THIRD INTERNATIONAL SYMPOSIUM ON THE CHEMISTRY OF CEMENT

A SYMPOSIUM on the chemistry of cement, sponsored jointly by the Building Research Station of the Department of Scientific and Industrial Research and the Cement and Concrete Association, took place in London during September 15–20, the opening session being held in the Royal Institution and the others at the Royal Society of Arts. Sir Ben Lockspeiser, secretary of the Department of Scientific and Industrial Research, was president of the symposium, and Sir Francis Meynell, director of the Cement and Concrete Association, vice-president.

More than two hundred and fifty specially invited representatives attended, including more than a hundred from overseas, twenty-six countries in all being represented. In addition to the scientific meetings, visits to laboratories and factories and social events were arranged, all of which were well attended and appreciated.

In opening the symposium, Sir Ben Lockspeiser outlined the organization of research on cement and concrete in Great Britain and directed attention to the close co-operation which is maintained between Government institutions such as the Building Research Station and the Road Research Laboratory and those supported entirely by the industry, such as the Cement and Concrete Association and the individual laboratories maintained by the larger manufacturers. The annual production of concrete and concrete products in Great Britain amounts to a value of about £180,000,000, and of this sum only about one-fifth of 1 per cent is spent on research. This leaves room for further expansion of research on cement and its derivatives. Sir Francis Meynell, in a following address, brought out in greater detail the functions of the Cement and Concrete Association. It is supported by a levy on the tonnage of cement produced, and by the end of 1951 the grand total raised in this manner amounted to nearly 1½ million pounds. Nearly £100,000 has been used for capital expenditure in the recently opened Research and Development Station of the Association at Wexham Springs. Other introductory addresses were given by Dr. R. H. Bogue, on behalf of Dr. A. A. Bates, vice-president of the United States Portland Cement Association, Prof. H. Lafuma, director of the Centre d'Études et de Recherches de l'Industrie des Liants Hydrauliques (France), and Prof. G. Wästlund, director of the Swedish Research Institute for Cement and Concrete. The final event of the opening session was a paper by P. Gooding and P. E. Halstead, on the early history of Portland cement in England.

The first of the technical sessions was devoted to studies of the constitution of Portland cement clinker. Papers were presented on tricalcium silicate (J. W. Jeffery, United Kingdom), dicalcium silicate (R. W. Nurse, United Kingdom), the interstitial phases (H. Insley, U.S.A.), the ferrite phase (G. L. Malquori and V. Cirilli, Italy), the alkali phases (T. F. Newkirk, U.S.A.), and tricalcium aluminate (F. Ordway, U.S.A.). Dr. R. H. Bogue, director of the Portland Cement Association Fellowship (U.S.A.), closed the session with a paper on "Studies on the Constitution of Portland Cement Clinker". It emerged from this series of papers that the crystal structures of the two main cementing agents, tricalcium silicate (Ca_3SiO_5) and dicalcium silicate (Ca_2SiO_4), are now known. Good approximations to the structures of tricalcium aluminate ($Ca_3Al_2O_6$) and the ferrite phase have been found. All these minerals take up minor oxides in solid solution, the composition of the ferrite phase being particularly variable, and some are further complicated by polymorphism. The information derived from crystal-structure studies has supplemented that obtained from phase-rule studies and from microscopic and X-ray examination of cement clinker. Methods of dealing with systems of four to six components were discussed by Dr. Bogue, and advances in technique, such as the high-temperature centrifuge and methods of growing single crystals for X-ray structure analysis, were described.

In the session devoted to the setting and hardening of Portland cement, papers were presented by Prof. J. D. Bernal (United Kingdom), H. H. Steinour (U.S.A.), G. L. Kalousek (U.S.A.), F. E. Jones (United Kingdom) and Prof. T. Thorvaldson (Canada). Much progress was reported in the chemistry and crystallography of the hydrated calcium silicates. The unit-cell dimensions have been determined for ten of the natural or artificial hydrated calcium silicates, which appear to form two groups, having respectively a fibrous or non-fibrous character. The fibrous group is characterized by a short fibre repeat unit of 3·65 A., which may imply the existence of silicate tetrahedra joined by hydrogen bonds, or may arise from columns of Ca—Si—O linkages. $(SiO_3OH)^{3-}$ ions have been shown to exist in afwillite. At normal temperatures two closely related calcium silicate hydrates are formed in the system $CaO—SiO_2—H_2O$, both belonging to the fibrous group and also having a layer structure, the spacing of the layer varying with the state of hydration between 9 and 14 A. This behaviour is reminiscent of certain clay minerals, and may be related to the shrinkage properties of concrete. The method of differential thermal analysis has been applied to the study of the hydrated calcium silicates, and many of the advances reported were made possible by new techniques in X-ray crystallography.

Some divergence of opinion developed regarding the constitution of set cement, the results of differential thermal analysis being interpreted as showing the existence of a single phase, whereas limited X-ray data seemed to show the independent existence in the set mass of calcium silicate and aluminate hydrates. The two methods do, however, give consistent results when applied to the study of cement cured at high temperature and pressure. Although steam treatment is commonly applied as a method of accelerating the development of strength in concrete products, it has long been known that under certain conditions the expected gain in strength may not materialize. This was shown to be related to the formation under transient conditions of a calcium silicate hydrate of the non-fibrous group.

An interesting development in the study of chemical attack on concrete is the use of radioactive sulphur as a tracer to determine the rate of diffusion of the sulphate ion in cement pastes and mortars.

