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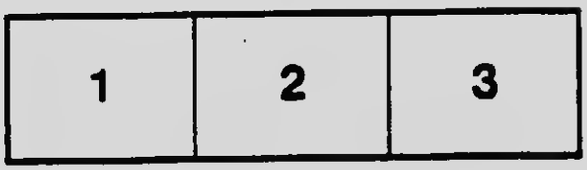

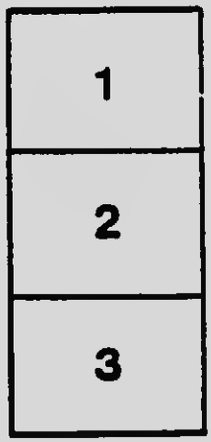

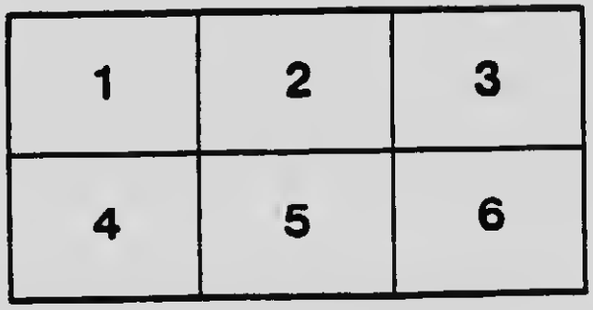

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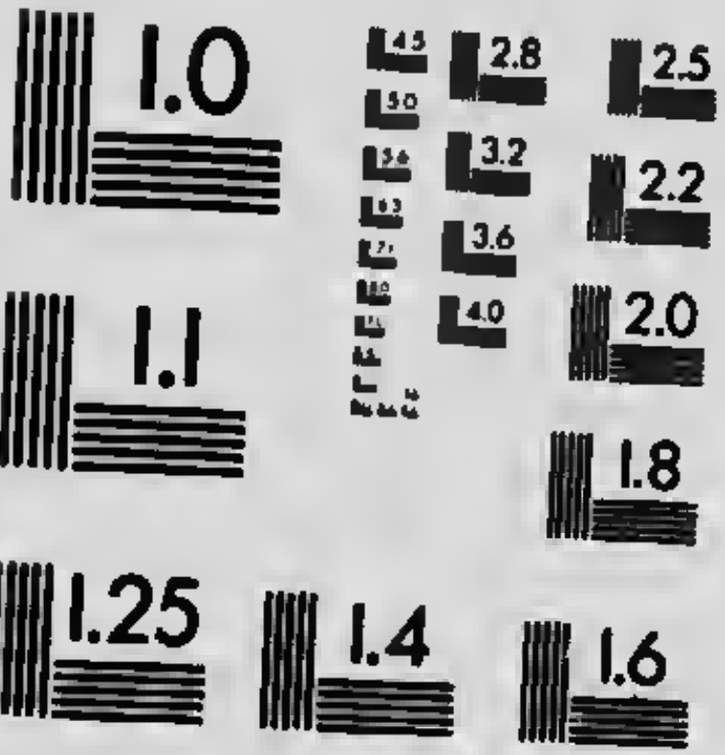

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Co-operation between Science and Industry in Canada

THE ROYAL CANADIAN INSTITUTE AS AN INTERMEDIARY FOR ITS PROMOTION

ESTABLISHMENT OF A BUREAU OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Royal Canadian Institute
198 College St.
Toronto

THE UNIVERSITY PRESS, TORONTO
1914

CO-OPERATION BETWEEN SCIENCE AND INDUSTRY IN CANADA

The Royal Canadian Institute as an Intermediary for its Promotion.

Establishment of a Bureau of Scientific and Industrial Research.

The Royal Canadian Institute, after prosecuting its work during the past sixty-five years in spreading abroad knowledge of the advances of Science and the results of Scientific Research, has arrived at the conclusion that its objects can be prosecuted with more advantage to all interested by the organization within the Institute of a Bureau of Scientific and Industrial Research for the use and advantage of the industries of Canada.

The past work of the Institute, its relations with learned bodies throughout the world, and its library embodying their exchanges and reports of the advances in science and scientific investigation during so many years, are part of such a proposition.

The reasons which have led to this conclusion and the general outline of a plan for carrying it out, it is the object of this publication to state.

The relation of the sciences to industrial progress is a subject that is to-day interesting all thoughtful men. So frequently have industrial methods and products been revolutionized by the application of a scientific discovery that it is becoming more and more apparent that to ensure a healthy and vigorous progress Science and Industry must go hand in hand. The consumer who requires some definite product, the manufacturer who can produce it, the producer who desires to increase the output of his manufactory or to reduce the cost of his products by a more satisfactory utilization of the by-products, all, more than ever in the past, are looking to Science to aid them in their endeavours, and more than ever in the past is scientific investigation being prosecuted in all civilized countries.

*"Science is the great instrument of social change, all the greater because its object is not change, but knowledge: and its silent appropriation of this dominant function, amid the din of political and religious strife, is the most vital of all the revolutions which have marked the development of modern civilization. It has practically transformed human life, to such an extent that the experience of men and women to-day is something radically different from what it has ever been before." Dr. Griffith, after citing the well known fact that Pasteur saved for his country more lives than were lost in the Franco-Prussian war, proceeded: "It should be our mission to make evident to the working man his indebtedness to the pioneers of science. Demonstrate to him the close connection between the price of his meat and the use of refrigerating processes founded on the investigations of Joule and Thomson; between the purity of his beer (this for the Englishman)! and the labours of Pasteur. Show the collier that his safety is to no small extent due to Humphrey Davy; the driver of the electric tramcar that his wages were coined by Faraday. Make the worker in steel realise his obligation to Bessemer and Nasmyth; the telegraphist his indebtedness to Volta and Wheatstone, and the man at the 'wireless' station that his employment is due to Hertz. Tell the soldier that the successful extraction of the bullet he received during the South African War was accomplished by the aid of Rontgen. Convince the sailor that his good 'landfall' was achieved by the help of mathematicians and astronomers; that Tyndall had much to do with the brilliancy of the lights which warned him of danger, and that to Kelvin he owed the perfection of his compass and sounding-line. Impress upon all wage-earners the probability that had it not been for the researches of Lister, they, or some member of their family, would not be living to enjoy the fruits of their labours. If we could but bring some 5 per cent. of our voters to believe that their employment, their security, their comfort, their health are the fruits of scientific investigation, then, but not until then, should we see the attitude of those in authority towards this great question of the encouragement of research change from indifference to enthusiasm, and from opposition to support. When we have educated the man in the street it is possible that we may succeed in the hardest task—that of educating our legislators."

"The field of industrial research may not be mapped off definitely from the area in which any seeker after knowledge labours for the service

* Taken from Principal Peterson's address to the Royal Canadian Institute in April, 1914. He quotes from an article based on what Mr. Balfour said recently of scientific study and from an address of Dr. Griffith, of University College, New South Wales, to The British Association.

of mankind. No one can tell in advance what discovery of to-day in 'Pure Science' may be 'Applied Science' in everyday affairs to-morrow."*

On this continent a new era in the history of scientific research began with the establishment of the Johns Hopkins University with its high ideals of training men for research in all departments of human knowledge. The incalculable value of such ideas was quickly perceived, and in the United States one University after another joined in the work until now in every state in the Union young men are being trained for investigation in all departments of the Arts and Sciences; not only so, but special institutions have been established, with large endowments, for the express purpose of conducting and promoting scientific research and carrying the results into the business and lives of the people generally. Prominent among these is "The Carnegie Institution of Washington" which, even in its few years of existence, since 1902, finds the demands upon its magnificent endowment of $22,000,000 too great to be satisfied, as may be seen from the following passage in a recent communication from its President to The Royal Canadian Institute. He says:

"The experience of our Institution indicates that there is the amplest room for something like a score of well endowed scientific research establishments on this continent. The widely spread notion that one or two endowments could supply the ends of all investigators have been proved hopelessly fallacious. The greatest Godsend that could come to our Institution, for example, would be the establishment of a dozen others in the United States about equally well founded."

