is now. Classical education bulked too large in the University, and the unequal distribution gave cause for just resentment. Though biology provided a parallel in the destruction of millions of eggs in order to produce one salmon, and though the Oxford system occasionally produced a man like Ingram Bywater, the feelings and the lost opportunities of the countless others who were destroyed in the process ought to be considered. It would be far better for the average man to infect him with the spirit of the humanities than to waste his time by too much laborious attention to grammatical detail.

The great philosophers of old—Hippocrates, Galen, Theophrastus, Hero, Aristarchus, and others—fertilised Science and went far on the way towards understanding the system of Nature, but in the Middle Ages the thread was broken; Roger Bacon was the only medieval student with a modern outlook, and the loss of connection with the Humanities was a serious set-back to Science.

Modern men of science might well read such books as Lucretius's "De Rerum Natura," in which a great deal of modern discovery had been foreshadowed; and scholars should not hesitate to point this out.

An attempt was being made at Oxford to start a new Honours School of Philosophy in relation to science. This should prevent scientific men from getting lost in the backwaters of premature research. The groundwork of this school should not be limited to modern ideas, but the continuity of the history of Science through all the ages should be grasped. There was a great need of both general and individual reconstruction, and this should be undertaken in the spirit of Hippocrates's maxim, *ἢν γὰρ παρῇ φιλανθρωπίη, πάρεστι καὶ φιλοτεχνίη*—"The love of humanity is the basis of the love of science."

Loan Exhibition of Early Scientific Instruments.

On May 16 Sir William Osler opened a loan exhibition of most remarkable instruments and manuscripts illustrating the scientific history of Oxford from the fourteenth to the eighteenth century. The greater part of the instruments now shown have never been publicly exhibited before. They have been unearthed in cupboards and corners of libraries of colleges and university departments. They are, for the most part, in their original state and of corresponding historic value.

The two earliest dated Persian and Moorish astrolabes, A.D. 987 and A.D. 1067, lent by Mr. Lewis Evans, form a worthy introduction to a wonderful series of instruments lent by Merton College. One of these is traditionally associated with Chaucer, and another of the Saphea type is considered by Mr. Gunther to have been the instrument left by Simon Bredon either to the college or to its great astronomer, Rede, early in the fourteenth century. The energies of these early astronomers were largely directed to the preparation of astronomical tables, which had a wide circulation, and Oxford was regarded very much as Greenwich is now.

The later astronomical exhibits illustrate the instrumental equipment of the Earl of Orrery, who must have been acquainted with the first members of the Royal Society. Many of his instruments are still in the state in which he left them to Christ Church. His telescopes of 8 ft., 9 ft., and 12 ft. focal length, with many-draw vellum tubes and lignum vitæ lens-mounts by Marshall and Wilson, form a unique series.

There is also a Marshall microscope of 1693 in excellent condition, as well as some magnificent planetaria and other astronomical models by Rowley, the maker of the original orrery.

The slide-rule of 1654 in the South Kensington Museum, described in NATURE of March 5, 1914, by Mr. Baxandall as the earliest known slide-rule, must now yield to an instrument lent by St. John's College, dated 1635. It is in the form of a brass disc 1 ft. 6 in. in diameter engraved with Oughtred's circles of proportion. Would space permit, the series of volvelles or calculating discs showing the age of the moon from manuscripts of the fourteenth and fifteenth centuries, and some early surveying instruments, are worthy of more particular description, as well as many other treasures now shown to the public for the first time. A printed catalogue of the principal exhibits, prepared by Mr. R. Gunther, of Magdalen College, is published by the Clarendon Press, price 1s.

ELECTRIC FURNACES.

THE importance of electro-metallurgy at the present time was made evident at the joint meeting of the Institution of Electrical Engineers and the Iron and Steel Institute on May 8, when six papers were read on electric furnaces. The descriptions given by the various authors related almost exclusively to furnaces suitable for the iron and steel industry, of which there are at present 117 at work in this country, as compared with 287 in the United States and 43 in Canada. The nominal output of the British furnaces was given by Mr. R. G. Mercer as 31,250 tons per month, but, owing to various causes, the actual production was only about 65 per cent. of this amount. It will be seen from these figures that electric steel is now a well-established commercial product, and with the advent of cheaper electric power large developments may be witnessed.

