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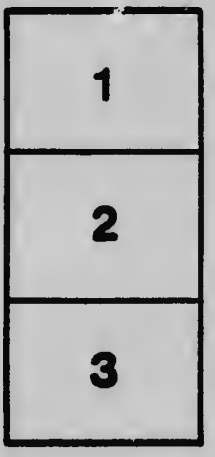

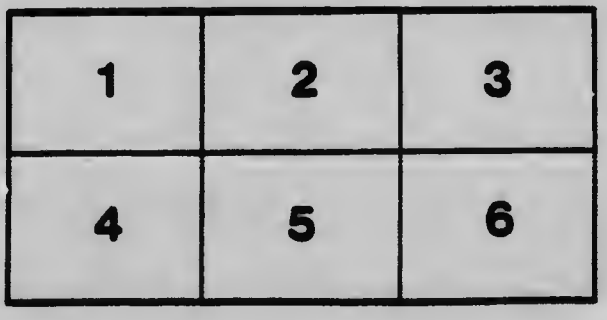

With the Compliments of the Royal Canadian Institute

Industrial Research in the United States

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Reprinted from the March number of the "University of Toronto Monthly"

THE UNIVERSITY OF TORONTO PRESS, TORONTO

1919

Industrial Research in the United States

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In June 1917 and in August and September 1918, the writer visited centres in the United States where there were organizations for industrial research. The effects of the war in stimulating research were in evidence on both occasions. On the former visit these effects were manifested largely in attempts to supply pressing economic needs. When war first broke out the people of the United States were deprived of important articles which they had formerly imported from Europe. The research workers of the country were called on to devise means of producing either the articles themselves or effective substitutes. The results surpassed all expectations.

Synthetic drugs and chemicals, which were formerly derived from Germany, are now prepared in the United States. Certain High grade steel alloys for which America looked to Austria, are now manufactured on this side of the Atlantic. The American dyestuffs industry has been placed in a position where it can cheerfully meet all competition. In 1914 the United States produced less than $2,500,000 worth of artificial dyes. In 1917 the output was more than $57,000,000. The total annual production of the world before the war was $92,150,000 of which Germany's proportion was $68,300,000.

The potash needs of the country are not as yet satisfied. Nevertheless in 1917 the product from various native sources totalled $14,000,000. Of this $8,000,000 worth came from the brine lakes of Nebraska and other States. The kelp of the Pacific coast furnished $2,000,000 worth and $1,000,000 worth was provided by the molasses residue from distilleries. Only $750,000 worth came from the chimneys of cement factories. Dr Van H. Manning, the Director of the Bureau of Mines, to whose kindness I am indebted for these figures, expects that ere long half the needs of the country will be supplied from the last named source. He is hopeful too that a considerable amount will ultimately be recovered from the dust from blast furnaces. Much valuable work has been done by the Bureau of Mines in connection with the two last mentioned sources of supply.

When I visited the United States in 1918 practically all the research laboratories were busied on war problems. The research men were working under pressure and in one laboratory I was told that they were doing in one month what in peace times it would have taken the greater part of a year to accomplish. The laboratories were not as accessible as they were on my visit of the year preceding and where one saw something of what was being done it was understood that much of it was of a confidential character.

When the United States entered the war the research workers in the universities and elsewhere volunteered their services. The scientific forces of the country were mobilized with results which have been far reaching. The achievements of science

in the war cannot but appeal to the popular imagination. When the ban of secrecy is completely lifted and it is realized how multifarious and how important these achievements have been, public opinion will surely insist on a more generous support of research and a better treatment of the research worker both inside and outside the university. The manufacturers, including the smaller ones, are becoming more and more impressed with the potentialities lying in the application of science to industry. I was told of a manufacturer of wooden ware on a small scale, who took up the construction of aeroplane parts and, in that connection, experienced the benefit of scientific advice. He stated that he had formerly had no faith in the scientist. He now realized however that many of his difficulties might have been solved for him ten years earlier had he been willing to consult a scientifically trained man. This instance was cited to me by a well known chemist who also told me the story of a group of firms which had muddled over a problem until they had expended $100,000, without result. They then came to him and stated that they were ready to spend $100,000 more on the problem and that they were willing to wait five years for a solution. Two research men were put to work on it and the matter was speedily cleared up. The bill was $2,000. The results atttained have proved of importance in the war.