The extent of the field so far occupied by the Carnegie Institution may be judged of by the activities mentioned in its Year Book for 1913. They are:

REPORTS ON INVESTIGATIONS AND PROJECTS.—"Department of Botanical Research", "Department of Economics and Sociology" "Department of Experimental Evolution", "Geophysical Laboratory", "Department of Historical Research", "Department of Marine Biology", "Department of Meridian Astrometry", "Mount Wilson Solar Observatory", "Nutrition Laboratory", "Department of Terrestrial Magnetism".

OTHER INVESTIGATIONS.—"Archæology", "Bibliography", "Chemistry", "Embryological Research", "Geology", "History", "Classics of International Law", "Literature", "Mathematics", "Mathematical Physics", "Meteorology", "Nutrition", "Palæontology", "Philology", "Physics", "Physiology", "Political Science", "Psychology", "Zoology".

*Report of Dominion of Canada Royal Commission on Industrial Research (1913).

Many other similar foundations might be mentioned as illustrating the appreciation of the value of scientific investigations by practical men of affairs. This is a scientific age. The output of scientific discoveries from the laboratories of our Universities and Institutions is rapidly increasing, and it is not unreasonable to suppose that ere long the work of the scientist will be appreciated as it deserves by all classes of the community.

One great need, however, must be filled before the scientist in his laboratory can play his full part in the industrial progress of this country. This is a need for a greater measure of co-operation between the laboratory and the manufactory. The results of scientific education afforded by the Universities are sent out into the world with no established medium to guide them to usefulness. The necessities of life in many cases compel graduates to occupations in which their special accomplishments find no place. Science and industry must be brought into more immediate relations with each other; the manufacturer should be able to ascertain where he may find competent men to undertake a scientific study of the conditions by which his output may be improved and the scientist should have some means of getting information as to the problems whose solution the manufacturers are demanding and means should be provided to preserve to the industrialist under proper conditions the property in the discoveries resulting from scientific research prosecuted at his instance. This evident need appealed to the genius of the late Professor Robert Kennedy Duncan, a Canadian and a Graduate of the University of Toronto. He devised a means of meeting it by establishing a scheme of Industrial Fellowships, a scheme that met with such success as to appeal to the generosity of two citizens of Pittsburgh, who endowed for its promotion "The Mellon Institute of Industrial Research". Professor Duncan was convinced that much of the industry upon this continent from the standpoint of manufacturing efficiency, was in a lamentable condition. There was a lack in the efficiency of the employees, and there was a lack of that efficiency "which would mean a conservation of waste, in the bettering and cheapening of the products manufactured and the discovery of new and useful products". It was this latter lack which especially appealed to him, and his scheme for its removal took the form of the establishment of Industrial Fellowships, which involved the co-operation of the manufacturer interested and the Mellon Institute.

The agreement evolved by Dr. Duncan's experience affords the necessary light upon the conditions of a Fellowship and the nature of the co-operation involved. These points are illustrated clearly and in a manner peculiarly apt to the proposition under consideration by the following excerpt from a recent publication of the Mellon Institute:

"Four different parties are affected by the agreement: (1) The Company, (2) the Fellows, (3) the University, (4) the Public".

"THE COMPANY.

"The Company obtains from the Institute such research laboratory facilities as but exceedingly few industrial concerns possess. Even more important, it obtains complete library facilities which are so valuable in research work. Much time is lost when past and contemporary scientific literature is not available.

"The men who are best trained for a particular problem are carefully chosen by the Institute and work under the supervision of a staff experienced in handling industrial research problems. The Company obtains for a small sum all the advantages of a large organization.

"The Institute by its affiliation with the University is able to offer the Company large and important consultative facilities—mathematical, physical, engineering, bacteriological, etcetera.

"The Company has an opportunity to obtain for its own organization young men who have had not only thorough scientific training, but very special training in the Company's own lines as acquired through its Fellowship.

"There is about university work, as differentiated from the factory, freedom from interference, correct judgments concerning progress, and an atmosphere sympathetic to research.

"All these advantages, laboratory, library, consultative and inspirational, together with the supervision and administration of these Fellowships, the Institute offers gratuitously to any company having important problems offering a reasonable chance of solution, and it undertakes, as well, to surround these researches with necessary secrecy.

"Experience has proved that through this system of Industrial Fellowships a company can do its research work better and cheaper in the Institute than in its own laboratory. Finally it has been found that where there exists a close and sympathetic co-operation on the part of the Company, many seemingly impossible results have been achieved.

"THE FELLOWS.

"The agreement gives to ambitious young men an opportunity to work out in a scientific manner great industrial problems, and not only to work them out in a laboratory, but if the laboratory solution appears to have commercial possibilities, to go further and to try out the methods evolved on a factory scale, and, ultimately, to put new processes into industrial operation.

"It gives young men a chance to obtain much experience in practical research while they are receiving a satisfactory remuneration. At the

same time, they may proceed in the University for advanced academic degrees.

"Finally, if the Fellows succeed in a practical way, they receive through their bonus a substantial, practical reward, and often the opportunity to become permanently connected with the Company concerned in the agreement.

"THE UNIVERSITY.

"The University, under the agreement, fulfils its function of increasing the sum of knowledge; the fact that it is useful knowledge does not make it any less valuable. Furthermore, the right, after a reasonable time, to publish such knowledge is assured to the University. The University also obtains a highly trained staff of specialists, as a faculty, for a school of chemistry and chemical engineering. Then, too, the University undoubtedly feels the stimulating influence of having in its midst a large body of trained investigators doing high class research work.

"THE PUBLIC.

"The public is largely advantaged through this system. No discovery can go to the public as a useful actuality except through some Company. Every useful and significant fact developed by a Company is a permanent asset to the human race. Even to-day, if manufacturing waste were eliminated and full advantage were taken of contemporary scientific discovery, shorter hours of labor would obtain and human need would vanish.

"There are some Fellowships now established in the Institute, the results of which will be applied directly to the public welfare. As time goes on there will be an increasing number of such Fellowships."

That the nature of the work done by the Fellows of the Mellon Institute may be understood, the conditions of the thirty-two Fellowships established since September, 1911, are given in the Appendix A.

The Report of the Dominion of Canada Royal Commission on Industrial Research, already referred to, presents Prof. Duncan's plan in these words—

"Without forgetting the immensities of realized values and unrealized possibilities of other arrangements and provisions for research work, the Commission considers the Duncan plan to be so suitable and adapted to Canadian conditions that it contents itself with only the presentation of Dr. Duncan's scheme in somewhat full detail."

What then is the condition to-day of the industries of Canada in respect of efficiency of employees and processes?

It may be answered without doubt that their condition is no better to-day than was the condition of those of the United States which moved Prof. Duncan to his great work in 1906. What he said on the subject may be read in the extract from the report of the Royal Commission already referred to, contained in Appendix B hereto, and is descriptive of conditions in Canada.

Work such as he performed is as urgently needed here now as it was in the United States then. The day is past when the workman promoted for his efficiency to management can supply by his own skill all that is called for. Science must be called in to keep the factory abreast of the times.

By reason of the Canadian Customs Tariff our industries are protected from the competition of the products of industries abroad unless those foreign products are able to enter the market by force of their better quality from the result of scientific processes and discoveries used in their manufacture. Investigation of trade returns shows this occurs very largely. Moreover, for want of the necessary scientific knowledge, many articles are not produced in Canada which have become necessities that cannot be dispensed with. To be deprived of these, say in the case of medicines by a state of war or otherwise, is a national danger. At the present time we are unable to replenish the supply of the many indispensable surgical and medical necessities exported alone by Germany or Austria which are the result of scientific research in those countries, and great distress may in consequence result. Scientific and industrial research can in time remove such a possibility. As a matter of prudent business if nothing else, industrialists must learn to protect themselves by consulting scientific research in aid of their operations much more generally than they now do.