The features common to all electric steel furnaces are (1) the use of alternating current with suitable transformers and (2) the formation of an arc between carbon electrodes above the charge, which plays upon the slag on the surface. It is customary to place one or more electrodes beneath the hearth of the furnace, so that a part of the current may flow through the charge when the hearth becomes hot enough to act as a conductor, the mixing of the molten metal being thereby facilitated. The electrical connections vary according to whether single-, two-, or three-phase current is employed, it being necessary in all cases to obtain a balanced polyphase load on the service lines.

In the two-phase furnace described by Mr. W. K. Booth two main electrodes are used, together with an auxiliary electrode which, at starting, is embedded in the charge, and serves to draw the arc between the charge and the main electrodes. Two other electrodes are located in the hearth, which, when hot, permits current to flow crosswise from these electrodes through the metal to the main electrodes, the auxiliary then being withdrawn. In Sahlin's furnace the electrodes enter at the sides, forming pairs inclined at an angle, the resulting arc being then directed on to the surface of the charge, several pairs, suitably connected, being used in the larger types. A single electrode is placed beneath the hearth. In the furnaces described by Mr. Victor Stobie vertical electrodes are used, the number depending on the size of the hearth, and the distribution being such as to ensure the heating of the whole surface of the charge. The hearth electrodes are stated by Mr. Stobie to be undesirable in large furnaces, though essential in small ones. A special feature of Stobie furnaces is a device for sealing the entrance of the electrode to the furnace, whereby oxidation at this point is prevented. The special electrical connections for obtaining a balanced load constitute the characteristic features of the furnaces dealt with by Mr. J. Bibby and Mr. H. A. Greaves, the former of whom gave an interesting account of the design of electric reduction furnaces for the production of pig-iron from ore, a process which becomes economically sound when 1 horse-power-year of electrical energy does not cost more than 2·3 tons of coke, and is now coming into extensive use in Sweden and elsewhere. In this country steel refining for ingots and castings and the production of ferro-manganese and steel alloys constitute the chief uses of electric furnaces at present.

The relative merits of amorphous carbon and graphite for electrodes were dealt with in several of the papers read, the balance of evidence being in favour of graphite, which, owing to its superior conductivity, permits of the use of narrower electrodes. Dolomite is generally used to form the hearth, but acid linings are said also to be employed in some cases. In spite of the higher cost of heat produced electrically over the use of fuel, the superior quality of the products, the small wastage by oxidation, and the ease with which scrap may be utilised justify the use of the electric furnace. It is to be hoped that the experience gained with steel will lead to the production of artificial abrasives such as carborundum and alundum in Britain, and also to the development of the higher refractories needed in many metallurgical processes. CHAS. R. DARLING.

BRITISH OPTICAL RESEARCH.

WE have before us several books and a large number of reprints from various scientific publications, all of which represent work done by members of the scientific staff of Messrs. Adam Hilger, Ltd., since the beginning of the war. We must welcome not only the fact that a British optical firm has realised the value of a considerable staff of highly qualified scientific collaborators, but more particularly the circumstance that this staff is encouraged by the firm in the *publication* of its work, and in thus helping to hasten the recovery by this country of the leading position in applied optics which it undoubtedly held in a rather distant past, but which it had almost completely lost in more recent years, largely through the narrow outlook of a majority of optical firms in seeking only immediate and certain profit and keeping down or totally excluding "non-productive" labour, but also through the failure of our educational institutions to teach real optics capable of application to actual technical problems instead of the transparent sham beloved by examiners and their text-books.