One of the laboratories visited by the writer last August was that of the Eastman Kodak Company located in Rochester, N.Y. This laboratory employs a staff of forty research workers and costs $150,000 for annual maintenance. When the United States declared war these research workers together with certain others in the employ of the Company organized themselves into a teaching staff for instructing members of the Air Force in aerophotography. After a sufficient number of the latter had been trained so that they could do the teaching, the research workers returned to their laboratory and devoted themselves exclusively to war problems. Their services cost the country nothing, their salaries being paid by the Company. The problems handled presented a considerable diversity in their nature. They concerned themselves, among other things, with anti-submarine devices, with liquid fuel and with aerophotographic apparatus. In particular much time and ingenuity were expended in originating new types of colour filter, that invention which plays such an important role in bringing out specific features of a landscape as photographed from an aeroplane.

It may be noted that the Eastman Kodak Company is collaborating with the University of Illinois in manufacturing and selling at cost certain important chemical reagents. These reagents, which were formerly imported from Germany, are employed in chemical research.

Another large industry in Rochester is that of the Bausch and Lomb Company. This Company employs nearly 6,000 workers and is the largest optical instrument company in America. Of its output 98%, I was told, was for war purposes. Among its most important products are the rangefinders for the navy and anti-aircraft service. Some of those I saw were thirty feet in length. For the construction of rangefinders the very finest optical glass is essential. At the time of my visit to the United States in 1917 such glass was not to be had. In the meantime scientific men brought their skill and methods to bear on the matter and when I visited

Rochester in 1918 a supply of optical glass was availab[illegible] which was equal to the best which had been imported from Germany before the war.

After leaving Rochester the writer visited Syracuse, Schenectady, Worcester and Boston. Near Syracuse is the laboratory of the Semet Solvay and the Solvay Process Companies. In this laboratory fifty research workers are employed. Much work has been done on processes for obtaining trinitrotoluol and on processes for producing benzalchloride and thence deriving benzaldehyde. A recent outcome of work done in this laboratory is a process for extracting potash salts from one of the larger brine lakes of California. They have also succeeded, in collaboration with Government chemists, in catalytically oxydizing ammonia for the manufacture on a commercial scale of nitric acid.

The Laboratory of the General Electric Company at Schenectady was visited by the writer both in 191[illegible] and in 1918. During the past year, I have, on several occasions, given details in regard to some of the achievements of this great research establishment.* Dr Dushman too, a member of the research staff at Schenectady and a graduate of our own University, has recently lectured here on the work of the laboratory. It may therefore suffice if I mention that in August last the Laboratory was given over completely to war work, that the members of the staff were in particular preoccupied with the submarine problem and that the expenditure on research in 1918 was more than double that in the preceding year. It would probably be a safe guess to say that the General Electric Company in 1918 expended on research in its various laboratories a sum which did not fall far short of $2,000,000.

At the Worcester Polytechnic it struck one as rather novel to find that the Department of Mechanical Engineering [illegible] conducted on a commercial basis. The Department has its own shops with [illegible] pay list of $1,800. It possesses its own patents and manufactures apparatus [illegible] the market. In the year 191[illegible]18 it did a business of $220,000. At the time of my visit 95% of the output of the shops was war work. A student, I was told, could help pay his way by working in the shops.

A number of pieces of research which had engaged the attention of members of the staff were described to me. In that connection stress was laid on the necessity of collaboration on the part of the engineer with the physicist and the chemist, as in so many cases his problems bring him up against difficulties of a purely scientific character.