There is no reason why the outlook should not be much wider. Other nations import from us the raw materials they require for manufactures, processes and products, which are rendered possible by the systems of scientific research, which their governments, especially those of Germany and Austria, have widely promoted—and Canadians until now have been content to import their results. A general scheme of research for the discovery of processes and products of our own and for the means of producing here the results already achieved in foreign countries is now forced upon us by war conditions which envelope the commerce of the world. Let Canada try to get along "without imports" resulting from scientific research and manufacture so far as possible.

The advances made in agriculture owing to the scientific researches and experiments of our agricultural colleges are apparent to every one. Those colleges furnish to the agriculturist specially what the proposed

Bureau of Scientific Research would aim to provide for all engaged in industry.

There can be no doubt that the encouragement of scientific research which would flow from the establishment of some such system of Fellowships as that already mentioned would be of the greatest advantage to the industries of Canada, and also to all our universities. Whether the system should have the scope of the Carnegie Institution or go beyond the scheme of the Mellon Institute is a matter for consideration in its foundation or its development.

Obviously the development of Canada's resources offer many problems for scientific research. Mining at every stage calls for assistance of this kind. It has been suggested that the search for radium could be taken up scientifically with systematic progress and with results quickly attained and recognized. We have in our higher institutions of learning both the men and the equipment for successfully carrying on such investigations as industrial and manufacturing conditions require, and what is needed is an intermediary to bring together the manufacturer or miner seeking solution of an industrial or mining problem and the investigator capable of solving it.

There are in fact a few Fellowships from time to time instituted by industrialists in our universities, and good work has been done in these instances.

The work at Queen's University in ores and metallurgy has been of very great value.

It is proposed to furnish a means of increasing this work of the universities with all the benefits flowing therefrom to those seats of learning.

Scientific research lies at the basis of every comprehensive forward movement in the development of modern industry. To foster this is a national duty, the task being too great, too important, to justify its abandonment to the initiative and resources of individual or local authorities. A Bureau for Scientific Research into the problems of industry should be established in Canada. It should be both an agency for research and a bureau for collecting the results of research throughout the world, and where the literature recording the attainments of science in the past is available. The proposition here outlined is not for any one city or province, or for any one university, but for all Canada and all its universities.* One main object of the Royal Canadian Institute is to promote the advancement of industrial efficiency and to extend

* The subject of Scientific Research in Canada is very fully treated both from an educational standpoint and the commercial point of view by Professor Bryce in his paper printed as appendix "C."

the development of the resources of Canada. Its Council feels that it can accomplish those objects in no surer way than by acting as the intermediary in some such plan as that evolved by the establishment of the Mellon Institute. The Royal Canadian Institute, therefore, stands ready to take upon itself the work of a central bureau for the establishment of a system of Industrial Fellowships and the promotion of scientific research in Canada, and its Council trusts that it may enlist the co-operation of both Canadian Universities and Canadian manufacturers and the aid of the Governments of the Dominion and the Provinces and the capital necessary in the promotion of a scheme which has proved so effective elsewhere.

The Council of The Royal Canadian Institute will gladly receive communications and suggestions from all who are interested in the proposed plan, and will be ready at any time to discuss its further elaboration. The Council respectfully requests all readers of this publication to give its contents careful consideration, and will especially welcome frank criticism of the proposal and suggestions for its betterment.

Issued by The Council of The Royal Canadian Institute.

JOHN PATTERSON,
Secretary.

FRANK ARNOLDI,
President.

Address all Communications to:
THE SECRETARY,
ROYAL CANADIAN INSTITUTE,
198 College Street,
Toronto.

APPENDIX A.
MELLON INSTITUTE FELLOWSHIPS

FROM PROF. ROBERT KENNEDY DUNCAN'S ARTICLE.
"SCIENCE," *May 8th, 1914.*

The ad inistration of the Mellon Institute consists at present of the director, with the associate director and assistant director. Their work of direction and supervision is greatly lightened by the senior Fellows. The Fellowships of the Institute consist of two kinds, individual and multiple Fellowships. An individual Fellowship utilizes the services of one man, directly responsible to the administration, a multiple Fellowship, the intensive services of several men under the direction of a senior Fellow who in turn is directly responsible and under the administration. There are seven senior Fellows in the Institute. The adequate supervision of the thirty-nine Fellows at present in the Institute and in the particular universities where the research work is done, is in this way entirely practicable and explains the results obtained.

In order that the Institute may not grow too large for maximum efficiency in its different researches and for the maintenance of its fraternal spirit, it has been determined to limit its members to seventy Fellows.

I am eagerly on the watch tower for men possessed of the rare qualities requisite for such positions.

The gift of tbe Messrs. Mellon has been divided for expenditure as follows:

For immediate expenditure—Permanent building, $250,000; Apparatus, $60,000; Library, $20,000.

For yearly maintenance for five years—$40,000 per year.

LIST OF FELLOWSHIPS ENDOWED THROUGH THE MELLON INSTITUTE SINCE 1911.

1. BAKING: $750 a year for 2 years. Bonus, maximum cash, $2,000. *Fellow:* Wilber A. Hobbs, B.S. (University of Kansas). (Accepted November 30, 1910.) Received a bonus of $1,000.

2. ABATEMENT OF THE SMOKE NUISANCE.—$12,000 1st year; $15,000 2nd year; $12,000 3rd year. Prof. Klotz (McGill University), Senior Fellow. Staff in charge 13. Advisory Board, 14. On the basis of the experimental and investigative work accomplished has been extended through a third year.

3. ON THE RELATION OF THE POTS TO GLASS IN GLASS-MAKING AND THE ELIMINATION OF "STREA".—$1,500 a year for 2 years. Bonus, $2,000. One Fellow. On the termination of this Fellowship the holder went over to the company at a salary of $2,500 per year.

4. BAKING.—(Wholly independent of but with acquiescence of No. 1.) $4,750 a year for 2 years. Bonus, cash, $10,000. Three Fellows. The bonus of $10,000 has been acknowledged by the company and the first instalment paid. The company then asked for a second Fellowship at an increased rate and with a second bonus of $10,000, which appears in this list as No. 18.

5. GLUE.—$1,200 a year for 2 years. One Fellow. In recognition of the work of this Fellowship the company on its expiration established a second Fellowship at an increased rate, which appears in this list as No. 20.

6. SOAP.—$1,200 a year for 2 years. One Fellow. On the termination of this Fellowship, the Fellow went over personally into his company with his process and in recognition of its success the company then established a second Fellowship on the same subject at an increased rate, which appears in this list as No. 21.

7. UTILIZATION OF FRUIT WASTE.—$1,000 a year for 2 years. Bonus, $10,000. One Fellow. On the conclusion of this Fellowship, in lieu of the bonus, under certain conditions, the proprietary rights in his process were conferred upon the Fellow.

8. COMPOSITION FLOORING.—$1,500 a year for 2 years. Bonus, 1% of sales for 5 years. One Fellow. While this Fellowship was successful, from the standpoint of the results of the investigation, it was a failure owing to changing circumstances in the specific example of the industry concerned.

9. CRUDE PETROLEUM.—$10,000 1st year; $10,000 2nd year; $10,000 3rd year, including apparatus fund. Bonus, collective interest, 10%. Nine Fellows. This large and important Fellowship, which had a tenure of two years, has been extended through a third year on the basis of the results accomplished. These results are of prime importance to the petroleum industry.

10. NATURAL GAS.—$4,000 1st year; $4,000 2nd year; $6,000 3rd year, including apparatus fund. Bonus, 5% industrial results. Two Fellows. This Fellowship, established for two years at $4,000 a year, has been extended through a third year for the sum of $6,000, the salary stipend of the senior Fellow being raised from $2,500 a year to $4,000 a year.

