Co-operation in Science and Industry.¹

By Prof. J. F. THORPE, C.B.E., F.R.S.

THE past ten years have witnessed a wonderful development of organised industry and organised science in Great Britain, and although conditions are still rapidly changing it is nevertheless possible to look forward and in some measure to determine the position in which we stand and the prospects for the future. The War, although one of the greatest economic disasters the world has yet experienced, gave without question a stimulus to discovery and production which no other event could have occasioned. Especially was this the case in the engineering and chemical industries, for the need of new appliances and methods, and the necessity for producing in large quantities and in the shortest possible time, caused the keenest intellects to be brought to bear on the problems at hand, and led to the discovery of new and important processes many of which have now been introduced into industry.

It is a principle conceded now even by the enlightened leaders of labour that the universal demand for a higher standard of living necessitates a general increase in the national productive capacity, the term 'productive capacity' being used to mean the capacity to render available the potential wealth of the nation in a suitable form. It is chiefly to the chemical and allied industries, mining, metallurgy, etc., that Great Britain turns, because it is their peculiar function, aided by the engineer, to make available its mineral, vegetable, animal, and atmospheric wealth. Provided chemical and allied industries are properly organised, they should be in a particularly strong position not only to increase the availability of wealth, but also to guide national policy in questions strongly affecting material prosperity. The age is at hand, if it is not already here, in which the changing majorities of governments will no longer be able to determine major policies as of war, financial and fiscal, except in directions approved by organised industry. Control by those who hold the keys of national prosperity, that is, of organised industry, is one of the alternatives to class control and is not only a desirable but also an eminently practicable ideal. To achieve it science and industry must organise so that they may become strong politically and financially.

Four kinds of co-operation are essential to strength: (1) internal co-operation, (2) co-operation with pure science, (3) co-operation with Government, (4) co-operation with labour. The last, that is co-operation with labour, is a human question rather than one of science or of policy dependent on science and need not be further discussed, especially since enlightened opinion on the part of employers now realises that labour relations are as vital to prosperity as any other factor.

¹ From the presidential address delivered at the annual general meeting of the Chemical Society on Mar. 21.

INTERNAL CO-OPERATION.

Apart from more purely chemical or scientific factors, there are two immediate advantages to be gained by the formation of big combines, in the pooling of capital and the pooling of engineering resources; the establishment of a balance in commodities produced and in the method used for their production being determined mainly by chemical and engineering conditions.

The standardisation of methods and the co-ordination of interests as regards production and distribution, the question of price and the prevention of over-production are problems which mainly concern the business organisation of industry, and do not directly affect the relations between industry and science. Yet their importance is manifest, and in some instances, especially in connexion with the standardisation of methods, the help of the chemist is essential. The need for obtaining a balance in all these factors, a consummation which can only be reached by a pooling of like interests, is obvious.

Probably the best example of the common use of a chemical substance by a number of different manufacturers is that of hydrogen, which is at the present time used in vast quantities for the production of (a) methyl alcohol, (b) liquid fuels from coal, (c) ammonia, to mention three of its most recent applications. In pre-War days it was used in large quantities, and still is so used, for the hardening of fat. Nevertheless, the three industrial operations mentioned also represent in a remarkable degree examples of progress and development that have taken place within the last ten years.

At the present time we know nothing of the reasons which determine the action of a catalyst, and although we have to hand a vast number of reactions which may be regarded as reasonable and likely to occur should the right conditions be discovered, the search for a catalyst is always attended with difficulty and often ends in disappointment. Prior to the original German patent for the production of methyl alcohol from carbon monoxide and hydrogen, many attempts had been made to realise this very simple reaction even on the laboratory scale.

Other reactions readily suggest themselves, such as, for example, the formation of acetic acid from methane and carbon dioxide. As a matter of fact, this, and other reactions of a similar type, forms the subject of patent specifications, but whether they have been actually realised experimentally must remain an open question in the absence of definite evidence. Our patent system unfortunately lends itself admirably to the production of 'blocking' patents, and there is no subject so suitable as organic chemistry as a medium for such patents.

CO-OPERATION WITH PURE SCIENCE.

