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Creative Science and Industry.

WHILE it would be difficult to find a more brilliant example of the value of creative science to industry than the experimental investigations of Michael Faraday, there is a tendency to regard such contributions of science as exceptional. Even on this point it is pertinent to recall the verdict of Huxley in 1877 in urging the value of technical education: "If the nation could purchase a potential Watt, or Davy, or Faraday at the cost of a hundred thousand pounds down, he would be dirt-cheap at the money. . . . What these men did has produced untold millions of wealth in the narrowest economical sense of the word." In scientific research, quality counts supremely, but industry owes an incalculable debt to innumerable investigators engaged in scientific research directed by no other motive than the pursuit of knowledge.

At the moment, our interest is centred chiefly on the discovery of electromagnetic induction by Faraday and its consequences—electrical industry and its ramifications of the present day. The dyestuffs industry is, of course, the classical example of the relation of scientific research to industry, and it is worth recalling that this industry owes much to Faraday's discovery of benzene. Chemical industry abounds in similar examples. The manufacture of synthetic drugs may be traced back to such purely scientific work as Kolbe's synthesis of salicylic acid, and its expansion has invariably been connected with external scientific work like Knorr's discovery of antipyrine, Ehrlich's salvarsan, Fourneau's 309, Kraut's aspirin, Molle and Kleist's veronal, the isolation and synthesis of adrenaline, Banting and Best's isolation of insulin, Kendall's preparation of thryoxin and its brilliant synthesis by Harington. Pasteur's scientific investigations on yeast prompted by a brewing difficulty led him to the discovery of the whole theory of fermentation, the existence and action of bacteria, thence to the pasteurisation process, and finally to the discovery of the antitoxin of hydrophobia. These discoveries have not merely transformed the brewing, yeast, dairy, and cheese industries, but have also led to the rise of important new branches in the production of solvents such as acetone and butyl alcohol by fermentation. It would be difficult to measure the debt of either the fermentation industries or, indeed, of humanity to the scientific work of Pasteur, whose chance discoveries were so momentous because he was prepared.

When we turn, however, to such men as Ludwig Mond and Sir William Siemens, whose names are pre-eminently associated with industry, we find once more that the technical processes associated with them equally had their origins in scientific research. Long and patient investigations led to the discovery of nickel carbonyl, and the Siemens process was similarly the outcome of the scientific study of heat economy. The remarkable progress during the last two decades in the metallurgical industries is also based on purely scientific investigations—metals such as tungsten, molybdenum, vanadium being little more than curiosities for years after they were discovered.

Even in our older industries, scientific research has been responsible for revolutionary changes and developments. The art of soap-making has been transformed into a science. Sabatier's observation of the hydrogenating properties of finely divided nickel is the germ from which has developed the industrial hydrogenation or hardening of oils and fats and innumerable processes in almost every section of organic chemistry, including the Berginisation process for obtaining liquid fuels from coal. Scientific investigations on nitrocellulose and cellulose acetate and their solvents have led to the discovery of lacquers which have not only revolutionised the paint and varnish industry but have also made possible the enormous expansion of the automobile industry. The leather-substitute used extensively in upholstering motor cars has itself been produced by industry as an outcome of the scientific investigation of nitrated cellulose. Equally important is the development of the whole rayon industry from scientific investigations and observations in the same field of cellulose—Chardonnet's discovery of nitrocellulose silk and Cross and Bevan's viscose. The technical possibilities of any one of these discoveries were scarcely dreamed of by industry when the first investigation was commenced. Finally, the great fertiliser industry, including the fixation of atmospheric nitrogen, is essentially based on Liebig's discovery of the superphosphate process and Lawes and Gilbert's patient investigations on the effect of fertilisers on plant growth, and from Sir William Abney's measurements of the absorption of light by silver halide emulsions have came the advances of modern photography leading ultimately to the cinematograph industry.

We might continue the story by referring to other industries, and particularly to the electrical industries, which have been developed from Faraday's discoveries in electricity and magnetism and from Maxwell's and Hertz's investigations on electromagnetic waves, but limitations of space forbid. We have only discussed one aspect, however, of the contribution of science to industry. Equally important is the contribution which science makes in technique—the provision of new technical methods. The importance of this aspect of the service of science to industry was enforced on British industry in the early days of the War, when our dependence on continental firms for all classes of scientific instruments and glassware imposed a considerable handicap on the expansion of the munitions and other industries to meet the war-time demand. Without the instruments of precision for measurement and control of temperature, pressure, refractivity, and other properties, which have been evolved by purely scientific work, industrial development would have been much more laborious. Essentially modern advances in the measurement of high temperatures paved the way for the developments in the metallurgical industries. The development of the newer industries such as the radio industry, the manufacture of synthetic resins and rayon, is indeed a record of advance closely related to the utilisation not merely of scientific discoveries but also of scientific methods and scientific instruments for purposes of control.