11. CEMENT.—$1,800 a year for 2 years. Bonus, $10,000. One Fellow. This Fellowship was a failure, owing in large measure to a lack of willingness on the part of the company concerned to co-operate with the administration and the Fellow.

12. FOOD, PROBLEMS RELATED TO THE MANUFACTURE OF.—$5,000 a year for 2 years. Bonus, $10,000. Three Fellows. This Fellowship is now in operation and it is believed that it will have a successful termination.

13. FATS AND OILS, BLEACHING OF.—$1,500 a year for 2 years, plus $300 apparatus fund. One Fellow. There is no question about the very successful operation of this Fellowship and of its ultimate results.

14. EFFECT OF HIGH POTENTIAL ELECTRICITY ON CHEMICAL REACTION.—$1,000 year for 2 years, plus $300 apparatus fund. Additional consideration. One Fellc This Fellowship has already yielded the essentials of an important industrial proces. It has a very large importance to the institute, owing to the fact that the donor has made over all results to the institute to be used for the establishment of further researches by the institute.

15. DISCOVERY OF METHODS OF COATING STEEL OR OTHER METALS WITH COPPER OR OTHER METALS.—$1,500 a year for 1 year; $500 apparatus fund, 3 months' extension. Bonus, $10,000. One Fellow. The laboratory investigation of this subject has been completed and its large-scale working is now being arranged for. Pending the completion of the large-scale operation, the Fellowship has been extended.

16. EXTRACTION OF COPPER FROM ITS ORES AND FROM COPPER "TAILINGS".—$1,500 a year for 1 year. One Teaching Fellow. This investigation has proved so important that it has been extended through the addition of another Fellowship, No. 24, at $1,500 a year, and, subsequently, of still another, No. 29, at $6,000 a year.

17. DESERT PLANT, AND ADDITIONAL PROBLEM.—$1,500 a year for 1 year; $300 apparatus fund. Bonus, 7% interest ind. results. Two Fellows. The original object of this Fellowship proved impossible of an industrial solution, owing to the fact that investigation of the plant concerned showed that it contained nothing of potential industrial value. The object of the investigation was thereupon changed and the ultimate results are not yet determinable.

18. BAKING.—$6,000 a year for 2 years; $500 apparatus fund. Bonus, $10,000. Three Fellows. Was established by the same company on the basis of the success of No. 4. While it has been in operation only since September, it already unquestionably deserves its bonus.

19. ALUMINUM.—$5,000 a year for 2 years, including apparatus fund. Bonus, $10,000. Two Fellows. A Fellowship yielding results of prime importance.

20. GLUE.—$1,500 a year for 2 years; $300 apparatus fund. One Fellow. Was established on the basis of the success of No. 5.

21. SOAP.—$1,500 a year for 2 years; $300 apparatus fund. One Fellow. Was established on the basis of the success of No. 6.

22. GLASS.—$1,500 a year for 2 years; $300 apparatus fund. One Fellow. Is already unquestionably successful.

23. RELATION OF ELECTRICAL POTENTIAL TO CATALYTIC ACTION.—$1,500 a year for 2 years; $300 apparatus fund. Bonus, 5% industrial results. One Fellow. A most interesting Fellowship on a most interesting subject. This research is remarkable in that the donor desires that the institute should receive for its own purposes 70 per cent. of the results.

24. EXTRACTION OF COPPER FROM ITS ORES AND FROM COPPER "TAILINGS".—$1,500 a year for 1 year; $300 apparatus fund. One Fellow. Established in correlation with No. 16. It is already yielding promising results.

25. YEAST.—$5,200 a year for 2 years, including apparatus fund. Bonus, $10,000. Four Fellows. A strong Fellowship in operation only since September.

26. HARDENING OF FATS.—$1,000 a year for 1 year; $300 apparatus fund. Bonus, 49% interest. One Fellow. This Fellowship was transferred from the University of Kansas. It has already yielded an important industrial process.

27. LEATHER SCRAP.—$1,000 a year for 1 year; $200 apparatus fund. Bonus, 10% interest. One Fellow. It is impossible to forecast the end of this Fellowship.

28. FERTILIZER.—$2,500 a year for 2 years, including apparatus fund. Bonus, $5,000. One Fellow. Begins operation on January 5, 1914.

29. COPPER.—$6,000 a year for 1 year, including apparatus fund. Three Fellows. Was established in co-operation with Fellowships No. 24 and No. 16. The results of this Fellowship would probably justify the total expenses of the whole Fellowship system.

30. RADIATORS.—$2,000 a year for 2 years, including apparatus fund. Bonus, $5,000. One Fellow. Went into operation in April, 1914.

31. TURBINE ENGINES.—$1,800 a year for 1 year, including apparatus fund. Bonus, $3,000. Fellow (not yet appointed). (January 5, 1914.) Has been accepted.

32. GLASS.—$1,800 a year for 1 year, including apparatus fund. Bonus, 25% interest. One Fellow. Has been accepted.

"APPENDIX B".

Prof. Robert Kennedy Duncan's statement of the case for a Bureau of Industrial Research—which is an extract from Chapter XI of the Report of Dominion Royal Commission on Industrial Training and Technical Education.

INEFFICIENCY AND ITS CAUSE.

The present condition of American manufacture is one of inefficiency. Every informed manufacturer, as well as most of those uninformed, knows that he has serious problems of such importance that in the conditions obtaining to-day their lack of solution means imminent loss for his individual instance of the industry. It may be safely said that wherever there is the smoke of a factory chimney, there are serious problems. Any intelligent chemist might very cheerfully accept a wager to go into any factory and within three days point out problems whose reasonable solution would make large differences in the dividends of the company; and these problems can be solved only by the chemist. Many a story might be told illustrating the amateurishness which pervades American manufacture, as differentiated from its expert office management.

The reasons for this inefficiency, as it appears in waste and lack of progressive factory practice, are clear and evident. Manufacturers of the past, though practically knowing nothing of applied science, forced their way to success through sheer fighting manhood and through the application of principles which they *did* understand. First among these principles was the creation of a tariff, which has injured the efficiency of American manufacture by shutting out the competition of the efficiency of foreign manufacture working through the application of modern knowledge; by hiding the importance of, and indeed by masking, the very presence of waste and non-progressive factory practice. To the difference between the cost of labour at home and abroad there has been added, among other things, the difference between scientific efficiency at home and abroad. In proof of this Dr. Duncan cites the procession of manufacturers before the Committee on Ways and Means, who in instance after instance, either consciously or unconsciously, claimed protection because of the waste and non-progressive character of his specific instance of the industry. Furthermore, many American manufacturers found it possible to rid themselves of the necessity for efficiency through the creation of combinations for the elimination of competition. Combined with these two methods of making financial progress at the expense of efficiency, there were large stores of raw material everywhere at hand, and the needs of a rapidly expanding and rather extravagant population which swallowed anything presented to it. Because of these reasons American manufacture flourished.

DISAPPEARANCE OF FOREGOING CONDITIONS.

Conditions now are rapidly changing. Every sensible man knows that the tariff on its present high pinnacle lies in an unstable equilibrium. Combinations for the elimination of competition are now illegal and ever more and more dangerous. The vast stores of raw material are now segregated into the holdings of a few men, who will release them only at an onerous and sometimes distressful rate. The increase of the population, though rapid, has not kept up with manufacturing production, and in certain lines manufacture is threatened with overproduction. In addition, economy

in purchasing is taking the place of extravagance. Finally, there is a world-wide increase in living expenses, necessitating increase in salaries, in cost of materials and transportation rates, to such an extent that even in the immediate future success or failure in many manufacturing operations will depend on the extent to which the manufacturer can eliminate waste and increase the value of his product. Speaking frankly and advisedly, and within the knowledge of all, American manufacture is proceeding to a crisis from the successful issue of which only efficiency will count. Most manufacturers now understand this, some of them dimly and gropingly, yet actually.