Training.—Chemical trade is at present in the midst of the most rapid expansion it has ever known and nowhere is the development more noticeable than on the research side. This is as it should be, for the researchers are the scouts and it is essential that they should be far ahead of the army (the working process). It is necessary also that the scouts should operate on a broad front in order that no channel of advance should be overlooked merely because it does not lie in the expected direction. The realisation of this principle by the greater manufacturers has led to a strong demand for university-trained men, and the number of research chemists in industry in Great Britain has been estimated at twenty times the number before the War; the demand is still increasing. The universities have had and are having difficulty in supplying this larger number of adequately trained men, for they have to fulfil the majority if not all the demands made by chemical industry. Manufacturers have come to realise that training should be essentially fundamental and that a wide knowledge of the principles of chemical science is a necessity. The vexed question in what manner is this to be attained is being answered by the gradual adoption of at least a four years' course, although the still more important one—that of the post-graduate course—is not yet settled.

A long experience of university teaching has shown me that it is exceedingly difficult to determine whether any particular individual is more fitted to succeed as a process chemist or whether he has that peculiar aptitude which will enable him to carry out effective work in the research laboratory. Unfortunately, the positions are not interchangeable. A student who has shown aptitude for research may, if occasion demands, make an excellent process chemist; indeed it often happens that he will have to elaborate a laboratory method so as to place it, with the help of the engineer, on the unit factory scale. But it is very doubtful if the individual who has shown that he possesses no aptitude for research can be usefully employed in that connexion excepting under control. The only manner in which the presence of the research aptitude can be discovered is by direct trial, and therefore it is always desirable to subject a student to one year's training in research after graduation in order to discover if he possesses this characteristic.

The term 'research training' must be interpreted in its widest sense to include training in special branches of chemistry related to the industries as well as more general training in the higher branches of chemical technology.

Industrial Research in Universities.—At no far distant period in the past the great potentiality for research residing in our university laboratories, and in the personnel controlling them, was not available for industrial purposes. The reasons for this were many. For example, industrial research was not regarded as of sufficiently 'pure' character to allow of its inclusion in the academic curriculum.

There was considered to be something essentially different between 'applied' and 'pure' chemistry, and this was emphasised in the 'eighties by the formation of the Society of Chemical Industry as a distinct body from the Chemical Society. The Americans knew better than this. They have kept their chemists together as a homogeneous body, and the American Chemical Society with its membership of 17,000 represents in no uncertain manner the considered opinion of the whole body of chemists of that country.

The fault lay mainly with the universities of Great Britain, which were loath to introduce science other than 'pure' into their courses of instruction. Hence there arose the multitude of technical schools which were originally intended to supply the need for a vocational training without undue reference to the science upon which the training was based. The establishment of new universities in industrial centres, a period of reform ushered in by the breaking up of the old Federated Victoria University, soon produced a marked change, and research and instruction in the fundamental principles underlying industrial science gradually passed into the hands most competent to deal with them.

Industrial research both of the fundamental kind as well as that which arises as the daily outcome of works practice should be and now is carried out for the most part by the firms themselves in their works laboratories. But there are a number of problems, mainly of a 'long-sighted' character, which are intimately related to industry. The personnel on the scientific staffs of the universities of Great Britain are people who have throughout their lives specialised in some particular branch of research, and are therefore eminently fitted to solve problems in their special field. This is now recognised by many leading firms who supply grants to enable post-graduate research workers to investigate specific problems under the guidance of professors of chemistry and other directors of research laboratories, and in this connexion must be mentioned the far-sighted policy of Imperial Chemical Industries, Ltd., which gives yearly substantial grants to research laboratories in order to enable them to obtain special types of apparatus and appliances which it would otherwise be difficult to procure.

Great advances in the development of scientific industry have been made in Great Britain since the War, and every effort must be made to maintain and strengthen the causes which have led to this condition. From the point of view of national prosperity it is essential that active research centres should be maintained and still further developed in our universities, not only to supply the scientific ability to foster and improve the industries of our own generation, but also to pave the way by discoveries in science for future commercial prosperity.

