THE THEORY OF OPTICAL INSTRUMENTS.

Theorie der Optischen Instrumente (nach Abbe). Von Dr. Siegfried Czapski. (Breslau: Eduard Trewendt, 1893)

HAPPENING not long ago to meet a German friend well posted up in physical literature, the present writer inquired whether any of the year's publications were specially worth getting and reading. The answer was a doubtful "No," and then "Oh, yes—Czapski's 'Theory of Optical Instruments.'" This was high praise, but not unmerited. For although the book will not appeal to a large circle of readers, it will soon become indispensable to all who are interested in the investigation of the merits and defects of optical systems, or who are concerned in turning out high-class optical work.

Although only a third of the book is devoted to the description of the microscope, telescope, and other instruments, there is no unnecessary rambling beforehand—either into the pleasant regions of developmental history or along the more dusty paths of the optical text-book proper. The author acknowledges the value of the undulatory theory as the ultimate test which must be applied when we wish to know how far the conclusions of geometrical optics are valid; and therewith dismisses it. He everywhere tries to be concise; and succeeds so far that the average student might complain of sometimes finding a day's work between one page and the next. But the condensation is not of that meaningless kind which so often irritates one in German school and college text-books. There are frequent (and valuable) bibliographical notes. The references to the works of Smith, Herschel, Lloyd, Airy, Rayleigh, Dallinger, and Pendlebury show that the English literature has not been neglected; indeed, Principal Heath's "Treatise on Geometrical Optics" (which is being translated into German) is recommended as the best of the modern text-books. But whereas these tend to treat optical instruments as convenient illustrations of optical theory or geometrical reasoning, the latter are here treated as strictly subservient to the former. The range is further limited by including among optical instruments only those which are strictly used for producing images of external objects—applications of reflecting mirrors in geodesy and astronomy, the stereoscope, &c., being included. Within these limits our author is at home and speaks with authority. As scientific adviser and technical director in the celebrated workshops of Carl Zeiss in Jena, he has daily opportunities of applying theory to practice with the aid of excellent glass, skilful workmen, and modern machinery; and has had the still greater advantage of continual intercourse with Prof. Abbe, to whose labours the perfection of high-power microscope objectives is so largely due. His debt in this direction is freely and gratefully acknowledged—most conveniently by stating what chapters are not directly or indirectly due to Abbe.

A short introductory chapter on geometrical optics is followed by three others on the geometrical theory of optical images, the fundamental properties of lenses and systems of lenses, and the theory of spherical aberration. In chapter v. (on chromatic aberration and the theory o achromatism) the author gives a simple method for calculating the magnitude of the secondary spectrum (the focus-difference) of a system of two infinitely thin lenses from the dispersion-constants. Assuming these to be achromatised for the lines F and C, he calculates the difference between the focus for light of a given wave-length (λ) and the light of the brightest part of the spectrum $\lambda = 0{\cdot}55\ \mu$. (According to König the position of maximum brightness in the spectrum of sunlight varies, as the total intensity increases, from $\lambda = 0{\cdot}53\ \mu$ to $\lambda = 0{\cdot}61\ \mu$.) The values of the differences $f_\lambda - f_{0{\cdot}55\ \mu}$ are given in thousands of $f_{0{\cdot}55\ \mu}$ for various wave-lengths. In the case of a combination of a flint glass of medium density with an English silicate-crown glass the differences decrease from + 1·79 (for $\lambda = 0{\cdot}77\ \mu$) and then gradually increase to 3·70 (for $\lambda = 0{\cdot}41\ \mu$). But the researches of Prof. Abbe and Dr. Schott have resulted in the production of improved grades of optical glass, and especially of pairs of flint and crown glass in which the dispersion in various parts of the spectrum is much more nearly proportional. These glasses have been manufactured in the Jena works since 1884, and by their use the magnitude of the secondary spectrum is greatly diminished. Thus in the case of a combination of a heavy barium-phosphate-crown glass with a borate-flint glass the above differences begin at $-0{\cdot}04$ (for $\lambda = 0{\cdot}77\ \mu$) and the maximum value is 0·79 (for $\lambda = 0{\cdot}41\ \mu$). Curves are given illustrating these results which have been confirmed by direct measurements of focus-differences of telescope-objectives made by Vogel, Hasselberg, and Wolf.

Chapter vi. contains an unusually complete and systematic treatment of prisms and systems of prisms, partly based upon Dr. Czapski's own investigations. The next chapter is devoted to stops and aperture, and the properties of an optical system which depend upon aperture, such as penetrating power and brightness. It is shown that in any instrument used for subjective observation the penetrating power (*i.e.* the total depth of vision) is exactly equal to the sum of the depth of focus of the objective and the accommodation-depth of the eye—a result which is of the greatest practical importance in microscopy. Next comes what is perhaps the most interesting and important chapter—that which deals with the principal types of optical instruments. The book closes with an account of the methods for determining the constants of optical instruments. Some of these will come as a revelation to students who are only familiar with the comparatively rough methods described in the ordinary text-books on practical physics.

Dr. Czapski appears to have at first intended to include in the book a tolerably full account of Abbe's theory of microscopical vision. One cannot help regretting that this intention was abandoned. A letter of his on "The Future of the Microscope," which is printed in van Heurck's sumptuous book ("The Microscope," English edition, pp. 357–364) shows his ability to present such a matter, not only with his usual accuracy, but in a fairly popular form. We understand that a separate volume on this subject may be expected from Prof. Abbe or Dr. Czapski, or both. *pv.*