Teaching of Technical Optics

THE teaching of optics may be divided into four sections: (1) physical optics; (2) optical computation and design; (3) ophthalmic optics; (4) practical optics—glass grinding and polishing.

Physical Optics. The first of these sections is included to a greater or less extent in the teaching of physics in nearly all schools, universities and technical colleges. As 'light' it is included among the subjects that may be offered in the school certificate and matriculation examinations. To more advanced stages it is treated in the courses for the science degree and for the honours examinations in physics at the universities. All these courses are so well known that they need be no further described.

Optical Computation and Design. The second section is an exceedingly important one, as upon the ability to carry this out depends our future progress in the construction of new forms of instruments for surveying, astronomy, gunnery (including such things as range-finding and air defence), photography and microscopy. The actual number of men required for these computations is not large—indeed it is exceedingly small in comparison with the numbers of engineers or chemists for which there is a demand; their importance, however, is not to be measured by their numbers but by the value to the nation of the work they do. The demand for such men has only gradually arisen in (say) the last fifty years. Until then, lenses both for the microscope and for photography had to a large extent been devised and produced by methods of trial and error by practical men, who had only a general acquaintance with optical principles; their calculations were mostly concerned with first-order quantities, and their corrections were the result of their own long experience of the results of changing one or other of the surfaces. This experience in the hands of such men as Andrew Ross and Tom Powell resulted in the production of lenses of excellent performance, but each lens had to be individually tested and adjusted. Then such computers as Schroeder, Hasselkus, Conrady, Booth, Aldis and Dennis Taylor in Great Britain, and Abbe, Rudolf, Goerz and others abroad, showed that there were great possibilities of improvement in the design of lens systems by the application of the theoretical work of Coddington, Seidel and others, and by the systematic computation of the paths of rays through a lens system. As a result, such firms as Zeiss now employ men who spend their whole time in the computation of lenses for optical instruments of all kinds.

The sudden large demand for optical instruments caused by the Great War and by the closure of the foreign supply of such instruments, made it imperative that special courses of training should be provided. Courses were already in existence at the Northampton Institute, set up first by Dr. C. V. Drysdale and later carried on under S. D. Chalmers and since his death in 1919 by H. H. Emsley, but these classes were sparsely attended and did not carry their students very far. A special Department of Technical Optics was therefore established at the Imperial College of Science under Prof. Frederick J. Cheshire with Prof. A. E. Conrady in the chair of optical designing and computing and with L. C. Martin as lecturer. Somewhat later, Prof. A. F. C. Pollard was appointed to the chair of mechanical design of optical instruments. In the first few sessions, the demand for trained computers made the classes abnormally large, but since then they have averaged an output of some half-dozen a year. They cannot expect to be larger, as the number of firms requiring such men is necessarily small; for example, in Great Britain there are only four firms making microscopes—Baker, Beck, Swift and Watson, and four making photographic lenses—Cooke, Dallmeyer, Ross and Taylor, Taylor and Hobson. To these must of course be added firms making surveying, navigating and astronomical instruments, and the army and navy have their own staffs for the design of the special instruments required for warfare; but when allowance is made for all these the total numbers still remain comparatively small, though nevertheless of exceeding importance.

The course at the Imperial College is a two-year one, usually taken as by post-graduates. It includes the theory, design and testing of the fundamental optical systems from both the optical and the mechanical points of view with practical work in all branches. Since their establishment, more than six hundred students have entered for these courses and must have proved of very great value to the industry. The research work of the College, which has been carried on both by students who have continued on after the completion of their course and by the members of the staff, has covered a wide field. Of great importance were Conrady's investigations into the tolerances allowable in an optical system (published in the *Monthly Notices of the Royal Astronomical Society* and later embodied in his "Applied Optics and Optical Design"). Other papers, on ultra-violet transmission of materials and the ultra-violet microscope, the electron microscope, on colour vision and colorimetry and on similar subjects amount in all to more than a hundred and fifty—no inconsiderable output for one department in a comparatively short period.

Some small amount of similar work has been done at both the Northampton Polytechnic Institute, London, E.C.1, and the School of Technology in Manchester, but more in the way of individual work by advanced students and by research than as systematic training, as it has not been worth while to run special classes for the small number of students who wished to attend in any one year.