Team Work.—During the War very valuable work was accomplished by means of team work, by which is meant the solution of some problem by the united efforts of a team of workers under a directing head. There can be no question that this

method of attack is usually most effective, especially in a works laboratory where some specific problem may require rapid solution. Its application to the university laboratory is subject to the difficulty that under team conditions the intellectual stimulus which attaches to the individual attack on specific problems is sometimes lacking, and it is in the highest degree desirable that this stimulus should be developed and maintained. Nevertheless, it is always possible so to divide a major problem as to make each section in itself a self-contained research and thus to give each investigator what is essentially a definite subject on which he can work in his own way and according to his own mentality.

CO-OPERATION WITH GOVERNMENT.

The Government of Great Britain has already discovered the two most valuable ways in which it can co-operate to the benefit of present and future chemical industry, namely, (a) by protecting young and struggling industries against competition from similar but established industries abroad and against competition arising from deflated foreign currency, and (b) by promoting research in pure and applied chemistry by financial assistance. Another way in which it has helped the application of science is by the provision of a free chemical advisory service in the interests of agriculture.

Research Associations.—There can be no question that the value of co-operative research in industry has been established. The Department of Scientific and Industrial Research has, therefore, rendered a valuable service to the industrial community and its initial policy has been fully justified. Nevertheless, the time has arrived when the varying appeal which the necessity for scientific investigation makes to different industries has made itself manifest, and the Department feels that any

further support on general lines would no longer be justified. It proposes, therefore, to treat each case on its merits.

Research Studentships and Fellowships.—The call for adequately trained research workers in science, and especially in chemistry, is increasing. It is therefore very disquieting to realise that the policy of the Department in connexion with the provision of maintenance grants for students in training appears to be changing. The outlook is serious, because it is quite impossible for the universities to provide funds for post-graduate training in any way commensurate with the present-day requirements of industry, and as the average science student is usually drawn from a comparatively poor class, it is not likely that the necessary money for an extended course will always be obtainable from parental sources.

Every director of a research school has had to tell some promising student who wishes to undergo post-graduate training and is, without question, likely to profit by such training, that no funds are available to enable him to extend his course and that he must, therefore, seek any minor post that may be open to him. The loss of such a man is a national loss, because his training is broken off at the stage where even one extra year would have enabled him to become a useful member of a research organisation, whereas, in the circumstances, he has to take up some position, probably one involving merely routine work, where the value of his early training will be lost and his initiative and enthusiasm destroyed. It is therefore to be hoped that the diminution in the number of research grants is merely a temporary expedient and that it does not indicate a reversal of a policy which has proved so fruitful during the past twelve years and has shown itself to be an essential part of research development in Great Britain.

The Functions of the Human Skull.¹

By WILFRED TROTTER.

THE development of science involves the two processes of collecting facts and of elucidating their relations. In the early days common experience so abounded with unrelated facts that an alert and contemplative mind was an adequate equipment for the man of science and could readily find material for generalisation. Knowledge was like an unexploited gold-field, in which the mere attentive wanderer might pick up nuggets of the metal. So were made the earliest discoveries in mathematics, astronomy, and physics. When the surface of the field no longer yielded such finds, the digger with his simple and homely outfit could still from easily accessible deposits gather with his own hand gold dust by the ounce and pound. This was the Golden Age of science; it lasted somewhere about two hundred years, and was nobly marked near its beginning by the "Principia" and near its end by

the "Origin of Species." It was the day of the individual digger, of simple apparatus and the still obvious predominance of the worker's mental quality over every accessory circumstance. It was a time in which relatively simple efforts in the collection of facts might have great results. Looking back at it we discern as a characteristic object Wollaston with his laboratory on a tea-tray, and as a characteristic incident Hans Christian Oersted noticing in 1819 the deflection of the magnetic needle by an electric current—an experiment it would not be very extravagant to call the most important event of the nineteenth century; or as not less characteristic Joseph Fraunhofer in 1814 observing and thinking it worth while to map out the dark lines in the solar spectrum—a dull-looking task that was, however, ultimately to yield a veritable measuring rod for the universe and a most effective probe of even its stupendous depths.

At the present day what we may call the surface

¹ Lecture delivered before the Anthropological Society of University College, London, on Jan. 25.