Fuel Research

THE report of the Fuel Research Board* for the year ending March 31, 1935, differs from its predecessors in the emphasis given to problems arising from the preparation of coal for sale. This follows naturally on the changes taking place at British collieries, where increasing proportions of coal are obtained by mechanical methods, and are also subjected to various cleaning processes. Again, consumers become more reluctant to pay a premium for size. Apart from the open fire, there are few uses for large lump coal. It is the modern tendency to employ automatic mechanical methods of firing boilers, furnaces and producers, and for such uses coal must be small in size and uniformly graded. Formerly, small coal was often deliberately rejected by the use of forks for loading underground. To-day collieries are increasingly finding it necessary to break lump coal to supply the demand for small fuel, and this has brought into prominence many chemical and physical problems previously unknown. The best methods of breaking to preserve sizes and avoid the production of dust have been investigated. Coals broken and graded suitably at the colliery were found to suffer little further degradation in normal transport to the consumer.

The development of schemes for coal marketing has disclosed the need and opportunity to reduce the number of sizes of marketable coal. The Board is collaborating with the Midland Institute of Mining Engineers and the South and West Yorkshire Coal Owners in an attempt to do this. It was found, in this area, that no less than 106 different size grades of coal below 3 in. size were being marketed; and yet seventy per cent of the coal fell within 15 size grades. With slight adjustment of the size mesh, these 15 grades would cover ninety-five per cent of the tonnage. It is difficult to see any technical reason for marketing coal in so many sizes, and there must be advantage in selling to reduce the number.

Considerable attention has been given to the question of mixing or blending coal from different seams. It is often forgotten that the supply of good coking coal is limited. The problem of blending coals, which though unsuitable alone, give good coke when carbonized after blending with others, is receiving increasing attention.

The supply of active carbon suitable for respirators and gas masks is obviously a very important matter. Some materials on carbonization yield an active residue, but it is known that less active carbon can be activated by gasification with steam. The report records that it has been found possible at the Fuel Research Station to carbonize selected coals, of the durain type, and treat the coke with steam at a high temperature to obtain an active carbon nearly as good as the best obtainable and at a considerably lower cost. The importance of this observation needs no emphasis. The cost of active carbon is a limiting factor in processes for recovery of vapours.

Systematic work on the hydrogenation of coal and tar oils has been continued. Attempts to prepare first-class lubricants from coal tar oils have not been successful—possibly because the molecular structure of these hydrocarbons is unsuitable. It now appears that the most hopeful line is to synthesize hydrocarbons from carbon monoxide and hydrogen, and experiments in this direction have been initiated.

The report touches most aspects of national fuel problems and may be commended to those who seek a conspectus of the current position. H. J. H.

* Department of Scientific and Industrial Research. Report of the Fuel Research Board for the Year ended 31st March, 1936; with Report of the Director of Fuel Research. Pp. x+217. (London: H.M. Stationery Office, 1936.) 4s. net.

Twenty-fifth Anniversary of Laue's Diagrams

IT has been a pleasure to men of science in Great Britain to see the growing interest taken and progress made in science in India. The rapidly increasing list of original investigators, and the importance of many of their papers, contributed not only to their own institutions but also to learned societies in Great Britain, are a source of sincere gratification. Forty years ago (1896) I was present at the opening of the completed Indian Institute in Oxford, by the ex-Viceroy, Lord Dufferin, accompanied by Mr. Asquith (afterwards Prime Minister and Lord Oxford), who made a remarkable speech in welcoming our Indian co-subjects of the British Crown to partake of the best of our educational facilities. The fraternal lead then given has borne such wonderful fruit that India itself is now providing all that is needful, without any longer feeling the necessity of expatriating its sons to Europe for their higher education.

