THE SETTING OF CEMENTS.

A GENERAL discussion on the setting of cements and plasters was held by the Faraday Society on Monday, January 14, when several interesting papers were contributed. The subject is one of great technical importance, in view of the large and continually increasing application of calcareous cements, especially of the Portland class, in engineering and building work. Although this country leads in the manufacture of Portland cement, very little attention has been given to its chemical study by British chemists, and it is not surprising that the most important papers in the discussion came from France and the United States.

Whilst the setting of plaster of Paris is now agreed to be brought about by the crystallisation of a supersaturated solution, there still exists a difference of opinion as to the mechanism of the process in the case of Portland cement. The recent work of the U.S. Bureau of Standards, as described in a paper by Mr. A. A. Klein, supports the view, originally due to Michaëlis, that the products of hydrolysis are colloidal in nature, and that the desiccation and induration of gelatinous aluminates and silicates, and even of free alumina and silica, are responsible for the mechanical strength of the cement when set. On the other hand, the veteran cement chemist, Prof. Le Chatelier, to whom the first explanation of setting is due, reiterated his opinion that the process is essentially identical with the setting of plaster, the hardness being caused by crystallisation. Incidentally Prof. Le Chatelier offered some criticisms of the tendency, observable in much of the literature dealing with colloids, to use new technical terms as if they afforded an explanation in themselves, whereas they only express known facts in new language.

Dr. C. H. Desch, who opened the discussion, and Mr. Hatschek pointed out that the difference between the two schools is in great part one of terminology. It is agreed that the particles of the hydration products are usually too small to be distinguished, so that they fall within the region of ultramicroscopic dimensions, and surface forces become comparable with those which bring about the crystalline arrangement. Under such conditions it is almost immaterial whether the particles be described as crystalline or colloidal, especially in view of the work of von Weimarn, who has done much to show the continuity of the passage from one condition to the other with diminishing size of particles.

The contributions of Prof. Donnan, Dr. Lowry, and Mr. Hemming dealt with the agglomeration and disintegration of simple salts, and it was shown that these phenomena have a close connection with those of setting. In both cases the greater solubility of unstable as compared with stable solid phases plays a part. Dr. Rosenhain carried the discussion a step further by comparing the hardening of plasters and salts with the process of solidification of a metal. The solid formed in each case is a crystalline aggregate, which breaks more readily, under ordinary conditions, across the individual crystals than between their boundaries. This has been attributed to the formation of an amorphous intercrystalline layer, and it is possible that the strength of hydrated plaster may be due, not merely to friction between the interlocking radiating needles of adjacent spherulites, or to their simple adhesion, but to the presence of such amorphous material. Portland cement would presumably contain a much higher proportion of the amorphous products.

Another group of papers dealt with questions more closely allied to engineering practice, and the discussion rendered evident the fact, well known to those who have studied the somewhat complex subject of the chemistry of cement, that there are numerous unsolved problems in connection with the setting and hardening processes, some of which bear in the most direct manner on the utility of cement and concrete as structural materials. Mr. Blount spoke of these difficulties from the point of view of the technical chemist, and Mr. Caröe from that of the architect. For the physical chemist some of the most interesting of these problems concern the spontaneous changes of setting time and their acceleration or inhibition in the presence of catalysts. The chemical constitution of Portland cement clinker is now established, thanks to the splendid work of the Geophysical Laboratory in Washington, a summary of which was given by Mr. Rankin, who was responsible for the investigation. The exact part played by impurities, such as magnesia, iron, and alkalis, still remains to be determined.

The addition of puzzolanic materials, containing soluble silica, has been practised since ancient times as a means of improving the qualities of lime mortar, and similar additions to Portland cement have been recommended. The work of the Bureau of Standards indicates that the strength after setting should be improved by such additions, and the practical question was directly raised in a paper by Messrs. Lewis and Deny, who showed a marked improvement in the strength of good brands of Portland cement, due to the addition of finely ground blast-furnace slag of suitable composition. The discussion brought out the fact that a difference of opinion exists on this question, although the evidence for improvement is very strong. Blast-furnace slag as a raw material for Portland cement manufacture has received little attention from chemists in this country, although the industry is now becoming an important one, and the utilisation of such a troublesome waste product deserves much closer study.

Discussions of this kind do a great service in reviewing the field for investigation in the branch of science or industry discussed, and also in bringing together work undertaken from quite independent viewpoints, the relations between which may have been quite unsuspected by the original investigators. Portland cement was an English invention, and this country has always led in its manufacture; it would be of advantage to the industry and to engineering if it were to receive more attention from British chemists than it has hitherto obtained.

C. H. D.

SECONDARY-SCHOOL EXAMINATIONS AND ADVANCED COURSES.

