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SCIENTIFIC RESEARCH AND PUBLIC EXPENDITURE

THE statistical survey of scientific and technical research in British industry recently made by the Industrial Research Secretariat of the Federation of British Industries, while admittedly incomplete, is a valuable supplement to the survey of expenditure on research and development which formed the subject of the Third Report of the Select Committee on Estimates for the Session 1946–47 (132–1. London : H.M. Stationery Office, 1947. 6*s*. net). The Federation's report is based on the 471 replies received to about nine hundred copies of a questionnaire circulated to industrial firms known or thought likely to be carrying out research. It is estimated that the survey covers some seventy-five per cent of the industrial research effort of Great Britain, although probably not more than fifty per cent of the firms carrying out research. On this assumption the total annual expenditure by industry on research and development within its own establishments is of the order of thirty million pounds, which represents about two thirds of one per cent of the total annual value of British manufacture.

This figure may be compared with that of £5,442,000 obtained from an earlier survey by the Federation and based on returns from 566 firms in 1938 ; but it is more pertinent to set it against the national estimated expenditure of £69 millions analysed in the report of the Select Committee on Estimates. The estimate for the Department of Scientific and Industrial Research for 1947–48 amounts to £3,118,289, or about ten per cent of the expenditure by industry itself ; but in addition it is estimated that other Departments are expending £1,500,500 on industrial research. The vote for Post Office research amounts to £750,000, for agricultural and fisheries research to £2,150,925, for medical research to £710,850, for research in the Dominions and Colonies to £538,825. In addition to miscellaneous grants for scientific investigation amounting to £70,560, account should also be taken of the expenditure by the universities on scientific research. This is of fundamental importance to the State as well as to industry, but it is difficult to obtain even an approximate idea of its magnitude. Expenditure on teaching cannot, of course, easily be separated from that on research, and the Select Committee estimates that of the present vote of £11,875,000 in aid of the universities, something less than £3,500,000 is for science, technology and agriculture. Part of the expenditure of just over £2 millions on medical and dental education will be for research, and there are also capital grants of probably not less than £1,800,000 ; but it would be rash to put the nation's expenditure on fundamental research as reaching anywhere near £5 millions, at least on these figures.

What overshadows all these sums, however, is the expenditure of £60,351,000 on research and development for the Admiralty and the Ministry of Supply, which is more than double the total estimated research expenditure of the whole of British industry. The Select Committee refrains from detailed

comment as it proposes to deal with the problem of expenditure on defence research in a later report; but there is a *prima facie* reason for questioning whether the present distribution of expenditure on research and development is that most to be desired in the light of civil and military needs and national resources at the present time. The diversion of at least a third of this effort from defence purposes to civil research has been urged by the Association of Scientific Workers; but without the detailed returns supplied to the Select Committee, which it was considered undesirable to publish, it is not easy to judge whether a diversion of such magnitude would be desirable.

What is imperative is that the nation's expenditure on fundamental research, upon which defence no less than industrial development alike depend, should be used to the best advantage. There can be little doubt that our first concern should be, as Sir Henry Dale urged at Dundee, to promote the extension of fundamental knowledge, and build up again our scientific capital on which the needs of war have drawn so heavily. It is vital that our academic leaders of research, men with ideas and inspiration, should lack neither disciples, assistants, nor equipment. In urging this, Sir Henry Dale was thinking largely of the diversion of scientific minds from creative research to administrative work; and the present shortage of scientific man-power makes it important that due regard should be had to this danger, all the more because our war experience has demonstrated that the field in which the scientific worker can usefully operate extends far beyond that of the laboratory where he normally pursues his business.

That point was well made by Sir Edward Appleton in his A. D. Little Memorial Lecture* at the Massachusetts Institute of Technology in November 1946, when he indicated that, as emphasized in the Barlow Report, the Government order of priorities is now: universities and fundamental research; civil research (Government and industrial); and defence research. What needs to be remembered first, however, in this connexion, is that the limitations on expansion of fundamental research are not primarily financial but those of man-power. It was made clear in the evidence received by the Select Committee on Estimates that lack of money is not the difficulty holding up the pursuit of profitable new lines of research at the present time: the principal needs are for men and accommodation.