These facts are remarkably illustrated at the moment by the appearance of a special number of *Current Science*, a monthly journal devoted to science published at Bangalore, with the aid of thirty natives of India. This special number is devoted entirely to marking the twenty-fifth anniversary of the discovery by Laue of the diffraction of X-rays by crystals, and to the review of the years of intense research into crystal structure which have followed. It contains a dozen articles by the leaders in this work, the first being by Prof. Max von Laue himself, with his portrait as frontispiece. Succeeding articles are by Sir William and Prof. W. L. Bragg, Prof. P. P. Ewald, Prof. M. Siegbahn, Prof. A. Sommerfeld, Dr. L. Pauling, Prof. C. G. Darwin, Prof. H. Mark, Prof. J. A. Prins, Dr. S. K. Allison, Prof. H. A. Kramers, and Dr. S. Rama Swamy; an introduction is also contributed by Sir C. V. Raman. The mere fact that such a remarkable jubilee 'Festschrift', celebrating Laue's epoch-making discovery, should be organized by our Indian scientific brethren, speaks volumes for the advance of science in India.

There is every reason why I should feel specially warm towards this interesting brochure. For, twenty-five years ago (1912) I was the guest for a week of Prof. P. von Groth, the veteran crystallographer, at Munich almost immediately after the discovery made in the adjacent laboratory, and was shown the first negatives taken by Laue and Sommerfeld's assistants, Friedrich and Knipping, of copper sulphate and zinc blende. I was, indeed, by Dr. Laue's kindness, provided with duplicates of these and of the negatives of the apparatus used, and lantern slides from them were shown in a Friday evening discourse given by me at the Royal Institution shortly after my return to England. It was only in the preceding year, 1911, that my treatise on "Crystallography and Practical Crystal Measurement" was published by Messrs. Macmillan and Co. Ltd., representing the state of crystallography at the moment of Laue's discovery; and the twenty-five years of X-ray analyses of crystals which have followed, have confirmed and substantiated the contents of that work, which was expanded to two volumes in 1922, including a full account of X-ray work. No structure has been revealed by X-rays which does not conform to one or other of the 230 types of possible crystal structure clearly defined by the independently corroborating work of Schoenflies, Fedorow, and Barlow. The relative dimensions of the crystal unit cells, containing one or more molecules of the substance, which were given by me for the members of the several series of isomorphous substances which I had investigated in sufficient detail, were not only confirmed but also—and this was the greatest achievement of X-ray analysis—converted into absolute measure, in Ångstrom units.

Moreover, the generality of the law that the whole of the crystallographical and physical constants of the members of isomorphous series showed a regular progression with the atomic number of the interchangeable elements forming the series, was at this moment being somewhat criticized (but only as to the generality of its application), on account of an apparent important exception in the case of the haloid salts of the alkali metals. I had been careful to stipulate that the law only applied so long as the type of structure (one of the possible 230 types) remained rigorously the same throughout the whole series. X-ray analysis at once cleared up the mystery, for it indicated that there was a change of type between rubidium and cæsium chlorides; for while potassium and rubidium chlorides resemble sodium chloride in belonging to the face-centred cubic type of space-lattice, cæsium chloride belongs to the body-centred type, so that the law is totally inapplicable, the members of the series not being all strictly comparable with each other.

Many other instances of the assistance afforded by X-ray analysis to the clearing up of doubtful cases could be quoted. It should further be pointed out that in obtaining the results, which led to the law of progression, extreme refinement in angular and other fine measurement was essential, and the use of only the most perfect small crystals, grown with the greatest care free from either mechanical or thermal disturbance, such, in fact, that those crystal-angles which were of equal value with respect to the symmetry would not vary more than two minutes of arc. The so-called 'mosaic' crystals, which appear to give better reflection results in X-ray analysis, owing to the use of the rotating integrating method of using the X-ray spectrometer, are merely imperfect hastily grown crystals, which I would have ruthlessly rejected as being useless for the purpose in view.