The Second International Symposium (Stockholm, 1938) dealt only with Portland and high-alumina cements; but the scope of the present meeting was extended to include a session on special cements.

Papers were read on high alumina cement (T. W. Parker, United Kingdom), slag cements (F. Keil, Germany), expansive cements (Prof. H. Lafuma, France), oil-well cement (W. C. Hansen, U.S.A.) and masonry cement (C. E. Wuerpel, U.S.A.).

The constitution of high-alumina cement is complicated by the division of its fairly high iron content between the ferrous and ferric state. Theories of constitution have, in the past, been based mostly on the results of petrographic examination, since phase-rule studies have not been of great value. At the recent meeting, it was shown that if MgO is used as a 'model substance' for FeO, phase data in the system $CaO—MgO—Al_2O_3—SiO_2$ can be applied to this problem. Thus the blue pleochroic mineral described by Sundius and others has been shown to have the composition $6CaO.4Al_2O_3.FeO.SiO_2$. In identifying the calcium ferrites and alumino-ferrites, measurement of reflecting power of the microscopic grains has been found useful.

The principal constituent of slag cements is a glass formed by the rapid quenching in water of molten blast-furnace slag. Such glasses vary widely in their reactivity as cements, and many attempts have been made to relate this activity to chemical composition. Work on artificial glasses containing only a few components was described, and also preliminary attempts to elucidate their structure by chemical means. A number of useful empirical tests for the quality of granulated slag were discussed.

The deliberate production of a controlled expansion is one method of compensating the shrinkage which accompanies the drying of normal cements. For certain applications, such as patching, underpinning and post-stressing, a larger expansion can be produced if necessary. The method employed is to bring about the formation of calcium sulphoaluminate in the set mass; this reaction is the principal cause of the disintegration of concrete in sulphatic waters; but in the present application the expansion is kept under careful control.

Oil-well cements are required to set at considerable depths below the ground under conditions of high temperature and pressure; but the setting time must be long enough for the cement slurry to be pumped down to the required depth. In the paper presented to the symposium, the various organic substances used for regulating the set were classified and it was suggested that HO—C—H groups are particularly effective in retarding the action of water on cement.

For use in masonry jointing or as a rendering, ordinary cement requires to be diluted with lime, limestone or fine sand, to reduce the formation of shrinkage cracks, and to improve the working properties of the mortar. Air-entraining agents may also be added. A modern development is to market the accurately proportioned mixture as masonry cement. Various problems arise in testing such cements, involving a knowledge of the rheological properties of stiff and semi-plastic pastes.

In the final session, the applications of research in cement manufacture were discussed in papers by H. Gygi (Switzerland) and T. Heilmann (Denmark), while A. R. Collins (United Kingdom) and M. A. Swayze (U.S.A.) presented papers on problems in the utilization of cement.

The closing address was given by Dr. F. M. Lea, director of building research, Department of Scientific and Industrial Research, who surveyed the work of the symposium and suggested lines along which future research might be developed. He referred to the great advances made since the last symposium in the application of X-ray analysis to cement research. One of the most baffling problems in this field has been the determination of the state of the water held in set cement. By means of X-ray structure analysis, it has been shown that some of the water chemically combined can be present as hydroxyl groups and some as molecular water. There must be a relationship between the expanding lattice of the hydrated silicates and shrinkage and moisture movement of concrete. The picture that is emerging as a result of this work and of the physical studies made on cement pastes using the adsorption isotherm technique is much more satisfactory than the earlier theories based solely on capillary phenomena and the Kelvin equation.

The combination of electron microscopy with electron diffraction is proving in this, as in other fields, a powerful research tool, and the use of ultrasonic energy for dispersing material and hastening chemical reaction is of great interest and may possibly have practical applications.

As a result of the research already done, the civil engineer is now presented with a choice of cements eminently suited to particular applications. As old problems are solved, however, new ones arise, and there is a constant need for a background of research in an industry so important as that of cement manufacture.

The proceedings of the Symposium, including the written and spoken discussion, will be published. Inquiries should be made to the Organizing Secretary, P. Gooding, Cement and Concrete Association, 52 Grosvenor Gardens, London, S.W.1. R. W. NURSE

INTERNATIONAL ASTRONOMICAL UNION

THE eighth General Assembly of the International Astronomical Union was held in Rome during September 3–13, on the invitation of the Consiglio Nazionale delle Ricerche. The inaugural ceremony took place in the Hall of Orazi and Curiazi in the Campidoglio, when the Mayor of Rome, the president of the Consiglio Nazionale delle Ricerche, Prof. Gustavo Colonnetti, and the Minister of Education welcomed the Congress, and the president of the Union, Prof. Bertil Lindblad, replied. More than four hundred delegates from thirty-six countries were present. After the opening session of the General Assembly, the Union resolved itself into a number of small groups: thirty-nine commissions of the Union covering all branches of astronomy met either separately for their special work or jointly for discussions of common interest. In addition, two Joint Commissions of the International Council of Scientific Unions—Spectroscopy and Solar and Terrestrial Relationships—took the opportunity of the gathering to hold meetings in Rome at the same time. Further, three symposia were organized, each for a full day. These were on "Stellar Evolution", on "The Astrometry of Faint Stars" and on "Instruments".

The following took part in the first symposium: V. A. Ambartsumian, O. Struve, B. Lindblad, W. Baade, E. Kukarkin, L. Gratton, F. Hoyle, A. Severny, G. A. Shajn, C. Fehrenbach, V. G. Fessenkov, E. Schatzmann, G. P. Kuiper, M. Schwarzschild,