APPLIED SCIENCE AND SHOP JEALOUSIES.

The American manufacturer, considering him in general terms, to which there are unmistakable exceptions, does not know how to proceed in order to gain this efficiency. For the main part he is ignorant of his own factory problems, at any rate of their full extent. He does not know how to go about the obtaining of adequate chemical aid, or how to choose the chemist, or the laboratory and library facilities with which this chemist should be provided; he submits the chemist to the jealousies of foremen, and by not granting him adequate power, to the stupidity and opposition of workmen; he does not know how to gauge his progress, and consequently subjects him to intolerable conditions of suspicion, intrigue and harassment. For the above reasons 90% of so-called research work carried on in factories is many times worse than loss, because failure places the finale on the possibility of that particular factory to understand the advantages of applied science.

MANUFACTURERS AS AMATEURS IN APPLIED SCIENCE.

Though the facts above stated are valid, it must not be inferred that because of them the American manufacturer is lacking in sense and judgment; for in shrewdness, acumen and energy, he may be compared with the representative manufacturers of any country on earth. His failure in successful factory practice is due, not to lack of ability, but rather to the fact that because of his many abilities he has so far managed to do without efficiency in his factory practice, so that when thrown suddenly into the necessity of this efficiency he finds himself outside his field of knowledge, and hence peculiarly liable to amateurishness and to the mistakes that follow it. The Keely motor and the idea of making gold from sea water are merely gross instances of the general amateurishness that pervades all manufacturing practice wherever it comes in contact with natural knowledge and modern science.

It may be said then, that the American manufacturer is inefficient sometimes to the extent of 50% of the value of his product; that he is confessedly so; and that to-day he knows he is inefficient, though he does not generally know this to the full extent; and that being an American, he is quick to learn and to act, and he desires help. This he can obtain by means of these Industrial Fellowships.

The practicability and value of these Fellowships come from the fact that they truly mirror the spirit of the times, which is steadily and inevitably doing away with the old age of destructive competition and placing in its stead an era of sympathetic co-operation; for men have discovered that they can do together what they could not do in conflict.

From the standpoint of the industrialist this arrangement is an immense privilege. The extraordinary facilities and powers which arise therefrom give him results which cannot be otherwise obtained, and the responsibility for obtaining these results is shifted from the officials of the company, who in most instances are wholly amateurs.

MUTUAL BENEFITS TO MANUFACTURERS, UNIVERSITIES AND PUBLIC.

When the young men who are conducting the experiments pass over to the corporations, the Universities do not lose interest in them or in the corporations; and the result is becoming apparent that through this arrangement Industrialists may learn how to apply science to practical ends. Wholly unexpected and valuable relations have also developed as the number of Fellowships has increased, in the way in which these Fellows are able to help one another; and it seems that as their number increases, this power of discreet mutual helpfulness increases in what may be called geometrical progression. It will be understood that personal integrity is a *sine qua non* to election into these Fellowships, and hence it is in a certain sense a fraternity.

With the increase in the number of Fellowships, there has appeared an increase of mutual helpfulness of the constituent corporations one to another, with striking results. Although these corporations do not know one another, as nearly all desire no publicity in the establishment of a Fellowship, yet the business of all of them passes through the office of the Director, and remarkable opportunities for helpfulness appear and are taken advantage of, some of these opportunities being for general helpfulness to the corporations quite outside of the actual direct business of the Fellowships.

It may be said, further, that what is called in chemistry the "catalytic influence" of these Fellowships is already beginning to be felt in regard to the industrialists of the country, and as the number increases, it may be reasonably predicted that their influence will leaven the whole loaf of American industry. As a matter of fact, they have proved to be a most efficient ferment.

The public is assured of benefit from every one of these investigations, the results of which will be published within reasonable time free to everyone to read and improve upon. While patents may be taken out at any time, as is the right of every human being, it is not generally understood as it should be, that the results of scientific investigation can reach the public only through the industrialists. Röntgen took out no patents on his discovery of the X-rays, but he did not give this discovery to the people, for it could only go into medical practice by the use of X-ray bulbs, and these were manufactured and improved by various corporations through whose factories they went to the people. These corporations, naturally and not at all improperly, placed on these X-ray bulbs all that the trade would bear. The fact that Röntgen took no money for his research simply added that much to the corporations concerned; his generosity did not make the slightest difference in what the people paid. But while industrialists may come and industrialists may go, every new significant fact hangs on forever as a permanent gift to the human race in its struggle for that unknown goal towards which it is proceeding.

A PROPER UNIVERSITY FUNCTION.

There can be not the slightest question that the establishment of these Fellowships is properly a University function, for the objects of every University worthy of the name are three:—(1) the adequate instruction of the young men and women who frequent its halls; (2) the creation of knowledge, both pure and applied; (3) the dissemination of knowledge, both pure and applied, and the rendering of service through such to its outside environment. This tripartite ideal is not to be questioned, nor is any one factor of the three any more important than the others. The University which does not devote itself to research, both pure and applied, is a dead limb on the tree of our civilization, for without research it can neither teach nor be of service. Researches carried on in accordance with these Fellowships result in new knowledge, both pure and applied. When the researches are ultimately published, it will be found

that each and every one has increased the sum of human knowledge quite outside of practical ends, though the latter function does not render them any the less valuable.

New useful knowledge obtained mainly at the expense of a private corporation is surely as valuable to the human race as the academic knowledge obtained through the expenditure of millions on the part of private benevolence. Through these Fellowships a University fulfils its educational function. It can take the best brains and training of the whole country, and form them, through notable and useful achievement, into the highly specialized service which modern manufacture and the human needs of modern men require. No one who has met the young men constituting the staff of these industrial Fellowships would for an instant doubt that they would grow into men of power and influence for good. It must be remembered that they are trained men, fully half of them having already their degree of Doctor of Philosophy from the great Universities, and that the University in giving them the opportunity of applying themselves to these highest and noblest ends is doing the highest University service.

APPENDIX "C".

THE CRYING NEED OF INDUSTRIAL RESEARCH IN CANADA*

By Rev. Geo. Bryce, M.A., D.D., LL.D., F.R.S.C.
Member of Royal Commission on Industrial Training and Technical Education.

(*Read 3rd February, 1912.*)

CANADIANS, I fear, Mr. President, are disposed to be a self-satisfied people. We have not yet reached our jubilee as a Nation of the Empire, but we are inclined to think that we have done pretty well. It may be that the contrast between our condition before Confederation and our status at the present time is so great that we are apt to think more highly of ourselves than we ought to think. The student who fears the result of his examination is hilarious if he should make a bare "pass," the workman who has been receiving a low wage regards himself as rich if he is given a slight increase, and the Government which has had a deficit or a falling revenue is highly pleased if expenditure does not go beyond receipts. But excellence in each case means more than that. So, when we recall the homespun garb and the impassable roads, and the unsettled markets, and the poor school facilities which some of us knew some forty or fifty years ago, we are inclined to self-congratulation over our present circumstances and achievements. No doubt to-day Canada is the land of opportunity, but that is just because it is still far from what it may become.

I am a patriotic, and, insome respects, a proud Canadian, but to-night I cannot be a prophet of smooth things.

After a survey of many countries, in the last year or two, I feel it to be appropriate to choose as a subject for this evening's address, "The Crying Need for Industrial Research in Canada."

I have been in the cities and towns of England and Scotland, in many of the centres of Germany and Holland, and in several of the States of the American Union, and all these places, I find, are earnestly taken up with enforcing laws of compulsory education and in organizing Continuation Schools, so that a general elementary education may be secured for virtually the whole population.

*Paper by Prof. Bryce read before the Royal Canadian Institute. (See R.C.I. Transactions for November 1912, volume 9, part 3.)