Ophthalmic Optics. In the third section of optical teaching, ophthalmic optics, there are much larger numbers of students. For these, special examinations were set up by the British Optical Association in 1895 and by the Spectacle Makers Company a year or two later. Before entering for the examinations of the former body, students must have passed a matriculation examination or its equivalent; for the latter they have to sit for a preliminary examination in similar subjects. For the certificates of both bodies the students have to pass in elementary optics; the general structure and functioning of the eye; practical sight testing for the prescription of spectacles; and in workshop practice—lens finishing and mounting and frame making and bending. In order to ensure

satisfactory training for the examination, the B.O.A. has 'recognized' certain schools which have been inspected to ascertain that their equipment, staffing, and courses are satisfactory. These schools are mostly in the technical institutes in such towns as Manchester, Edinburgh, Glasgow, Bradford, Cardiff, etc. The largest classes are those at the Northampton Institute, London, where last session more than two hundred and thirty attended organized courses in addition to some sixty who took special courses or individual classes in optics. In Manchester in the same session twelve students were taking full-time courses and about forty were taking part-time courses for these examinations. In the other schools the numbers are of the order of a dozen students in the session. In addition to the optical training in these schools, arrangements are made in all cases for the students to attend some form of hospital course in order to enable them to recognize diseases of the eye, to ensure that patients so suffering shall be sent to obtain proper treatment.

Practical Optics. The fourth section of optical training, practical optics, is provided to a limited extent at all the 'recognized' schools, since it is included in the training of the sight-testing optician, who is expected to be able to grind, polish and edge a lens for a spectacle frame; but it is also arranged as an independent course both at the Northampton Institute and at the Manchester School of Technology. These special courses are planned for workers in optical factories; the students attend on three evenings a week for instruction in drawing, in optical calculations, and in actual lens- and prism-grinding and polishing. The industry so far does not seem to have appreciated the potential value of these classes, as there were less than ten students at either of the schools last session. In spite of the large use of machinery for the grinding and polishing of lenses and prisms, the very exact workmanship required in some cases (roof-prisms, for example, have to be worked to an angle which is correct within two seconds of arc) still necessitates hand finishing; for this and similar work, as well as to enable the men to use the machines in a more intelligent and less 'rule-of-thumb' manner, such classes should surely be of very great value.

Inauguration of the German State Council for Research

IN March of last year, the foundation of a new State Council for Research ("Reichsforschungsrat") was announced in Germany by the Minister of Education, Herr Rust. Within ten weeks the fourteen departments of the research organization were formed. In December last a handsomely printed quarto publication describing the Council and its purposes was issued with No. 23 for the year 1937 of the Official Gazette of the German Ministry of Learning, Training and National Education (Amtsblatt der Reichs-Ministeriums für Wissenschaft, Erziehung und Volksbildung). It is entitled "A Celebration of German Learning" (Ein Ehrentag der deutschen Wissenschaft, 25 Mai 1937).

The publication sets out the system on which research is to be organized and the principles on which it is conducted in the Third Reich. It is illustrated with scenes of the inaugural ceremony and with large portraits of the Führer, the Minister of Education, the president of the new Council, Artillery-General Professor Dr. K. Becker, his acting deputy, the vice-president, Dr. O. Wacker, and the directors of the various departments. Fourteen of these departments, all of a definitely technical character, have been established. The speeches of Herr Rust and of Prof. Becker are set out in large type and are followed by detailed records of the career of each director of a department.

In his address, Herr Rust directed attention to his ready action and indicated the need for the establishment of the Council. "The Council," he said, "is initiated at a moment when the German people is preparing, in a manner hitherto unprecedented and by an unexampled expenditure of its utmost effort, to win its rightful foundations of existence, independent of its environment. . . . Not long ago many of us felt that learning (*Wissenschaft*) was too aloof from the great decisions of our time to co-operate in the great struggle of the German people. But the course of German history has itself brought this idyllic attitude to an end and with it has ended also certain idyllic forms of scientific work. The Nazi Revolution summoned science to the decisive battle."

Herr Rust then turned to the question of the freedom of science and of learning: "Complete freedom of opinion and judgment," he said, "are not marks of a truly free science, but rather of an estrangement of the spirit from the eternal forces of Nature and of history. . . . Freedom is assured to science neither by its abstractness nor by its independence of current events. . . . It is rather the hopes of the German people and of the Nazi State in the share of science in the Four Year Plan . . . that give proof of the recognition of the freedom of science.

"If the Nazi State calls on German science to co-operate in the Four Year Plan, it is not because it anticipates the findings of science but because the first task of science will be to give us those materials which Nature has denied us. Such a task can only be accomplished by free science. For science is unfree if her findings be dictated by an unscientific force, but she is free if she sovereignly masters those problems which are posed to her by life. . . . With the foundation of this Council no new principle of scientific behaviour is introduced. . . . What is new is the determinate and planned co-operation of technology and of science for the self-sufficiency of the German economy."

The president of the Council, General Becker, spoke of the reduction in number of the independent centres of research in Germany with the object of concentrating research on more immediate ends. He then turned to consider the way in which the new Council would further the unification of research on methods of preparing raw materials and on their employment. Here, he pointed out, a special position was occupied by the Kaiser Wilhelm Gesellschaft zur Förderung der Wissenschaften.

"The status of the Kaiser Wilhelm Gesellschaft," he said, "will not be disturbed by the new process of