It is thus obvious that it is the combination of the most refined of the older (pre-1912) crystallographic methods, with the newer X-ray analysis, that will give us the fullest knowledge of crystal phenomena and structure, one being complementary to the other, and the two together giving us the truth in full. The fascination of X-ray analysis has caused almost a cessation of crystal-angle and optical and other physical constants measurement, and one must hope that now so many structures have been unravelled by X-rays, of both inorganic and organic substances, more attention will be paid to goniometrical, optical, elastic, magnetic and electrical measurements with crystals. The purely structural X-ray work will then occupy its proper important position in the complete research.

In his personal article, Prof. von Laue throws a little further light on the circumstances in which in February 1912 his discovery was made. One evening in that month, P. P. Ewald went to him for advice as Privatdozent as to a difficulty which had arisen in preparing his (Ewald's) thesis for the Munich doctorate, on a subject which he had undertaken at the instance of Prof. Sommerfeld. During the discussion, the fact became prominent that a crystal is essentially a three-dimensioned lattice, and the question suddenly dawned in Laue's mind, as to what would happen if such a lattice were approached by a radiation of which the wave-length was short compared with the lattice-constant (unit cell dimension). The analogy of light waves and gratings suggested that diffraction must ensue. Remembering that Wien and Sommerfeld had only recently found Röntgen rays to possess a wave-length of the order 10^{-9}cm., and that the lattice constant must be somewhere about 10^{-8}cm., Laue came at once to the inspiring conclusion that the conditions for diffraction were highly favourable. Just at that moment entered W. Friedrich, Sommerfeld's assistant, and hearing the conclusion of the discussion, at once expressed a wish to put the matter to an immediate experimental test. Now Laue was obviously accepting Sommerfeld's view that the X-rays were a wave-motion, electromagnetic waves of excessively short wave-length, and not corpuscular, as was at that time supposed by Prof. W. H. (now Sir William) Bragg.

Friedrich obtained the help of a specially able experimental colleague, P. Knipping, and the apparatus was soon rigged up for passing a beam of X-rays through a crystal, and interposing a photographic plate in the path of any transmitted or diffracted rays. But unfortunately the crystal chosen, from being so easy to obtain well developed, was copper sulphate, which crystallises in the triclinic system of lowest symmetry. The effect on the photographic plate after development, although very promising, was confused, owing to the lack of symmetry. But on substituting a crystal of zinc blende, as advised by Prof. von Groth who lent the crystal, which is of cubic symmetry, the now well-known excellent pattern of cubically symmetrically arranged spots was obtained. After repeated confirmations and discussions of the meaning of the results, Prof. Sommerfeld was able to present the epoch-making paper of Laue, Friedrich and Knipping, on June 8, 1912, to the Munich Academy.

It would appear that the subsequent entrance of Sir William Bragg, and of his son W. L. Bragg, into the field was due to an attempt to discover whether Laue's effects were caused by the X-rays themselves (as corpuscular) or by electromagnetic wave-radiation associated with corpuscular rays. W. L. Bragg, then a student at Cambridge, was soon able to show that the zinc blende pattern of spots was due to the symmetry of the crystal, and not to the character of an X-ray spectrum; and he followed it up by determining the actual arrangement of the atoms in the still simpler cubic crystals of potassium and sodium chlorides. Sir William Bragg then found that the reflected X-rays, when analysed by an ionization spectrometer, consisted both of a general (continuous) spectrum and of rays of characteristic wave-lengths (Barkla's K and L rays), and that indeed Laue's explanation of the effect as a diffraction of electromagnetic waves must be accepted.

Moseley's brilliant measurement of the wave-lengths or frequencies of the characteristic X-radiations of the various elements immediately followed, and their relations were shown to offer a complete explanation of the Periodic Law of the elements; and the sequence number (atomic number) of the element suddenly developed a wonderful and unanticipated meaning, in expressing the positive charge on the nucleus of the atom, and the number of the surrounding planetary negative electrons. By a combination of the use of the Laue photographic method and the Bragg ionization spectrometer, together with the Debye powder method when good crystals are not available, and the rotating methods more lately introduced, all the important subsequent progress in unravelling the internal structure of crystals, not only of very simple substances but also of many complicated ones, including organic substances containing a large number of atoms in the molecule, has been achieved.