What have we seen in Canada? Several provinces with no compulsory educational requirement; except in a few places no real insistence on general education, and the adjuncts of a sympathetic and persuasive education entirely lacking. When we think of the hundreds of small groups of children in Canada in the so-called little red school-houses, when there are uncertificated and incompetent teachers by hundreds in many provinces, and when there are thousands of boys and men unable to read or sign their names to a pay-roll, we may well be ashamed to see in Belgium or Switzerland greatly higher general school opportunities; indeed we may see enough to give us pause as self-confident Canadians.

It is surely with pain that we contrast the thorough preparation secured from the Gymnasium in Germany and the High Schools of Edinburgh, Glasgow or London, with what those of us who have been Educationalists for years have seen of hundreds of our poorly prepared matriculants, who present themselves for a University course.

An investigation into our factories, machine shops and business places all through Canada tells the same story, that the working lads coming from our schools have been very poorly instructed. We used to think the three Rs a very modest measure of acquirement for a lad leaving the public schools, but now we are quite familiar with his having not even that acquisition.

We cannot disguise the fact from ourselves, that, though Governments seem to make liberal donations to education, though many municipalities take pride in their public schools, though the inspectorates are well manned, yet there is in almost every province of the Dominion growing up a very considerable percentage of the young who are practically illiterate.

Now, this very lamentable state of things, which in the last forty or fifty years of our experience has been forming the standards of hundreds of our communities in all the provinces from the Atlantic to the Pacific, has produced a public opinion none too favorable to higher culture and the acquisition of a good sound education. The Mechanics in many cases do not value the reputation for efficiency. Men, as we have seen them—"handymen"—undertake to do work which they cannot do and "turn their hand" to anything that may present itself. A member of the Royal Commission had a stock question for carpenters:—"Could you build a winding staircase or a complicated house-roof?" Not one quarter of the witnesses could answer "Yes."

Teachers on permits without knowledge or facility make teaching a farce. Doctors have entered their profession who did not adorn it, and even, I am afraid, ministers innocent even of "Scant Latin and less Greek" were none too strong either in philosophy or general erudition.

I state these things because I fear that they indicate a serious imperfection of training, a carelessness about standards, and an unwillingness to surrender some of our fallacies, that may interfere with any effort to rouse our educational boards, our civic authorities, our cabinets and parliaments, to look on thoroughness and efficiency in education, labour and professional life, as absolutely essential to our Industrial success.

Complaints are made all through Canada that our schools do not fit the scholars for the factory, that apprentices are changeable and unreliable, that the apprenticeship system has broken down, that art as applied to Industry is not properly taught, and that writing in the schools is very bad. These are all marks of imperfection and poor training. What are the consequences of these things in the Industries? They are these:—The Employer and foreman are poor judges and poor purchasers of the material needed; the management of the offices and shops is careless; the quality of the labour is poor; the business as a whole is badly managed, and the waste is enormous.

These are the things which the people who know have been telling us all through Canada; and we are bound to say that in older countries, where custom is strong and communities are better established, the efficiency in industry is greater. An observing writer has said: "The Manufacturers have not been men educated in the knowledge of the schools, but are men who know practically nothing of applied science and who in consequence forced their way to success through sheer fighting manhood and through the application of principles which they did not understand."

Many of the manufacturers think it sufficient to have a so-called "practical man," one not instructed, but simply an expert mechanic, who serves as "guide, philosopher and friend."

1. Thus the Manufacturer does not value true expert advice.
2. He shuts his eyes to the waste.
3. He settles down to a career of non-progressiveness.
4. He agitates for a higher duty on his products.
5. Dissatisfied, he turns his thoughts to making a Combination or combine—which is illegal.

The real remedy for many of his difficulties is Scientific Research.

This is the solution of his difficulties, used by the German manufacturer. The following are the figures as to the employment of experts in Germany in 1897. They would be still more startling in 1912.

GERMAN MANUFACTURERS.

Description of Chemical Works.	Trained Chemists Employed.
Artificial Manures	90

Description of Chemical Works.	Trained Chemists Employed.
Explosives	50
Petroleum, Lampblack	50
Inorganic Compounds	250
Organic Compounds	1000
Various works	610
Sugar Works and Refineries	300
Starch, Dextrine, etc	50
Oil, fat, tanning, and dye works	100
Smelting works	400
Laboratories and Agricultural Stations	700
Government works	100
Apothecaries (Qualified)	100
Various Chemists	100
	4000

The total number of chemists who had been trained in Germany in 1897 was:—

Technical Chemists in Works in Germany	4000
Technical Chemists in foreign countries	1000
Professors, lecturers, etc. of Chemistry:	
In Universities	150
In Technical Schools	250
Mining, Veterinary and Agricultural Schools	100
Building, Engineering and Industrial Schools	200
Chemists employed by the States	100
Private Chemists	400
Apothecaries (qualified)	300
Various Chemists	500
	7000

Thus thinking men are saying to-day—we need better elementary education, better High School training, more practical University Science, more men who know the principles and reasons of things. Especially do we need more Science in our Industries. Look at the wasted opportunities. Out of many letters, relating to from fifty to a hundred fields of Industry which I have received from keen sighted and intelligent scientific men in Canada, I may give examples of the tremendous waste of valuable things, and of unused opportunities. Nature has given us great resources in Canada and we do not know how to use them. All these problems are suggested to us by experts:

1. In our Silver Ore regions the great heaps of metallic Cobalt and Cobalt Oxide for which we have found no use.
2. We need a plan to separate out nickel from low-grade ores.
3. Investigation as to qualities of Illuminating Gas.
4. Investigation of Anhydrite.
5. Remedy for Sulphur in Coal.
6. To find cause of explosibility of Coal Dust.
7. How to utilize Straw.
8. How to utilize wood waste.
9. How to utilize smoke.
10. How to utilize hardwoods.
11. How to utilize sewage.
12. How to utilize tar as a by-product.
13. How to utilize waste in Wood pulp (50 per cent).
14. How to utilize peat.
15. How to utilize by-products of shales.
16. How to treat pulp of various kinds.
17. How to obtain a safe bleaching agent.
18. How to improve paper making.
19. How to acclimatize corn,
20. How to acclimatize Alfalfa.
21. How to acclimatize Wheat.
22. Investigation of water-lifting in the soil.
23. Methods of meeting hurtful insects.
24. Improvement in Leather.
25. Improvement in Glass.
26. Improvement in Glue.
27. Improvement in Enamel.
28. Improvement in Gas producers.
29. Treatment of British Columbia ores by electricity.
30. Methods of utilizing fish waste; and so on.

But in Canada, though we may be far behind the Industrial Nations of Europe, we have the future before us. How are we to meet these and hundreds of other prohlems? We are to follow men who observe and men of experience, who know.

Our late King Edward inherited from his father, the wise Prince Albert, the true spirit of a forward Industry. This is what King Edward said:—"The prosperity, even the very safety and existence of our country, depends on the quality of the scientific and technical training of those who are to guide and control our industries." And not less decided and far-seeing are the words of our late King's nephew, the present Kaiser, Wilhelm of Germany. In opening a new University in

Breslau in 1910, the German Emperor said: "The close connection between Technical Science and Industry becomes year by year more manifest, and it is not only by chance that the immense advance made by our industrial work is contemporaneous with the progressive development of our Technical University system in Germany. The times are past in which a school of practice sufficed for the engineer. Whoever wishes to be equal to the demands made by technics in our time must go into the battle of life equipped with a solid scientific education."

Surely when Emperors, Professors, Manufacturers, foremen and even halting apprentices, say there is need for improvement, we must grapple with the question and master it. It is useless, however, to think that there are no difficulties, and serious difficulties, in the way of Research.

Almost all the principles dealt with in our search are included in Chemistry and Physics—with, in some special departments, the principles of Biology. These sciences deal with the most intricate problems and the most recondite principles of the world in which we live. Nature presents the most complicated of her puzzles to us in the commonest things of life. The seemingly simple problem of the sustenance of the growing plant in the soil involves the deepest processes of Chemistry, Physics and Bacteriology.

