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Industry and Scientific Research.

THE close relation between the dyestuffs industry and general organic research emphasised in the course of recent Parliamentary debates on the Dyestuffs (Import Regulation) Act was not controverted by those who considered that the Act should be allowed to lapse. On the other hand, doubts as to whether Imperial Chemical Industries, Ltd., by which the major proportion of dyestuffs research in Great Britain has been conducted, was doing so much for research as might be expected, and a suggestion that such research was being or might be curtailed, were alleged by certain members as reasons for not voting for a measure which they would otherwise have supported. The report of the Dyestuffs Development Committee, indeed, shows that there has been a slight decrease in the number of research workers employed in the dyestuffs industry between 1920 and 1928. This difference, however, as Major A. G. Church has pointed out, is largely due to the attraction of such research workers into other industries. Apart from this, the figures given in the report are too early to record the full effect of the extension of research activity in this field which has resulted from and only become possible through the pooling of resources following the formation of Imperial Chemical Industries, Ltd.

The relation between industry and research is extremely complicated, and there are certain aspects which were by no means covered in the recent debates and discussions. It must be conceded that industrial research inevitably has an economic trend, which may at times impose limitations. There is a certain amount of justification for making research obligatory when State support is given in any form. On the other hand, the prosperity of the dyestuffs industry and the organic chemical industry depends essentially upon continuous and wisely directed research. Any relaxation of effort in that direction would speedily result in decay. It is open to debate whether any stipulation regarding research could be made without involving machinery for control which would be a serious hindrance to scientific management.

The problems raised are not peculiar to Great Britain. Prof. R. Willstätter has recently directed attention to the changed relations between the universities and chemical industry in Germany (*Chem. Zeit.*, **54**, 793; 1930; **55**, 1; 1931), and views with serious concern the increasing difficulty with which the newly qualified chemists are absorbed into industry and their insecurity of tenure. Such conditions he regards as dangerous to the scientific

position of Germany, which cannot be maintained if students of ability are no longer freely attracted by scientific studies and careers.

The opinion has been expressed that the world is suffering from over-production of chemists and of research, in common with over-production of all kinds. This view is probably encouraged by the common impression that there are now no striking advances to be made in the field of organic chemistry, pure or applied. Its main principles have in general been discovered, and the research chemist, whether in industry or in scientific laboratories, is now occupied with the intensive study of relatively small parts of the field.

While the apparent orderliness of the immense edifice developed from Kekulé's theory undoubtedly strengthens the impression that chemistry is a static science, such a view is fundamentally false. If propounded twenty or thirty years ago, since when the main structure of theoretical organic chemistry has remained essentially unchanged, this view would have been confounded by subsequent discoveries and advances in almost every branch of organic chemistry. Well within these three decades we have seen the development of the rayon industry, the synthetic resins industry, the cellulose lacquer industry, oil-cracking, and low temperature carbonisation. Immense developments have been recorded in the production of insecticides and synthetic drugs and in the vulcanisation of rubber. The technical production of indigo essentially dates from the Deutschen Gold- und Silberscheideanstalt or Roessler sodamide fusion patent of 1901, the Sandmeyer process from thiocarbanilide being still more recent. Moreover, within this period there is scarcely one of the older fields which can be described as exhausted or failing to produce fresh wealth. The oldest section of the dyestuffs field, the triphenylmethane or aniline colours, formerly regarded as comparatively fugitive, was found in 1915 to be capable of yielding with phosphotungstic acid a series of lake or pigment colours of surpassing light fastness, whilst the azo section is still providing new dyestuffs to overcome the dyeing difficulties presented by the new rayon fibres.

Although many of the branches of organic chemical industry have sprung from the discoveries, often fortuitous, made in scientific laboratories—as, for example, Perkin's mauve, Griess's azo dyes, Baeyer's phthaleins and synthetic indigo, Knorr's antipyrine, Ehrlich's salvarsan, the nitrocellulose silk of Count Chardonnet, the viscose of Cross—the significance of such discoveries was frequently unrealised at the time either by scientific workers or industry. This alone should make us cautious in advocating any restriction of research. There are too many problems in our national and industrial life urgently demanding scientific solutions for such a policy to be either timely or wise. It is almost impossible to predict just where the next important advance will be made, or, in reviewing the results of a year's investigations, to single out the one discovery by which posterity will mark the year.

The influence of industry on scientific research is, however, fully as important as that of scientific research on industry. Even in the field of technique it is impossible to assess the contributions of either on a cash basis. The greater resources of the industrial research laboratory and its improved and frequently more advanced technique are continually reacting on scientific laboratories. The range of reaction conditions open to the organic chemist has enormously expanded in the last decade, and processes can now be effected in extremely high vacuum or under pressures of several thousand atmospheres and at temperatures ranging from the neighbourhood of absolute zero to those of the electric furnace; whilst the activators or catalysts available range from the new organic catalysts, bordering on biochemistry, over almost the whole field of inorganic chemistry.