Another engineering institution is the Massachusetts Institute of Technology which is now housed in its magnificent new buildings on the bank of the Charles River. The Institute conducts a course in physics [illegible] industry which is specially intended to train men for industrial research. It has extensive research laboratories which at the time of my visit were being utilized for war purposes. It is also well-manned—a prerequisite in order that individual members of the staff may find time for research. A point which I noted was the emphasis which is laid on the calculus as an instrument for the engineer.

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*See, *e.g.*, "Science and Industry" (an address delivered to the Board of Trade of the City of Toronto).

Not far removed from the Institute of Technology, on the bank of the Charles River, stands the laboratory of the A. D. Little Company, Inc. This is a model commercial laboratory employing forty research workers. One of its products is cellulose acetate from which artificial silk, bristles and other articles are manufactured. A complete pulp and paper mill constitutes a part of the equipment. There is also a distillery which is working on the extraction of alcohol from bananas. At the time of my visit war work was being carried on in the testing of foodstuffs on a large scale for the United States Government and the New England Food Administration. A study was also being made of varnishes for aeroplanes.

An interesting feature of Dr Little's laboratory is an industrial research museum. This museum, which is still in its infancy, has as its purpose to exhibit the historic development of a variety of industries which depend on research for their growth. For example the evolution of cottonseed oil and its by-products from cottonseed is illustrated. What was here dead waste forty years ago now means, thanks to the research worker, a product whose value to the United States for the year 1918 was $320,000,000.

Intermediate between Boston and New York I made a stay at Woods Hole, a Mecca for research biologists during the summer months. Here is located the Marine Biological Laboratory, on whose staff by the way are several good Canadians domiciled in the United States, including the Director, Professor Frank Lillie of Chicago. Investigations were under way on a variety of subjects. In particular a good deal of work was being done on problems connected with heredity. A touch of the war was in evidence in that the effect of poison gas on cell tissue was being studied. The war too was responsible for an attempt which was being made at a station of the U.S. Fish Commission in the vicinity to obtain a substitute for gum arabic from the kelp which is found along the coast.

In New York the writer met a number of scientists with whom he discussed industrial research. Among these was Dr Takamine, the eminent Japanese chemist who is responsible for the research movement in Japan. Dr Takamine informed me that a sum of $5,000,000 (10,000,000 yen) was being raised to establish a research institute for physics and chemistry in Tokyo. The Emperor had subscribed $500,000, Parliament $1,000,000, commercial and industrial concerns $2,000,000, and it was expected that the remaining $1,500,000 would soon be in hand. The buildings are at present under construction. Members of the staff are now visiting other countries in search of the latest information and will be on hand prepared to assume their duties as soon as the buildings are ready for occupation.

In its research undertakings the Japanese Government has been advised by Dr Alcan Hirsch of New York who is also adviser to the Japan Dyestuffs Company on whose capital of $4,000,000 the Government guarantees 8% annually for ten years.

On the waterfront in New York are located the laboratories of the Western Electric Company. These are the greatest laboratories of their kind in the world and Dr F. B. Jewett, the Chief Engineer, on his recent visit to Toronto told us something of their weird achievements in the realms of wireless and multiplex telephony and telegraphy and in long distance telephony. It is now possible to hold more

than one telephone conversation and to transmit several telegraph messages simultaneously over the same wires without the slightest interference or confusion. It is now possible for a man standing on the ground and speaking in his ordinary tone of voice to give orders to aeroplanes at a distance of ten or fifteen miles. These, among others, are recent advances made in the laboratories over which Dr. Jewett presides. The research workers in these laboratories number more than three hundred and the expenditure on research for the year 1918 was approximately $2,500,000.

At Wilmington on the way from New York to Washington are located the research headquarters of the Dupont Company. For the current year I was informed that the expenditure on chemical research was $2,000,000. A certain amount was also being expended on research in physics and engineering. There are four chemical laboratories employing in all 200 research workers. Associated with each of these laboratories is an analytical division whose chemists make analyses and do other routine work for the research chemists in order that the time of the latter may be spent to best advantage. There are also forty-four chemists who are experts on the different processes in which the Dupont Companies are interested. All told there are 1,100 chemists employed in various capacities in the works. The total number of employees at the time of my visit was 65,000.