The questions of Animal Husbandry include deep problems of life and of physiological chemistry. The common health of the people brings us face to face with the unseen agencies that threaten our very existence, while the foundry, the mine and the blast furnace present processes which so often go wrong and baffle the most competent of experts. Every science is simply the attempt to know som phase of nature presenting its most perplexing complications in the ordinary course of life, progress, and Industry. Now, if this be a true view of our environment, it is plain that we are in a world full of mysteries, some of which we may to some extent penetrate, others that will remain unsolved. This being so, it will appear that not alone splendid laboratories, not high-sounding titles, not alone institutions posing as practical centres, can guarantee successful research, for a very observant American Scientist has said, "a great deal of unimportant work masquerades under the name of Research." In a letter written to me by Dr. McLaurin, the distinguished President of the Massachusetts School of Technology, there occurs the following sentence: "I need hardly say to you that almost the only equipment that really counts for much in scientific research is the equipment in MEN."

We may say of the true man of Research—in a more earnest sense than old Lucian used the expression: "outos ekeinos"—that is the man!

While of course every system may be faulty, and while even the best system may not always supply the inventive, penetrating, persevering and intense qualities needed by the man of research, yet, as a general requirement such a man, following the best models, should have:

1. A thorough Primary and Secondary Education.

2. Training in a modern University, where the Science Option has been fully followed, or in a Technical College of University rank, in either case among students under competent science professors and where the aspirant has completed satisfactorily a practical science course.

3. A post-graduate course of several years absolutely devoted to the department in which the candidate is to specialize, and this under a professor who has a "fine frenzy" and devotion to his subject.

4. Certificates of competence, of skilfulness and of success in solving a prescribed problem.

Even under all the power and pressure of a great guiding intellect, the aspirant may at times fail. But that there is a certainty of a general average of fair results is seen when we but name over, and recall the work achieved and the impulse imparted by the

DEANS OF RESEARCH IN ENGLAND.

Lord Lister, London, in Preventive Medicine.
Sir H. H. Roscoe, London, in Chemistry.
Sir. J. J. Thomson, Cambridge, Physics.
Sir Oliver Lodge, Birmingham, Physics.
Sir William Ramsay, London, Chemistry.
Sir William Slich, Oxford, Forestry.
Dr. Silvanus Thompson, London (Guilds School), Physics.
Dr. Ernest Rutherford, Manchester, Physics.
Sir James Dewar, Cambridge, Chemistry.

What then is Research?

1. *It is a great National Asset.* Think of what it would be to have a hundred men of high attainments and practical skill working under favorable conditions in Canada upon the hundred problems to which we have referred. Yes, we have had them, but we did not set them to work on our National Science problems. Our Commission met Canadians highly educated and occupying places of scientific distinction in twos and threes in New York, Cornell (Ithaca), Johns Hopkins (Baltimore), Washington, Pittsburgh, Buffalo, Madison, Wis., Minneapolis, Kansas, Missouri, California, Washington State—our brightest minds. From Toronto University alone there have gone to high educational positions in the United States hundreds of Canadians, and I have a list of graduates of the Guelph Agricultural College who have left Canada to hold high

educational and research positions in 30 agricultural colleges and experiment stations, from the Atlantic to the Pacific in the United States. I am informed that in Institutions of Higher Learning and Scientific occupations in the United States there are no fewer than 600 graduates of Toronto University, and I know that McGill and Queen's are similarly represented.

One of the most brilliant of these wanderers said to me lately: "I am a Canadian; my wife is a Canadian; we are bringing up our little girl here as a Canadian. When I was in a Canadian University the only outlook I could see for myself at that time was as teacher of a High School. For that I did not care. I came here to be a Research professor." In harmony with this complaint one of my own students in Science, now a dean of Faculty in one of the most prominent Universities in the United States, lamented to me lately the few positions in Canada open to Canadians of higher grade. Even to Oxford, Manchester, Edinburgh, London, have our men of scientific mark been taken from us. These bright minds of ours are a national asset. We need them. We have no right to let them leave us. They are the Creator's gift to us for our higher development. Our Governments, our Universities, our private citizens of means, and our manufacturers should take hold of them, open positions for them, not specially for their own sakes, but because the field of profitable research requires them.

2. *Research is a spirit or a passion.* The brilliancy, the inventiveness and the aptitudes of the true disciples of Research seem to carry with them a certain unsettledness and variability from rule, that some would call genius. It is the power of keen mental vision, which reaches its object by a species of intuition. It involves a sensitive intellect which can be in touch with the deep fundamental principles of the Universe. The bird sings because it cannot but sing. Wordsworth saw visions because he was in responsive touch with Nature. Kelvin saw the practical application of principles by a sort of instinct, and Edison simply imagines the line of search which experiment ensures to him.

3. *Research is a concentrated piece of Intellectual work.* The essence of the process of Research is experiment, and continued trial. It means to some extent isolation from the world. It means long nights and watching and laborious days to him who would succeed. The laboratory has to be to a certain extent to the seeker his curling rink, golf links, his cricket field, and his hunting ground. He should be provided with all the resources of a high and scientific civilization. He must, however, know what is going on in the world about him, what his fellow workers are doing, what mistakes they have made, and what results they have achieved. And if he is all this, just as when we call for soldiers in time

of war and give our best to the volunteer, so we should see that our best of support, or respect, and consideration, is given to the men who will seclude themselves in the laboratory and will give up the pleasures of gaiety or even of general culture. To secure the safety of the country, the soldier is honored on his return from the war, so the experimenter who overcomes ignorance and inefficiency should be crowned with laurels by his country.

4. "Laborare est orare" is an old motto, and so, when we see the high ideals of a Newton, a Kepler, a Clerk Maxwell or an Agassiz, worked out into discovery we regard their research as high work—a moral exploit. In short, the persistent, honest, self-denying work of the earnest seeker after truth is surely a high virtue.

THE MEANS.

If then Research is all this how are we to secure it to our Country?

1. If it is a national asset and a benefit to all the people, then it is a fit subject for Government assistance. Probably the hundreds of brilliant Canadians who have gone abroad and are in the service of foreign nations could all have been saved to Canadian education and Canadian manufacture by judicious Government action. If during our rising entrance upon manufacturing in Canada which has been very remarkable in the last forty years, the Government had understood and taken action, the result would be very different.

The total for additional Government grants to Universities and other high-class institutions (chiefly for Science) in the British Empire for 1910 was about six and a half millions of dollars. All that I find included in this from the Dominion Government is for Experimental Farms, $87,500. Of large sums voted for the Universities and Technical Schools in Germany for general purposes, it is well known that a great portion of this is voted by the States in order that advanced Technical Education may be given. Even little Switzerland, among the clouds, is so practical that a Swiss professor remarked to me:—"When we want a new professor in our Universities and Technical Schools, we choose him first on the basis of his being able to carry on Research, and after that on account of his power to teach." The Federal Government of Switzerland, while allowing the Cantons to carry on and pay entirely for the Universities and subordinate schools, keeps up at its own expense the only Technical School of University rank in Switzerland, and it does this in a most generous way. In Holland, while the Universities are left to manage general culture, in the old town of Delft the most magnificent of Technical Schools is found. It carries on every variety of Industrial Research and is maintained entirely by the General Government.

In Denmark, which we have not been accustomed to look upon as a rich country, the General Government gave last year to Agricultural Societies for Research and Experiment:

Experiments in Agriculture and Veterinary High School	$ 2,530.
Royal Society for Research in Plant Culture	29,500.
Bacteriological Investigation of Serums, Vaccine, &c	78,000.
Total for Research	$144,580.

PRIVATE BENEFICENCE.