From the practical optician's point of view the most valuable of the publications are probably those by Mr. Twyman, the present head of the firm, which deal with the Hilger interferometer for the correction of lenses and prisms (*Phil. Mag.*, January, 1918, and *Photogr. Journ.*, November, 1918). By directly indicating the residual imperfections of a lens or prism in the form of a contour-map built up of interference-fringes, this instrument enables a skilled workman systematically to remove those imperfections and to perform, without other guidance, the process of "figuring" which hitherto had to be directed by a highly skilled and experienced observer on the basis of repeated tests of the lens or prism by the in- and out-of-focus appearance of a real or artificial star, and which then was an expensive, slow, and uncertain operation. For the present this valuable method is, unfortunately, limited to small sizes owing to the cost and difficulty of producing large plano-parallel plates of the requisite almost absolute perfection.

Mr. Twyman also contributes an instructive paper on the annealing of glass (Trans. Soc. of Glass Technol., vol. i., 1917), which deals more especially with the importance of passing the glass very slowly through a comparatively short range of temperature. In describing methods of fixing this range, and in working out the law according to which the viscosity of the glass increases within the critical range, Mr. Twyman goes decidedly beyond the publications of the Jena works on this subject of "fine annealing."

Two members of the staff, Mr. R. G. Parker and Mr. A. J. Dalladay, describe another valuable innovation in optical precision work, viz. the permanent union of very closely fitting polished glass surfaces by raising them to a very closely gauged temperature at which they become welded together without any distortion which would affect their optical perfection (Trans. Faraday Society, vol. xii., part 1, 1916). In the case of glasses which agree sufficiently closely in their rate of expansion, this promises to prove a very decided improvement on the usual cementing processes.

In an interesting paper to the Physical Society (Proc., vol. xxx., part iii.) Mr. Simeon discusses the accuracy attainable with critical angle refractometers. As is probably widely known, these instruments are now built by Messrs. Hilger, Ltd.

Dr. L. Silberstein, the scientific adviser of the firm, is widely known as an extremely able mathematical physicist. His two books on "The Electromagnetic Theory of Light" and on "A Simplified Method of Tracing Rays" have already been reviewed in these columns. In the collected researches before us we find five additional contributions from his pen to the *Phil. Mag.* A paper on "Fluorescent Vapours and their Magneto-optic Properties" and two on "Molecular Refractivity and Atomic Interaction" are purely theoretical investigations on subjects only remotely connected with technical optics. In a paper on "Multiple Reflections" (November, 1916) Dr. Silberstein gives a very general treatment, by his favourite vectorial method, of the reflection of light at combinations of plane mirrors, more particularly with the view of elucidating the behaviour of the important "central" or "corner-cube" mirrors which have proved so valuable for signalling and range-finding purposes. Finally, there is a paper on "Light Distribution round the Focus of a Lens at Various Apertures" (January, 1918), in which the problem of the spurious disc in the presence of spherical aberration is attacked. One would like to see the subject worked out in a more practically useful form; the example of the phenomena at the paraxial focus of a plano-convex lens which is chosen for numerical treatment is not very interesting, and there is an obvious numerical error in the working out of the "best relative aperture" on p. 47. By the author's own formula (20) this comes out at rather more than twice the stated values, and the results then agree fairly well with everyday experience as to the permissible aperture of plano-convex lenses as used in ordinary eye-pieces and magnifiers. But, apart from this little slip, the matter of real interest to optical designers is the appearance of the image at the point of best concentration of the light, which is easily shown to lie very nearly midway between the geometrical foci of the paraxial and marginal rays respectively, for in this position the maximum difference of phase is only one-fourth of that at either the paraxial or the marginal focus. At the correctly worked out "best relative aperature" the lens of 5·56 cm. radius of curvature chiefly calculated for by Dr. Silberstein has a longitudinal spherical aberration of about 0·6 mm., and the interesting region would therefore be found about 0·3 mm., say 600 λ. from the paraxial focus. It is, therefore, not surprising that the author finds no appreciable change in the light distribution on trying a change of focus of "even" 10 λ. It is greatly