Nor is it only refinements of technique that are continually changing the conditions of scientific and industrial research. Almost every year sees fresh compounds, formerly curiosities and accessible only by tedious and costly laboratory processes, produced on the commercial scale at a price which allows their use in industry or in scientific laboratories as the raw material of further researches. The papers published in the journal of any chemical society reveal the way in which the scope of scientific research has been enlarged and influenced by industrial advances. The utilisation of waste materials, the delicate balance between by-product and main-product, the fall or rise in price of basic materials like sulphuric acid, methyl alcohol, glycerol, which alone may result in new routes for existing products—the war-time shortage of sulphuric acid, for example, led to the development of alternative processes for phenols and amines which have not been entirely replaced by the earlier methods—these are factors which continually emphasise the dynamic character of industrial research and frequently have far-reaching effects on scientific research.

If, however, the increasing complexity of the field of organic chemistry makes restriction of re-

search inconceivable, the demands made on leadership are increasingly severe. It was never easier than to-day for research ability to be wasted in an attack on unprofitable problems. Scientific progress has almost invariably come from the ideas and work of a talented few, and depends as much upon the quality and personality of the investigator as upon his technique. The most serious problem is the production of research leaders of the requisite imagination, foresight, and enthusiasm to direct wisely the team work which modern industrial research demands. Any circumstance, whether of rates of pay, status, or insecurity of tenure, which hinders the recruitment for industrial research of potential leaders of the requisite calibre is a national and not merely an industrial danger. There is little doubt that if the concentration of professional opportunities within at most one or two firms, as in Germany, does affect adversely the position and prospects of chemists, industry will quickly suffer from the reaction.

The distinction between scientific and industrial research to-day is not easy to define. Their relationship is dynamic and so intimate that circumstances which injure or cramp one react likewise on the other: neither can advance while the other is starved, and on this fact Prof. Willstätter based his plea for more generous assistance for the German universities from chemical industry. Such assistance is now being given more freely in Great Britain, and the closer relationship between the universities and industry are undoubtedly to their common advantage.

It is easy, however, to overstress from either side the economic aspects of the relation between industry and scientific research. If there are ways in which scientific research cannot compete with industry, there are still inestimable services which scientific research can render to the nation as well as to industry. Scientific research, in its freedom from the economic motive, can do much to counteract that tendency in industry for the good to be the enemy of the best, and to secure our advance to the best of all possible solutions. Scientific research, in the widening fields opened to it by industrial developments, can use its resources to explore the byways, the economically unattractive fields from which will come in the future, as they have so often in the past, the fundamental and epoch-making discoveries. On such workers, too, in their quest of truth for truth's sake, must ever fall the responsibility of kindling and rekindling that enthusiasm and devotion to which alone Nature yields her most precious secrets.

Faraday's Worth in Wisdom.

A Tribute to Michael Faraday. By Rollo Appleyard. Pp. xiii + 204 + 21 plates. (London: Constable and Co, Ltd., 1931.) 7*s.* 6*d.* net.

"A magnet hung in a hardware shop,
. . . . .
(said it) If I can wheedle
A knife or a needle,
Why not a Silver Churn?"

HOW this was to be done was shown at the Royal Institution, ages before Gilbert stated the fable of the magnet and the silver churn and knowing no physics gave it the wrong 'moral'.

The industrial value of Faraday's discoveries has long been patent, throughout the civilised world: little heed has yet been given to the example he set and to the spiritual doctrine he professed. Perhaps, in near days to come, hastening as we now are the exhaustion of natural resources, through disproportionate use of machinery and greed of gold, his spiritual legacy may be of more value to us in overcoming and directing the crude, untamed human nature within us, which our modern advance in knowledge serves but to cover with a thin veneer. In celebrating in September, this year, the centenary of his greatest discovery, we shall do well to consider his moral worth and teaching at least as fully as his contributions to knowledge. Something we must do to save the world from government by *Alfalfa Bills* and Oklahoma waste of oil (*Times*, Feb. 17, 18).

The appearance of Mr. Appleyard's book is opportune. He has not only sought out particulars of Faraday's forebears in their north country homes and of Faraday's father at his Newington, South London, forge but has also delved into Royal Institution archives and elsewhere: thus garnering not a few items of interest which are welcome additions to the story of the immortal scientific magician. He also has an interesting chapter touching on Clerk Maxwell's work in connexion with Faraday, as the mathematical exponent of its meaning. The book is one to ponder well. Various arresting moments in the philosopher's life are dealt with in a way that will appeal to all who can appreciate the charm of Mr. Appleyard's style and his sympathetic attitude towards his subject. We can picture him, upon an Athenæum sofa, browsing in search of inspiration. We can ourselves browse with delight upon the lawn which he has consequently laid out for us: as sward it would scarcely appeal to the Sutton firm; the herbage is more that of a Swiss upland pasture, in which gentian blue is mixed with anemone