These two needs are closely linked, and both are bound to be affected by the Government's policy of priorities and of the restriction of capital expenditure due to the economic crisis. The Select Committee emphasizes that, while it may be open to question whether the allotment to pure research and to scientific teaching is adequate to secure the twin objects of gaining natural knowledge, which provides the foundation for the whole structure of applied science, and of providing the required output of trained research workers, the evidence suggests that the allocation for the current year is probably as much as can be usefully and economically absorbed. This problem is raised, and also the further question whether the expenditure on defence research represents an equitable distribution between civil and military needs; and on the adequacy of the rough estimate of 21 per cent of national expenditure on research for industrial research, no comment is made.

On that point an appended memorandum from the Department of Scientific and Industrial Research gives a little further information. Of the present vote, £942,000 represents grants to research associations, a figure which it is estimated will reach £1 million when the expenditure of the Department reaches its full post-war level of £4,035,000. Of the firms replying to the questionnaire from the Federation of British Industries and expending more than £1,000 per annum on research, ninety per cent possess their own separate research laboratory or department and thirty per cent carry out research in their own production department; while available estimates indicate that half the firms contemplate a twenty five per cent increase of qualified research staff by the end of 1947 and a comparable further increase between 1948 and 1950.

These figures alone attest the importance of precise surveys of man-power requirements in relation to the expansion of the universities and colleges of technology, as was indicated recently in these columns (see *Nature*, November 29, p. 742). The memorandum from the Department of Scientific and Industrial Research, however, directs attention to the third factor in the situation, on which the Select Committee also comments. The Department of Scientific and Industrial Research, in addition to its primary responsibility for promoting and organising scientific work with a special view to its application to trade and industry, has also a duty to carry out scientific research within its scope required by other Departments of State. The memorandum indicates the provision being made for the discussion of common problems necessary for the most effective co-ordination; one responsibility of the new central intelligence group of the Department will be to make themselves generally familiar with what is going on in university and Government research organisations and, so far as possible, with the needs of industry, and then to effect such cross-fertilization as they can.

On the industrial side, the Federation of British Industries, through its Industrial Research Secretariat, is already doing much to promote the general exchange of scientific and technical information, and the inquiry indicated that most firms are satisfied with present arrangements. The Select Committee on Estimates, commenting on the dangers of overlapping and waste of effort in the present administrative organisation, emphasizes the value and need of a first-class system of liaison at all levels and the greatest possible interchange of information not only on results, but also on projects. It was satisfied that, in general, improvements in the existing organisation are being made as weak spots are revealed, and since

* Science, Government and Industry. By Sir Edward V. Appleton. (Inaugural of the Arthur Dehon Little Memorial Lectures at the Massachusetts Institute of Technology, at Cambridge, Massachusetts, November 19, 1946.) Pp. 38. (Cambridge, Mass.: Massachusetts Institute of Technology, 1946.)

these matters are under consideration by the Defence Research Policy Committee and the Advisory Council on Scientific Policy, it makes no further comment.

The Select Committee agrees with the opinion, which Sir Edward Appleton expressed at the British Commonwealth Scientific Conference last year, that it is far too early to decide what the ideal Government organisation for research should be, and the machinery for fostering scientific effort must remain for many years in a state of active development. That, however, does not exclude the need for closer study of the whole question of the organisation of scientific and industrial research in Great Britain, and indeed is a reason for further trial and experiment with the forms of institution best likely to achieve our purposes. There is general agreement, both in Great Britain and in the United States, that fundamental research is seldom a proper field for Government expenditure and that Government assistance is best given indirectly, through block grants to universities, research institutes and even individuals; but even here there may be room for inquiry as to whether there is in Britain a sufficiency of research institutions of the range and type to ensure that all branches of science are adequately covered. While the urgency of the present need for more and more production makes it essential to drive existing institutions to the utmost, the general unrest following a great war nevertheless provides both the right atmosphere for experiment with new ways of approach and the incentive to extract from each everything that can be of value for the future.

