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Team Work.

We welcome the appearance of another report of the Committee of the Privy Council for Scientific and Industrial Research, that for the year 1926–27, which will doubtless be received as an encouraging document in progressive political circles. For one thing, it represents the credit side of a balance sheet on the debit side of which there stands an item of some £450,000 of public money. In these days of necessary economy—and of even more necessary judgment in its incidence—a recital of the kind of goods that an outlay of half a million pounds will buy in the scientific market is an education by itself. For another, it gives some indication of the dimensions of the quarry in view. The Department performs the dual function of taking a part in assuring a supply of trained and experienced research workers, capable of applying themselves in their respective spheres to the solution of problems confronting British industry, and of instituting and co-ordinating the researches themselves for the benefit of the community.

It is, of course, unfashionable, almost indecent, to scoff at research in this twentieth century; the devotion and skill of the pioneers may have been taken for granted, but there have at least been enough of the more spectacular kind of successes in one branch or another not only to attract the popular attention, but also to awake a genuine concern for the vigorous prosecution of scientific researches with a view either to the amelioration of the conditions of life or to ultimate commercialisation. What is not so fully realised is the enormous amount of untiring, expensive, fundamental team work which must precede the successful completion or application of a discovery; the amount of minute and often apparently inconsequent detail which must be accumulated in order to fashion a single signpost of progress. The ten per cent. of inspiration in genius is readily acclaimed, but the ninety per cent. of perspiration is little appreciated, because undisclosed in the ordinary non-technical report. The labours of the less prominent members of the research community, moreover, although normally receiving due recognition at the hands of those who afterwards make use of them, are often more in the nature of fuel for the furnace than the heat itself.

Our contention, however, is not that the prizes are unequal, or even that the opportunities are equal, but merely that every honest contribution to the advance of our knowledge, provided it is accurately reported and adequately indexed, possesses a potential relative value which may far exceed its actual intrinsic value. In particular, the major problems of national concern lend themselves to organised team-work, and the Department of Scientific and Industrial Research, together with the laboratories and associations working under its ægis on co-operative lines, are effectively and unobtrusively 'delivering the goods.' The backing of the State puts selected investigators in the position of being able to spend both energy and money on an exploration of the foundations of industry to an extent which would be impossible were the rise of a superstructure the immediate and sole concern. Thus there is a solidity, as well as a catholicity, about the work done under such auspices.

Another important aspect of the Department's activities is the part which it takes, in conjunction with the universities, in making it possible for specially promising students to devote themselves to the preparation for and the practice of a career of research. It is recognised that such support is a means—possibly only a temporary means—and not an end ; it is not of the nature and quality of a prize, but rather of an insurance. As we consider that, despite the enormous advances of the past decade, Great Britain has scarcely left the threshold of the scientific development of industry, we realise how necessary a policy this is. The premium costs but five per cent. of the expenditure.

Much thought has been devoted to the question of the propriety of giving or continuing maintenance grants to students. It is satisfactory to find that inquiry shows the number of cases in which the award proves unjustified to be negligible ; it is equally satisfactory to find that, even in the chemical profession, where there is a superfluity of aspirants, 66 per cent. of the former recipients are now employed in research in industry, in Government laboratories, or in the universities. It seems clear that the policy of the Department in this respect, although it may require some modification from time to time to meet the changing aspect of industrial and scientific affairs, has proved both economic and fruitful ; it is evident that some such opportunity for training in the application of academic knowledge and of academic methods in the industrial arena, whether it be carried out under public or private direction, is an essential link in the chain.

Probably the weakest link is here, in the use which we make of scientific knowledge, scientific potentialities, and particularly of scientific method. We hear much of the lack of appreciation of industrial conditions evidenced by young university graduates, of their unpractical equipment and the like, but too little of the new directions in which the methodical, critical, analytical, and finally synthetic processes of thought and of action in which they have been trained can be brought to bear on the difficulties and the opportunities of the work-a-day world. This application is by no means an automatic process, and the Advisory Council emphasises its significance. Britain, it declares, is not behind others in purely scientific work ; what she lacks is the application of scientific discoveries, and above all of scientific method, to industry. It is to such organisations as the research associations that we look specially to hold fast to both partners, and to make their co-operation both possible and profitable. "New industries," says the Report, "may spring up from individual discoveries and by individual effort, but as a new industry grows or merges into a staple industry it will depend more and more on co-operative effort for its health and progress. In this co-operative effort, which is needed to preserve and develop our great industries, the scientific man must take his share ; he must be concerned with the necessity for improvement in detail no less than with more spectacular endeavours to strike out into new paths."