The significance of such methods of X-ray analysis, ultra-violet light, hydrogen ion determination, thermionic valves for control purposes, including automatic control, in industry is only now being appreciated. In high-pressure reactions as well as low-pressure reactions and distillation in very high vacuum, science has provided industry with a whole range of new technique. Scientific work on the two forms of hydrogen has recently simplified the evaluation of industrial catalysts, while almost simultaneously the discovery of the selective properties of a copper chromite catalyst has enormously increased the possibilities of development in the industrial hydrogenation processes.

X-ray methods themselves provide a striking example of the reaction on industry of scientific technique. The recent application of X-ray methods to textile research has led to discoveries relating to the structure of cellulose, wool, and hair which throw new light on just those typical properties of wool which are of fundamental importance in manufacturing operations. As a result, a correct interpretation of the conditioning, dyeing, and other absorptive processes has been facilitated and a method elaborated for measuring the surface scale structure of the wool fibre which represents the first step towards placing the important technical operations of milling on a scientific foundation. In addition, the discoveries *suggest* an interpretation of the structure of cellulose which has a direct bearing on the mercerisation process.

While science has thus provided industry with instruments of precision and methods of attack on technical problems, an important contribution has also been made in the field of industrial health and safety. Until science had revealed the cause of yellow fever and the methods of its prevention and control, the resources of the engineer were inadequate to construct the Panama canal. Merely to walk through a modern dry battery or accumulator factory is to realise how medical science, by examining the causes of industrial poisoning, dusts, and their prevention, has revolutionised conditions of work. Hundreds of industrial processes operate smoothly every day because the scientific study of the properties of materials has enabled working conditions to be devised which satisfy stringent requirements of safety and efficiency.

In the past hundred years, industry has come to adopt not only the results of scientific discoveries but also scientific methods both for the development of new processes and for the control and improvement of existing processes or products. Individually or collectively, progressive industrial firms are now invariably associated with research departments or institutions in which the investigation of technical problems is systematically undertaken. Such technical research work will, however, usually be restricted either in the subject or the object of the work, and occasionally in both, leaving the investigator only freedom to select his methods. Without detracting from the merits of such work, which frequently compares in brilliancy with the ablest research conducted at the universities, the importance of fundamental scientific investigation, with its full freedom of aim, method, and materials, must not be overlooked. Great as has been the service of science to industry in improving or elaborating technique, it is from the fundamental discoveries of creative science that industry has derived its greatest benefits. While recent *rapprochements* between the universities and chemical industry indicate that this is fully realised, at any rate by chemical industry, economic reasons limit the possibilities of fundamental research being organised in industry. Authorities like Sir Harry McGowan and Dr. Levinstein have recently stressed the relations between industrial research and profits which influence the research policy of any sound industrial organisation, and Major F. A. Freeth has pointed out that the drift of modern life is against discovery. The vertical organisation of industry and of science restricts the exchange of technique, upon which probably the technique of discovery largely depends.

We are, however, as far to-day from a technique of discovery as when Francis Bacon wrote his "Novum Organum". A century of industrial progress testifies to the interdependence of science and industry. The great names on science's roll of honour are again and again to be found on the roll of the greatest benefactors of industry and of humanity. There is no truer touchstone of the sincerity of the tributes paid by industry and the State to the memory of Michael Faraday than the volume of support accorded to scientific research in Great Britain and elsewhere, and although we live in times of unprecedented depression, we must maintain the facilities, the institutions, and the technical and monetary equipment which will make it possible for others, though like Faraday of humble birth, to devote their splendid gifts unhindered to the service of mankind. The dynamo, broadcasting, the aeroplane, the cinematograph were not further beyond the imagination of Faraday's listeners in the Royal Institution than future developments from our own, if creative science continues to exert its fertilising influence on industry and the ties between discovery and service are knitted closer through the whole fabric of modern life.

Nansen's Last Journey.

Through the Caucasus to the Volga. By Fridtjof Nansen. Translated by G. C. Wheeler. Pp. 255+23 plates. (London: George Allen and Unwin, Ltd., 1931.) 12*s.* 6*d.* net.

IN 1925 Nansen visited Armenia on behalf of the League of Nations as one of a commission of five appointed to investigate the possibility of settling refugees from Turkish Armenia on the land. An earlier book, "Armenia and the Near East", was a record of the mission up to the end of its labours in Erivan. Nansen now reopens the story in the train as he leaves Armenia on July 2, 1925; but he does not get into the swing of his narrative until he reaches Tiflis. Here he opened negotiations with the Transcaucasian Federation of the three republics, Armenia, Georgia, and Azerbaidjan, with the view of raising a loan in order to carry out the proposals of the Commission—a project which, he tells us, later failed to mature.

Nansen made a short stay in Tiflis, of which he gives a brief description. He speaks of the manifold different races to be seen in its streets and of