THE Consultative Committee of the Board of Education some years ago prepared a report on examinations in secondary schools, and this was published by the Board in 1911. Following the Committee's recommendation, the Board of Education invited the English universities to confer with representatives of the Board on the whole subject. These conferences took place during 1913, and in the same year the Board explained the general nature of the proposals it was about to make to representatives of local education authorities and of associations of secondary-school teachers. In July, 1914, the Board issued the now well-known Circular 849, on "Examinations in Secondary Schools," and invited criticisms from responsible authorities upon the scheme proposed in it. The scheme provides for the annual examination of grant-earning schools in connection with the Board. Two examinations are proposed, and they are to be conducted by one of the recognised university examining bodies. The first examination is to be suitable for forms in which the average age of the pupils ranges from about sixteen years to sixteen years eight months. The second examination will be designed for those who have continued their studies for about two years after the stage of the first examination. The first examination is intended to test the pupil's general education before he begins his school specialisation. It should, under certain conditions, serve the purposes of a matriculation examination, and it is hoped that eventually it will replace the numerous entrance and preliminary examinations to which pupils leaving the secondary school have had to submit themselves. The second examination will be based on the view that older pupils should have enjoyed a more concentrated study of a connected group of subjects, and the courses suggested in the Circular are (*a*) classics and modern history, (*b*) modern "humanistic" studies, and (*c*) science and mathematics. The Board's scheme naturally involves increased expenditure by the schools, and in Circular 849 the Board promised further financial aid, but in a later circular of December, 1915, it was announced that proposals involving increased financial aid were to be considered in abeyance. Circular 996, issued on May 25, 1917, however, announced the Board's ability to take up its examination scheme again, and the appointment of the "Secondary-School Examinations Council" to assist the Board to undertake its functions as the co-ordinating authority for secondary-school examinations. This council is at work, and the schools are awaiting its first report.

Closely connected with the two examinations which are being instituted by the Board of Education for pupils in grant-earning secondary schools is the scheme for the provision of advanced courses in such schools outlined in the "Regulations for Secondary Schools" issued by the Board last year. The Board states that the secondary schools are not sending forward to institutions of higher education and research a number of properly qualified students adequate to the national need. The Board regards this deficiency as due partly to an insufficient provision for advanced work in secondary schools, and to meet this need the new advanced courses have been planned. They are intended for pupils of about sixteen who have reached the standard of the Board's first school examination, and are to last for two years. The advanced course must be in one or other of three groups of subjects, the Regulations state:—(i) Science and mathematics, in which preponderance may be given to either; (ii) classics, *i.e.* the Latin and Greek languages, together with the literature, history, and civilisation of Rome and Greece; (iii) modern studies, which must include the study of (*a*) two languages other than English, with their literature, (*b*) modern history on broad lines, and including the history of England and of Greater Britain, but also bearing special relation to the two languages chosen. Two, or even three, of these advanced courses may be organised in a large school, where pupils enough normally remain until about eighteen, but probably the number of advanced pupils in the school will not allow of more than one course. An additional grant for each of these courses is promised; it will not be calculated on the number of pupils and will in no case exceed 400*l*. Up to the middle of November last between 270 and 280 applications for recognition of advanced courses were received by the Board. About half of the applications were in respect of courses in science and mathematics; of the remaining half, those for courses in classics were little more than one-third of those for courses in modern studies. Up to the same date sixty-three courses in science, thirteen in classics, and nineteen in modern studies have been recognised. Nearly fifty were still undetermined. In the remainder (about 130) recognition was withheld, because the syllabus of instruction submitted was unsatisfactory, or because it was not shown that it could be satisfactorily carried out, or because a reasonable number of pupils qualified to enter on the course was not forthcoming.

GERMAN ECONOMICS AND TECHNOLOGY.

THE first meeting was recently held of the German Union of Technical Scientific Societies, formed by a combination of thirteen associations and unions, when problems involving economics and technology during and after the war were discussed. Prof. Dr. Wiedenfeld, of Halle, spoke on the subject, and showed that whilst, during recent pre-war years, Germany had become more and more dependent upon foreign countries for many articles of prime necessity, the blockade had thrown her back upon her own resources, and technical science had been called upon to furnish her requirements out of these, under conditions which were so far novel in that the question of cost of production became one of secondary importance. The problem had been met in three different ways:—

(1) By re-establishing industries that had been rendered unremunerative by foreign competition, such as the production of manganese, the increased production of iron, the production of sulphur, and the intensification of agriculture.

(2) By the increased utilisation of what had been waste products so much that the term "non-utilisable substance" had been eliminated by the war, examples being the production of lubricants from coal-tar and of clothing materials from various waste products.

(3) By the production of substitutes and of various substances by synthetic processes, as of nitro-compounds from atmospheric nitrogen, and of cattle feed from straw.

It is interesting to note that this speaker objected to the multiplicity of Government authorities controlling production, and holds that the production of materials in large quantities can be assured after the war only by means of monopolies, though not necessarily State monopolies. Finally, he insisted upon the immense importance of close co-operation between technical science and industry, neither of which can exist without the other. It need scarcely be added that many of these observations apply quite as forcibly to conditions in this country as to those in Germany.

THE NEW INTEGRAL CALCULUS.

THE ancient Greeks determined various areas and volumes by a method known as that of exhaustion; but they had no integral calculus properly so called, any more than (*pace* Prof. Burnet) they had a differential calculus, although they were familiar enough with the idea of a locus described by the motion (or flow) of a point. Even Fermat missed the analytical method devised by Barrow, Newton, and Leibniz. This was so rapidly developed as to assume a form which (except in notation) remained practically unaltered for a century and a half. The reason of this quiescence—a sort of dormant vitality—was the neglect of function-theory, or, rather, its non-existence. The appearance of Fourier's work on the theory of heat compelled mathematicians to study the properties of trigonometrical series, and the conditions under which they could be used for the representation of so-called arbitrary functions. Dirichlet and Riemann shed a flood of light upon the matter; and Riemann gave a definition of a definite integral which could be applied to functions more general than those that could be integrated