The subject of Research has a peculiar attraction for men of large means. First—Research takes a great deal of money to be effective. Then, it has a very definite aim which appeals to men of large fortunes and business habits. In 1910 in the British Empire—none of them, I am sorry to say, in Canada—thirteen men of large means gave or bequeathed for Research no less than $3,441,500, the largest one sum of this being for the Otto Beit Scholarships for scientific students, the capital amounting to $1,075,000. The two great American capitalists, Messrs. Carnegie and Rockefeller, have shown great interest in Research and have been very liberal towards it. A purely Research Institution—the Carnegie Institute of Washington, during the past year, 1911, gave to ten different departments of Research the sum of $450,160. Rockefeller's Foundation for Medical Research, which had received from him for the Institute and the Hospital in former years $3,820,000 had from him in 1911 the princely gift of $3,520,000. It was also interesting to note that a bequest for Research—unique in being left by Alexander Agassiz, one of the professorial class, which does not as a profession usually possess a plethora of wealth, was given last year, amounting to $225,000.

UNITED SUPPORT OF RESEARCH.

One of the strong features of German advance in Research is the union of all classes of the people in supporting it. Kings and Grand Dukes find their highest pleasure in being patrons and liberal supporters of learning.

The latest example of this is seen in Germany. The Emperor has become head of an organization called "The Kaiser Wilhelm Society for the Promotion of Science." Individuals or firms pay $5,000 for entrance, or may make an annual contribution of $250, commutable by a lump sum of $10,000. The Emperor announced in 1910 that the Society already had a capital of $2,500,000. The object of this society is to subsidize from this fund men of distinction in Science and thus reward and stimulate Research.

CO-OPERATIVE RESEARCH WORK.

Several of the United States Universities, imitating somewhat the German Universities and the Modern Science Universities of England in obtaining the co-operation of Manufacturers have accomplished a great work in Research. A few examples of these are well worth our attention.

1. THE MASSACHUSETTS SCHOOL OF TECHNOLOGY.

This remarkable Institution, of University rank, has a world-wide fame. In 1911 it celebrated the jubilee of its founder, Dr. Rogers. It does a great work in Research. While in this field individual members of its staff have gained fame, the Institution aims rather at developing "Departmental Research," i.e. Research carried on by the joint work of individuals of the Department. Dozens of intricate problems, and this frequently at the expense of large manufacturers, have been dealt with by its departments. Problems in 1, Naval construction and architecture; 2, in Electrical Engineering, have been solved. Perhaps most remarkable as showing its policy of taking up practical questions as they arise has been. 3. The problem of Public Health. Seven volumes of past researches have been printed as Contributions from the Sanitary Research Laboratory and Sewage Experiment Station. 4. Most notable is the work of the Physical Chemistry Laboratories. Ten members make up the staff. The Research staff is organized as made up of professors, associate professors, and assistant professors. The associates and Assistants do not teach, but deal only with practical work. Research Conferences are held by the whole staff every week of the Session. A vast amount of work is done, and the enormous sums saved by manufacturers stand to the credit of the faculty.

2. CINCINNATI AND PITTSBURGH UNIVERSITIES CO-OPERATIVE PLAN.

In these two Universities the Engineering Departments are carried on by a close co-operation of the Faculty with certain manufacturers in their several cities. The students for Engineering are carefully selected as to their ability and attainments. In the first of these Universities there is a waiting list of several hundred applicants for entrance. The students for Engineering are divided into two shifts; and each shift takes week about in shop and classroom. For their shop work the student apprentices receive the fixed pay of the mechanics of similar status beside them. Each alternate week the student confers with his professor and on his efficiency receives his credits. The connecting link between the shop and the classroom is the Shop Co-ordinator, who is a highly paid College graduate acquainted with shop practice. He spends every morning in the University classroom and every afternoon in the

shops, giving advice and direction to the students. The yearly course extends over ten months and the remaining two months are employed in doing remunerative work on railways or in factories. The Course lasts over four or five years and the plan is said to be popular with the manufacturers.

3. THE FOREST PRODUCTS LABORATORY, MADISON, WISCONSIN.

One of the most remarkable examples of co-operation in Research is that between the Forestry Department of the United States and the University of Wisconsin at Madison. The University erected a $50,000 building on its own site, and agreed to supply water, light, and heat to the Department. The Department of Forestry have complete control, appoint and pay the staff, of whom there are sixty and more than one third of them experts of high standing. The staff is bound to supply a certain limited number of lecturers to University students who desire them. The Laboratory is organized under nine sections:—

1. Maintenance.
2. Engineering.
3. Timber Tests.
4. Wood Preservation.
5. Wood Technology.
6. Wood Distillation.
7. Pulp and Paper.
8. Chemistry.
9. Pathology.

The building consists entirely of laboratories and offices. Every phase of wood investigation is carried on. Daily reports are made. The high-class of experimenters, thorough men of Research—the practical work for railway companies, lumbermen, and all the wood-using industries, suggest a suitable institution for Canada with its forests. The Forest Products Laboratory staff is supported entirely by the Federal Government—the local expense by the University.

COMMERCIAL CHEMICAL RESEARCH.

This is carried on in Kansas and Pittsburgh Universities under a distinguished scientist and author, who is a graduate of Toronto University—Prof. R. K. Duncan. His plan, to quote his own words, "is a mutually advantageous arrangement between manufacturing companies on the one hand, and the University on the other for the adequate solution of important manufacturing problems." Professor Duncan is a University professor, formerly of Kansas University, and still has supervision of his scheme there, but now resides in Pittsburgh, Pennsylvania, and is entirely paid by his University. His laboratory in Pittsburgh is a temporary building with accommodation for twenty-two experts—all of the highest class of experienced Research men. His

annual pay roll of these men is $40,000, individual salaries varying from $700 to $3,500. These amounts are paid entirely by manufacturing interests. The scheme in Pittsburgh promises to be one of great importance. In Kansas there are twenty fellowships paid by manufacturers and in Pittsburgh nineteen. Professor Duncan deals with the manufacturer as to his problem and what he is willing to pay for investigation for two or three years. The professor has sole choice of his experts. As a matter of fact three of the Pittsburgh experts are from Toronto University, and the remainder are graduates of various Universities. If a discovery is made it is the sole property for three years of the manufacturer contributing to it. At the end of three years it is the property of the public. The experimenter has a share in the profit, but Professor Duncan has none. The most important questions taken up in Pittsburgh Laboratory are Baking, Smoke Nuisance, Glass perfection, Soap making, Glue, Orange Culls, Crude Petroleum, ($10,000 a year for two years and bonus), Cement, Natural Gas, etc.

The advantages of this system as stated by Professor Duncan are:

1. A great advantage to the Industrialist.

2. The general elevation of Industry by introducing experts into factories (much after the fashion in Germany.)

3. The co-operation of a large expert staff in which personal integrity is the sine qua non to election to these fellowships. Thus is constituted a fraternity of mutual helpfulness.

4. A remarkable effect upon the Industrialists, interested in elevating and widening their aims and projects.

5. A most important effect on the University concerned, in their relation to the Industrial communities.

Gentlemen of the Canadian Institute, Research is a practical subject. It is no dream or visionary fad. I have endeavored to describe it in its different phases. If Canadian Manufacturers are to succeed, this cannot be done by artificial bolstering up, or sleight of hand, or industrial cornering, or anything else except plain, intelligent hard work. I have pointed out how success may be obtained. It can only be done by Governments—Dominion, Local, and Municipal co-operating heartily in advancing Technical Education, by the co-operative association of Universities and Technical Schools, and it can be greatly assisted by the shrewd but interested support in co-operative plans of the Canadian Manufacturers. Besides, all these may be mightily stimulated by the gifts of rich and generous Canadians—and I am further sure that the Local Governments will pardon us if we should advise the wealthy men to take steps to escape the Legacy Tax by giving hundreds of thousands of dollars while they are still living, that they may see the fruit of their labours.