These considerations bring us fairly and squarely in view of the main business of the Department, namely, to accumulate, either by assembly or direct inquiry, scientific results of a character suitable for immediate application in support of industry, and to lay sure foundations for its further development. No one who knows anything about the subject nowadays disputes the contention that organised research is, broadly speaking, a paying proposition, although there may be a considerable lag between the expenditure and its profitable return. Individual researches may, and often do, lead to no practical advantage, whereas others realise a handsome profit out of all proportion to the cost ; in consequence, only the larger industrial concerns can support capital charges adequate to ensure a profitable proportion of commercially successful results of major dimensions, whilst the smallest firms can share in the rewards of such investigation by supporting the work on a co-operative basis. There are twenty-four such associations, and the majority are in receipt of financial assistance from the Department. It is surprising, however, to find that the Research Association of British Motor and Allied Manufacturers receives so little support from the now prosperous industry — substantially less than an amount represented by sixpence per motor vehicle produced annually by the industry—as to render it ineligible for a grant from public moneys. We cannot claim to know all that is necessary for maintaining a world-wide supremacy in this direction, so that it would appear that we are more afraid of our competitors at home than abroad. If this is in fact the case, or if the attitude of the industry is determined by some other reason, our hopes for the future must rest entirely on the experimental work which individual firms are able to carry out. This work, of course, is a very long way from being inconsiderable.

The existence of a National Research Council in Canada, a Commonwealth Council for Scientific and Industrial Research in Australia, a Department of Scientific and Industrial Research in New Zealand, and technical boards in South Africa and India, is one of the most encouraging premonitions of a reawakening Empire prosperity. Team work on a national scale can scarcely fail to be as productive of results as team work on an individual basis. The Empire Marketing Board rightly advises us to spend our money in such a way as to keep as much as possible " in the family " ; the duty is also laid upon us as members of that family to advise one another concerning the use of our diverse opportunities in the common weal, and to explore our heritage in concert with a view to the efficient exploitation of the family estates. In such a case not only wealth, but also better health and greater happiness are unlikely to be denied us.

The Electronic Theory of Valency.

The Electronic Theory of Valency. By Dr. Nevil Vincent Sidgwick. Pp. xii + 310. (Oxford: Clarendon Press; London: Oxford University Press, 1927.) 15*s.* net.

WHEN the electronic structure of matter had been demonstrated, and the electrons in the atom had been not only counted but also classified by means of spectroscopic data, it was inevitable that attempts should be made to correlate the new data in reference to atomic structure with the commonplace facts of chemistry. In the case of metallic salts, which have been shown by X-ray analysis to be ionised completely even in the solid state, the application of physical data has been comparatively easy, since the attractive forces in an aggregate of ions can be calculated, and the principal unknown quantity is the compressibility or deformability of the ion. This can be expressed as a repulsion varying inversely as the nth power of the distance, the value of n being about 9 for crystals of the sodium chloride type, in which each ion is surrounded by *six* atoms of opposite sign; in crystals of the cæsium chloride type, however, where the envelope includes *eight* ions of opposite sign, the value of n is greater, whilst the *four* ion envelopes of the zinc sulphide type require a smaller index. These simple considerations are complicated by the mutual polarisation of the ions, which introduces another independent constant in the calculations; but, by assigning an arbitrary value to this constant, it has been possible in a considerable number of cases to calculate, by means of data derived from independent sources, the physico-chemical properties (*e.g.* the heat of sublimation, and the molecular volume) of crystalline compounds of this type.

On the other hand, when atoms are united into molecules by means of ' bonds,' the problem at once passes beyond the present scope of physical calculations, since the nature of these bonds cannot yet be defined in terms of known physical quantities. An interesting situation has thus been created. On one hand, physicists have yielded only too readily to the temptation to ignore these inconvenient linkages, and have assigned ionic structures to compounds in which the chemical evidence points clearly to the existence of molecules, held together by real bonds. Thus, since water at 25° contains only one ion-pair for each 500,000,000 molecules (and this proportion decreases as the temperature falls), chemists will view with profound scepticism the suggestion that ice is ionised to the extent of 100 per cent. and contains no molecules at all; and they may even regard this suggestion as a *reductio ad absurdum* of the physical method of attacking chemical problems. On the other hand, when once the electrical structure of the *atom* has been accepted, chemists cannot avoid making mental pictures of the electrical structure of *molecules*; and these pictures have a definite value even when they cannot be reduced to precise physical forms.

Thus, although the idea of ' shared electrons ' as an explanation of the chemical bond was introduced by Sir J. J. Thomson before the nucleus atom was invented, we are indebted to Prof. G. N. Lewis for exploiting the general proposition that it takes two of these shared electrons to make a bond; and this general proposition is now so firmly established that physicists may look upon it as a chemical fact for which a physical explanation must ultimately be devised, although at present we do not know in what way a pair of electrons can come