The bonus system has been introduced among the research workers and a bonus may run as high as $50,000. The policy of the Dupont Companies in this regard is somewhat in contrast with that of a large manufacturing concern, cited by Professor Stieglitz of Chicago, which added a little over $200 a year to the salary of the Director of its research work for a device of his which netted the Company a profit of $80,000 annually.

Another great research establishment whose upkeep for the year 1918 cost $2,000,000 is the Bureau of Standards maintained by the Federal Government in Washington, D.C. Besides the current expenditure just indicated $1,500,000 was being expended on new buildings. At the time of my visit there were 785 research men employed in the laboratories besides which there were 75 men in the field. Of the 785 men here referred to 300 had been detailed to do research work and were in uniform. I was told that about 600 problems a month were presented to the Bureau of Standards by the military services alone. Practically all the work of the Bureau last year had a bearing on the war. Of the problems handled 65% were direct war problems. The remaining 35% had an indirect bearing on the war.

Confidential reports were issued in bulletin form several times a month. These were sent to a limited number of persons all of whom with a few exceptions were heads of military, naval or aeronautical departments or organizations. Each bulletin indicated in a general way the progress made on a number of problems.

The Bureau of Mines is also a federal institution whose activities are largely those of research. Its appropriation jumped from $1,250,000 in 1917 to $8,000,000 in 1918. Nearly all of the latter sum has been spent in connection with the gas warfare service. The Bureau had begun its investigations in connection with the gas warfare in February 1917, that is to say, before the United States declared war. Its first investigations had to do with gas masks. These were later extended so as to include all sorts of materials and apparatus employed in gas war-

fare. It collaborated with the National Research Council, the universities and other bodies, as also with individuals. When in June 1918 the Chemical Warfare Service of the National Army was formed and the War Department took charge of the work which the Bureau of Mines had been doing in connection with gas warfare the Bureau was able to turn over to the Department a complete organization with a personnel numbering 1,800. This included a corps of 700 chemists.

The Bureau of Mines conducts investigations on metallurgical problems, on lignites, on the composition of coal and on its utilization. It studies in fact everything connected with mining. It has for instance done a great deal of experimental work on the flotation process for treating ores. It does work on the technology of petroleum and natural gas. The methods employed in obtaining oil have been very wasteful. For example, in Oklahoma oil has been obtained under circumstances which would mean a loss of $75,000 worth of natural fuel gas for $25,000 worth of oil recovered. In one field of Oklahoma, it has been estimated, that the waste of fuel gas in one year was equivalent to 5,500,000 tons of coal. A very large proportion of this waste can be eliminated, as the Bureau of Mines has shown, by employing what is called the mud laden fluid method. A very large proportion of the oil too, from 30% to 90%, is left in the ground. If it is able to cause the adoption of practices whereby the production is increased 10% the Bureau of Mines estimates that the ultimate aggregate saving to the country will be $450,000,000.

It would appear that the time is not so remote when the United States will have to look to its shales as a source of supply for oil. The Bureau of Mines has been studying processes for recovering oil from this source.

The Bureau of Mines has been instrumental in effecting a great saving in the by-products of coke. The United States had been wasting $50,000,000 a year by using the beehive oven instead of the by-product oven in the coking of coal. A great change, due to the war, came about in 1917 during which year 22,600,000 tons of coke came from by-product ovens. This amount was greatly increased in 1918. During the latter year according to the Director of the Bureau of Mines the by-product ovens in operation were expected to produce 5,000,000 more tons of coke than if the coal had been coked by the beehive process. Furthermore he estimated that these ovens in full operation would produce 315,000,000 gallons of tar which could be used in the arts or which as a fuel would have the same efficiency as fuel oil. He also pointed out that they are capable of yielding 168,000,000 feet of gas or sufficient to melt 12,000,000 tons of steel in open-hearth furnaces. The by-products here in question have been of immense importance in the production of explosives for the war. They have made it possible too to establish the great American dyestuffs industry.

