational systems and institutions of their respective countries. It is obvious that the work of Universities and other institutions for advanced scientific and technological education will both affect and be affected by a State system of research, and that the systematic

development of research must ultimately depend upon an adequate supply of men and women who are fitted by their training to undertake it. So far as the extended scheme or research involves consideration of the educational problems of different parts of the Empire, it would possibly form an appropriate subject for consideration at the next Imperial Educational Conference and the next Conference of the Universities of the Empire.

8. It is too soon for the Committee of Council to speak as to the working of the scheme which has been established in the United Kingdom. One of the most important functions of the Advisory Council is to promote a better understanding and a closer union between men engaged in science and in industry. Considerable use has already been made by the Advisory Council of sub-committees reinforced by suitable experts in particular branches of science or industry, such as were contemplated by paragraph 8 of the White Paper, and arrangements are now being made to give effect to the principle of paragraph 7 of the White Paper by setting up certain representative Standing Committees for the great scientific industries of Engineering, Metallurgy and Mining.

9. The Committee of Council would gladly co-operate with the Secretary of State in establishing and conducting any central organisation which it may be found desirable to set up in London for the purpose of facilitating and carrying on the business of an Imperial Scheme of Research. Some kind of central office, information bureau, or clearing house would be required, and, to start with, it might be possible to us, and, as occasion requires, to extend for this purpose the staff of the Advisory Council. A beginning has already been made by the Advisory Council in the compilation of a Register of Research, the scientific and industrial utility of which would be obviously greatly increased if its scope were extended to all parts of the Empire.

10. No reference has been made in this memorandum to the research work which is already done on behalf of the Overseas and Ex-quer-aided Colonies and Protectorates by such institutions as the National Physical Laboratory and the Imperial College of Science and Technology, as well as by the laboratory of the Imperial Institute. Close relations between the Advisory Council and these institutions are being established, and it is, of course, assumed that in any extension of the Research Scheme to the Overseas Dominions full use would be made of the facilities offered by these and similar institutions, and of the experience possessed by the bodies and persons concerned in carrying on their work.