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The State and Productive Research.¹

BY Order in Council of July 28, 1915, the Committee of the Privy Council for Scientific and Industrial Research was established "to direct, subject to such conditions as the Treasury may from time to time prescribe, the application of any sums of money provided by Parliament for the organisation and development of scientific and industrial research." The Order in Council further provided that there should be an Advisory Council to which should stand referred, for its report and recommendation, proposals—(1) for instituting specific researches ; (2) for establishing or developing special institutions or departments of existing institutions for the scientific study of problems affecting particular industries and trades ; and (3) for the establishment and award of research studentships and fellowships.

On December 1, 1916, the work of the Committee of Council for Scientific and Industrial Research with that of its Advisory Council, hitherto under the ægis of the Board of Education, was assigned to a separate department—the Department of Scientific and Industrial Research—having its own estimates in charge of a minister responsible to Parliament. This was followed by the creation, under His Majesty's Sign Manual, of the Imperial Trust for the Encouragement of Scientific and Industrial Research, to hold funds, to enter into contracts and agreements, and to do other things in furtherance of the objects of the Committee of Council for Scientific and Industrial Research.

Parliament having voted the sum of one million sterling for the purposes of the Department, the fund was deposited with the Imperial Trust to be expended in accordance with the directions of the Committee of Council. On the recommendation of the Advisory Council, the Committee of Council decided that the money should be spent in the form of grants in aid of research in any industry undertaken by firms which might combine to conduct it on a co-operative basis. The means devised to this end was the establishment under the Companies Acts of Associations for Research limited by guarantee and trading without profit. The number of these industrial research associations in actual operation to-day is twenty-three, and there is one which has not yet commenced full operations.

The position of the Research Associations and their future in the industrial system of Great Britain are well worth separate consideration, but as the policy of establishing them at all has been challenged, even in quarters unquestionably anxious to promote the fullest use of scientific knowledge, it may be well to say a

¹ Report of the Committee of the Privy Council for Scientific and Industrial Research for the year 1923-24. (Cmd. 2223.) Pp. iv+139. (London : H.M. Stationery Office, 1924.) 3s. net.

word on the general question. That question is, granted that a million fund is for disposal to bring the results of scientific research to the continuous aid of industry, is the method of establishing research associations the best method, or at least as effective as any other method, of doing so? The Advisory Council, in its annual report for 1919-20, says:

“It may be said that a million spent upon research work done at the National Physical Laboratory and other research laboratories up and down the country would produce much greater scientific results of value to industry than the same sum spent in subventions to associations that have to buy their experience as well as their staff and equipment at a time when the country is short of both. It may be so. But it is only after the industries have done research for themselves that they can appreciate either its difficulty or its worth. They are trained to suspect that what can be got for nothing may have a corresponding value. Had the million been spent on research directed by the Government itself, its effect upon manufacturers would at the best have been destructive of their self-reliance and at the worst a free gift to their competitors in other lands.”

To the writer these considerations seem sound and over-riding. The essential problem would not be solved by the mere increase, in quantity and quality, of the results of scientific research of value, direct and indirect, to industry. It was a part, and not the least part, of the problem to get science domiciled in the industries themselves; to bring about an interfusion, not only of the theoretical knowledge of the man of science and the practical knowledge of the manufacturer, but also of the corresponding personalities; and to make the manufacturers themselves (in greater or less degree, according to the character of the industry) working, and not sleeping, partners in scientific research. It is difficult to see what better means to these ends could have been adopted than the method of industrial research associations.

On one major point, however, there may well be doubt and criticism. The scheme was based on the expectation that at the end of the first five years the industries concerned would find themselves both willing and able to continue the work of their respective research associations without direct assistance from the State. On this, two things may be said. In the first place, five years is too short a period in which to bring practical conviction of the benefits and necessity of co-operative research to industries, presumably, needing to be convinced, and the course of economic events since the War, including the long period of industrial depression, has enhanced this difficulty. In the second place, the State may well lose more of real wealth by cutting the research associations adrift than it can gain in money saved by the withdrawal of grants in

aid. It is to be hoped that the Committee of Council will give further careful consideration to this aspect of the question and will not regard as an axiomatic principle the proposition that research associations must, after a limited period, “look solely to the industries they represent for their maintenance.”

To obtain a just idea of the work of the Department of Scientific and Industrial Research, we have to consider, however, much more than the work of the Research Associations. In carrying out its duties, the Advisory Council gradually evolved a definite programme under four main heads: (1) the encouragement of the individual research worker, particularly in pure science; (2) the organisation of national industries into co-operative research associations; (3) the direction and co-ordination of research for national purposes; and (4) the aiding of suitable researches undertaken by scientific and professional societies and organisations. It would be impossible in a single article to give even the barest summary of the work done under these heads, and the reader who is interested may be referred to the annual reports of the Department. There, for example, he will learn what has been done and attempted “in the direction and co-ordination of research for national purposes” in the records of the Fuel Research Board, the Food Investigation Board, Forest Products Research Board, Building Research Board, and so on.