In their article Sir William and Prof. Bragg scarcely do justice to the really great progress which had been made in crystallography previous to 1912. They state that "at that time crystallography was so much a science apart, and played so little part in physics and chemistry, that the idea of a crystal pattern had never presented itself to the majority of scientists". If this were really the case it was the fault of workers in other scientific fields; for a small band of devoted crystallographers were insistently, in season and out of season, directing attention to the subject, and to its immense importance to physicists and chemists.

My own "Crystallography and Practical Crystal Measurement" set it forth clearly in the year 1911. The Laue discovery came at the most psychologically appropriate moment, to clinch the facts, to arouse universal interest in the subject, to reveal the 230 types of crystal structure already specified and defined by the genius of Barlow in Great Britain and simultaneously and independently by Schoenflies and Fedorow on the Continent, as real entities and not merely the natural deductions from all the accumulated experimental work on crystals, and to add that to crystallographic knowledge which rendered it assured and incontrovertible.

Sufficient will have been said to indicate the value of this Laue special number of *Current science*, and it is with all sincerity that we congratulate our Indian scientific colleagues in so admirable a production. In the preface, it is foreshadowed that other special numbers are being prepared, on canal rays, genetics, and on animal development, and among the articles in the first mentioned we are promised contributions by Sir J. J. Thomson, Dr. F. W. Aston, and Dr. J. D. Cockcroft. We shall look forward to these further special numbers with all the greater interest, from the pleasure which the perusal of the present issue commemorating the initiation of Laue diagrams has afforded us.

A. E. H. TUTTON.

The Chemical Research Institute, Warsaw

THE Chemical Research Institute of Warsaw (Chemiczny Instytut Badawczy w Warszawie) was founded by Prof. Ignacy Mościcki, who is now President of Poland. Firm in his conviction that the independence of Poland would be restored and that the country would then need the services of such an institute, Prof. Mościcki took the first steps to realize this aim during the Great War, in 1916. He founded the Metan Company in Lwów, the object of which was to carry out chemical research for industry. The shareholders of the Metan Company voluntarily resigned from their material interests in this organization in 1922, and transformed it into the Chemical Research Institute Association, which pays out no dividends, in accordance with its by-laws, and expends all revenue and earnings on the prosecution of new research work. Having thus arisen without the help of the Government or of industry, the Institute was in 1925 transferred to Warsaw, where it has since 1927 occupied its own commodious, modern building, erected thanks to the donations of Poles, both at home and abroad. The building was officially declared open in 1928 by Prof. Mościcki, who had in the meantime been elected President of the Republic. The Institute contains a Department of Inorganic Industry, a Coal Research Department, an Analytical Department, an Alcohol Research Department, a Department of Rubber Synthesis, etc.

The personnel of the Institute at present numbers 161. The director is Prof. Kazimierz Kling, one of the co-founders of the Metan Company. The other members of the executive board are: Prof. Wojciech Świtoesławski (at present Minister of Education), Prof. Jan Czochralski, Prof. Wacław Lesnianski, Mr. Jerzy Pfanhauser, Miss Halina Starczewska and Mr. Zdzisław Zaleski. The chairman of the Board of Curators is Mr. Eugeniusz Kwiatkowski, the present vice-premier and Minister of Finance.

The Institute is engaged in tracing out the lines of the technical progress of the chemical industry of Poland, with special reference to the possibilities of extending the use of and improving Polish raw materials on one hand and of substituting imported raw materials by home-produced ones on the other.

The research work conducted by the Institute is chiefly concerned with petroleum, natural gas, sulphuric acid, aluminium, the analysis and standardization of coal, metallurgical coke and rubber. The twentieth anniversary of the foundation of the Institute was celebrated in the Warsaw Polytechnic on December 9, the president of the Republic of Poland being present.