As a result of the war the American Government developed temporarily into the greatest manufacturer of chemicals in the world. Its appropriations for nitrate and sulphuric acid plants have run into the hundreds of millions. It has been suggested that the products of some of these plants be now utilized for the manufacture of fertilizers. In this connection one might remark that it has been stated on good authority that a reduction of the cost of soluble nitrogen compounds to a price comparable with that prevailing in Germany before the war would add $1,000,000,000 to the annual value of the crops of the United States.

The National Research Council has interested itself in the fertilizer question. It is felt that the farmer should be taught to use fertilizer. In the past however the fertilizer companies have not always been fair to the farmer [illegible]ey have sold him constituents which were in many cases superfluous for his land. To remedy this abuse, the National Research Council has, with the concurrence of the Fertilizers' Association, organized a commission of five scientific men who will be paid by the Association. This commission, in co-operation with the individual states, will undertake a survey of lands in the Middle West with a view to determining the specific needs of the soils in different parts of that region.

It might be well to here say something more about the National Research Council, as it is an organization of comparatively recent date which has already abundantly justified its existence and which promises to exercise an immense influence on scientific and industrial research and on the intellectual life of the country in general.

"In April, 1916, immediately after the attack on the *Sussex*, the National Academy of Sciences voted to offer to the President its services in organizing the scientific resources of the country. This offer was accepted, and the Academy was requested to secure the co-operation of all agencies Governmental, Educational and Industrial, in which research facilities are available. The National Research Council, comprising the chiefs of the technical bureaus of the Army and Navy, the heads of Government Bureaus engaged in scientific research, a group of investigators representing educational institutions, and research foundations, and another group including representatives of industrial and engineering research, was accordingly constituted by the Academy with the active co-operation of the leading national scientific and engineering societies. To these were added representatives of the Government designated by the President."

Early in 1917 the National Research Council was requested to act as the Department of Science and Research of the Council of National Defence. On May 11th, 1918, the President of the United States issued an executive order in which he commended the work of the National Research Council and requested the National Academy of Sciences to perpetuate its organization. At the same time he specified its functions as follows:

(1) In general, to stimulate research in the mathematical, physical and biological sciences, and in the application of these sciences to engineering, agriculture, medicine and other useful arts, with the object of increasing knowledge, of strengthening the national defence and of contributing in other ways to the public welfare.

(2) To survey the larger possibilities of science, to formulate comprehensive projects of research, and to develop effective means of utilizing the scientific and technical resources of the country for dealing with these projects.

(3) To promote co-operation in research at home and abroad, in order to secure concentration of effort, minimize duplication, and stimulate progress; but in all co-operative undertakings to give encouragement to individual initiative, as fundamentally important to the advancement of science.

(4) To serve as a means of bringing American and foreign investigators into active co-operation with the scientific and technical services of the war and navy departments and with those of the civil branches of the Government.

(5) To direct the attention of scientific and technical investigators to the present importance of military and industrial problems in connection with the war, and to aid in the solution of these problems by organizing specific researches.

(6) To gather and collate scientific and technical information at home and abroad, in co-operation with Governmental and other agencies and to render such information available to duly accredited persons.

Under its war organization the National Research Council counted more than one hundred members. It had as officers a chairman, three vice-chairmen, a treasurer, an executive secretary, and two assistant secretaries. With these was associated an executive board. The Council worked through eight so-called *Divisions*. The chairmen and vice-chairmen of these divisions were members of the Council. This however was not the case with the great majority of the members of the Divisions.