The Department has also done much to co-ordinate the various scientific activities of government. In 1918 the property of the National Physical Laboratory, together with the responsibility for its maintenance and development, was transferred to the Department, and in 1919 the administration of the Geological Survey and Museum was similarly transferred. In 1919-20 on the decision of the Cabinet, Co-ordinating Boards were established, with the object of so organising all the scientific work which is of common interest to the Fighting Services of the Crown as to ensure the utmost economy of expense and personnel, and the due co-ordination of the technical work of the various naval, military, and aeronautical establishments so as to avoid overlapping, either with each other or with the research organisations of the Civil Departments of State. At present there are four such Co-ordinating Boards, for chemistry, engineering, physics, and radio research. They include technical representatives of the Fighting Services and Civil Departments.

Reviewing the work and development of the Department of Scientific and Industrial Research since its foundation, the question arises, has the experiment of governmental participation in the organisation of scientific research, especially in its relation to industry, so far as it has gone, been justified? To that question,

there can be little doubt that the answer is in the affirmative. If there have been mistakes in detail, unrealised expectation here and, apparently, wasted effort there, the instances have been at least as few as, and perhaps fewer than, could reasonably be counted on, for a like period, in the early stages of development of any new government department. As to the value of the work itself, it is sufficient to quote the words of the Advisory Council: "Scientific research is, in our judgment, the main, if not the only source of fresh productivity in industry, and it is only by increased productivity that the world will find a way out of its present economic difficulties."

What, taking a broad view, has been done towards this end by the establishment and work of the Department of Scientific and Industrial Research?

We have now a Government Department as fiduciary for science, charged with the duty and responsibility of ensuring, in so far as Government can ensure, that scientific knowledge and methods play their full part in the Government services and in the trade and industry of Great Britain.

We have Research Associations in twenty-three or twenty-four diverse industries, not only engaged directly in scientific research, but also acting as scientific centres where all scientific questions affecting their respective industries can be brought to a focus, and in the solution of which the scientific worker, the manufacturer, and the user can each play his appropriate and co-ordinated part.

The scientific worker and the manufacturer have been brought into closer co-operation, the gulf between theory and practice has been narrowed, and, in greater or less degree, the manufacturers themselves have become productive partners in research.

The spirit of co-operation between individual firms in an industry and between industries generally and the Government services has been quickened and enlarged.

Researches have been initiated and prosecuted, already with appreciable success, into fundamental problems of national importance (for example, fuel, food, and building materials), which no one firm and no one industry could be expected to undertake on an adequate scale.

The man of science has been helped to come into his own, and a powerful reinforcement has been brought to the aid of those who have long sought to bring vividly to the minds of all classes a realisation of the degree and extent to which our modern industrial civilisation is based upon, and must be shaped by, the progress of scientific discovery.

Not least, a good beginning has been made in the evolution of a national scientific policy. Continuity in foreign policy has been the aim of successive governments since the days of Lord Salisbury. By wise and prudent direction, by advancing, to use a phrase of Lord Morley, "with daring caution," the Department of Scientific and Industrial Research may give us an accepted national scientific policy, definite, continuous, and consistent.

J. W. WILLIAMSON.

History of Mathematics.

History of Mathematics. By David Eugene Smith. Vol. 1: General Survey of the History of Elementary Mathematics. Pp. xxii + 596. (Boston and London: Ginn and Co., 1923.) 21s. net.

IT is only during the last fifty or sixty years that the history of mathematics has been systematically studied. In that time, however, the field has been gradually covered by an increasing number of students, and their output has become so extensive that it was no work of supererogation when Prof. Gino Loria thought it necessary to publish a guide to the literature of the subject, old and new, "Guida allo studio della storia delle matematiche" (Hoepli, 1916). There are indeed already in existence general histories of mathematics of all sorts and sizes, designed to meet the requirements of almost all varieties of readers. The great work of Moritz Cantor ("Vorlesungen über Geschichte der Mathematik"), which may be regarded as the inspirer of most of them, appeared in the years from 1880 to 1908 and consists of four volumes, with an aggregate of some 3800 large pages. Yet it contains no unnecessary details—in many places in the earlier volumes the reverse is the case—and it does not carry the story beyond 1799: this is a sufficient indication of the extent of the material.

Cantor's history has not been translated into English, partly, we may suppose, because it would be a formidable undertaking, but also, no doubt, because the book is, so far as the early volumes are concerned, already out-of-date, the later editions having failed to take sufficient account of the results of recent researches and of the many corrections and well-founded criticisms of details in the first edition. Among the shorter histories covering approximately the same ground may be mentioned the "Geschichte der Mathematik" designed for the "Sammlung Schubert," in two volumes, the first (1908) by Siegmund Günther (pp. 427), and the second in two parts (1911 and 1921) by Heinrich Wieleitner (pp. 251 and 220), a competent work of convenient size. Much smaller still was the "Geschichte der Mathematik" in the "Sammlung Göschen," by A. Sturm, which essayed to tell the story in 155 small pages; this has now been re-edited in two parts (1922–1923) by Wieleitner (pp. 136 and 154), and contains the very utmost that could be compressed into the small space, so much so that it can scarcely be read continuously for any length of time without inducing a headache.

The histories in French, apart from the pioneer work of Montucla (first edition 1758, second edition, completed by Lalande, 1799–1802), are of no great account. One is by M. Marie in twelve slender volumes ("Histoire