SYNTHETIC RUBBER

Butalastic Polymers

Their Preparation and Applications; a Treatise on Synthetic Rubbers. By Frederick Marchionna. Pp. vii+642. (New York: Reinhold Publishing Corporation, 1946.) 8.50 dollars.

THE development of synthetic rubber is one of the outstanding achievements of chemical industry in recent years. The chronicler of the story of this achievement is, however, faced with a multiplicity of difficulties. A comprehensive account must include, first the manufacture of the monomer, second the polymerization of the monomer, and third the fabrication and properties of a wide variety of articles made from rubber. The first part is a matter of large-scale industrial catalytic chemistry where the essential techniques are already well established in other fields of chemical engineering. The second is based on scientific principles, but is also compounded of much empiricism because there has not been time to go into these principles in an adequate manner so that the mechanism of polymerization is fully understood. The third is rubber technology applied to materials which have usually turned out to be rather more difficult to work with than natural rubber. Further, developments have mainly occurred in the United States, Germany and the U.S.S.R., and there has naturally been no interchange of information between these countries. Even if there had not been a world war, it is extremely doubtful whether the operators in these respective countries would have divulged the 'know how' regarding these processes so that an author could write a critical summary of the present-day position.

Dr. Marchionna has therefore had to face very considerable difficulties in writing an up-to-date account of the subject. The book was written before much information became available through the Allied teams of investigators sent to Germany and before the vast amount of work done for the rubber research programme in the United States began to appear in the scientific literature. There was thus only available to the author a considerable volume of earlier published work on the attempts made to synthesize rubber-like materials and a host of patents relating to the possible processes for the manufacture of monomer, for the polymerization of monomers and for the working up of the rubbers so produced; but of course with little guidance as to their real worth or economic practicability. In view of this awkward state of affairs, it is impossible to prepare a critical account of the various phases of the subject or even to give a personal opinion of the relative merits of competing processes or the various types of rubber now commercially available.

The contents of the book are restricted to what the author conveniently terms butalastic polymers, that is to say, synthetic elastomers in which the repeating unit was originally a diene. The volume is divided into three parts. The first deals with laboratory and technical methods of making isoprene, dimethyl butadiene, butadiene and halogen derivatives of dienes. Although butadiene is now regarded as the most important diene, the space devoted to it is perhaps a little disproportionately small. Part 2 is devoted to the problems involved in polymerization. Here the emphasis is mainly on the methods found empirically for diene polymerization, and there is no general account of polymerization from the kinetic point of view. Again this is reasonable, because diene polymerization has not yet yielded to accurate kinetic methods in view of the many complications that arise, especially in emulsion or sodium polymerization. Unfortunately, the lack of published information has precluded a detailed description of the processes currently used in the United States. Part 3 describes the technology of synthetic rubber, dealing with the coagulation of the emulsion and the incorporation of the usual rubber-compounding agents. Then there are sections dealing with all the usual applications of rubber in industry, special note being paid to the properties of synthetic as contrasted with natural rubber. There are comprehensive indexes to the book, which is well produced and excellently printed.

This, then, is the first comprehensive attempt to give a balanced and connected account of an industry which started many years ago, developed very slowly indeed and did not really come into its own until war compelled a tremendous amount of scientific and technological effort to be brought to bear in order to make certain that synthetic rubber would, in fact, be a practical proposition. Dr. Marchionna has attained success in a very difficult task. Any shortcomings which the book possesses are in the main due to the information not being available. It is to be hoped that when a second edition is required the war-time experiences will be incorporated, so that the reader can then discover what indeed are the scientifically and economically satisfactory ways of making and manipulating synthetic rubber.

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