The territories covered by the activities of the several Divisions are more or less vaguely suggested by their titles, as follows: (1) General Relations, (2) Military, (3) Engineering, (4) Physics, Mathematics, Astronomy and Geophysics, (5) Chemistry and Chemical Technology, (6) Geology and Geography, (7) Medicine and Related Sciences, (8) Agriculture, Botany, Forestry, Zoology and Fisheries. Under Division (1) are included foreign relations, relations with educational institutions, industrial research, reconstruction problems, etc. Division (2) includes the Research Information Service. This service has branches attached to the embassies in London, Paris and Rome. The appointment of a scientific attaché to an embassy is an innovation for which the National Research Council is responsible. The departure has however been amply justified and the office is likely to be made a permanent institution. One of the functions of a scientific attaché is to keep headquarters in Washington informed on all scientific developments which take place in the country to which his embassy is accredited. Another is to place American army and navy officers in his vicinity in a position to obtain any scientific information which they may require.

The National Research Council has utilized workers in all branches of science. The layman would hardly expect results of military value from an astronomer. Yet a remarkably expeditious method of reducing observations made in soundranging is due to a Princeton astronomer who has been working under the auspices of the National Research Council Astronomers in the United States have also made important discoveries relating to the trajectories of projectiles and the dropping of bombs and an American astronomer is said to have perfected a new instrument which will be of great use to navigators whether on the sea or in the air.

Another surprise for the layman is to be found in the effective war service rendered by the psychologists. At the suggestion of the National Research Council a psychological examination of the troops was undertaken. This proved a great success and sufficed in many cases to determine in advance that it would be impossible to fit a man for a given post.

Until the close of hostilities the activities of the National Research Council were almost wholly absorbed by matters relating directly to the war. It is now reorganizing and has already adopted a new constitution under which, among other

changes, a modified classification of Divisions has been introduced. In the new arrangement the Divisions are grouped into two classes A and B. The Divisions in these classes are as follows:

A. Divisions of general relations: (1) Government Division. (2) Foreigh Relations. (3) States Relations. (4) Educational Relations. (5) Industrial Relations. (6) Research Information Service.

B. Divisions of science and technology: (7) Physical Sciences. (8) Engineering. (9) Chemistry and Chemical Technology. (10) Geology and Geography. (11) Medical Sciences. (12) Biology and Agriculture. (13) Anthropology and Psychology.

We shall not here go into detail with regard to other changes in the Constitution of the Council. Its peace plans are not as yet completely defined. Whatever shape they may take however there is reason to believe that the necessary funds will be forthcoming from other than Government sources. Before the close of the war it was already planning an extensive campaign for the promotion of industrial research. In this it was to receive the support of some of the most prominent commercial and industrial men in the country as well as of men in the scientific and technological professions. On his visit to Toronto already referred to, Dr F. B. Jewett informed us that the National Research Council is now proposing that the leading universities found research professorships. He also told us something about the generous dimensions of the research fellowships which the Council intends to establish, the necessary funds thereto being furnished by corporations which have benefited by research. Last year the National Research Council received $122,000 from President Wilson out of the fund of $100,000,000 which was voted to him by Congress to dispose of as he deemed best for the national security and defence. Financial aid to the extent of $50,000 was furnished by the Rockefeller Institute and the Carnegie Corporation of New York contributed $100,000.

Toronto is to be honoured by a visit from the distinguished Chairman of the National Research Council, Dr George E. Hale, early in April, when he will address the Royal Canadian Institute on the work of the Council.

As a sign of the times it may be noted that one of the largest corporations in the United States has under consideration a project for establishing a graduate school in connection with its laboratories where selected students on fellowships would be trained in research methods and whence later on the brightest among them would be drafted into well-paid positions in the Company's research department.

It may be pointed out that at a meeting of representatives of National Academies held in the rooms of the Royal Society at London in October last it was proposed that each of the allied countries should have a National Research Council and it was furthermore suggested that there should be an International Research Council made up of representatives from the several National Research Councils. What would Canada's part be in such a scheme? Is Canada doing all that she should do in the matter of research? A prominent American scientist in conversation with the writer stated that Canada should be doing as much research as the United States actually is doing and that the United States should be doing ten times as much as she is doing. If this statement is correct Canada's multiplier would be considerably in excess of ten.