THE PULKOVA REFRACTOR.

ON the completion of the Pulkova Observatory, the jubilee of which has recently been celebrated, the late W. Struve published his "Description de l'Observatoire," which made the scientific world acquainted with the complete equipment of that institution. The additions which have been recently made to the Observatory, in order to preserve its high character and deserved reputation, have induced the authorities to publish what may be regarded as a supplement to that work, and the details now given of the history of the erection, and the results of a systematic examination, of the new refractor are not less interesting than were those of the old 15-inch.

The optical work of this recent addition, as is well known, is the work of Messrs. Alvan Clark, and the parallactic mounting that of Messrs. Repsold, and both of these eminent firms appear to have given, in their respective departments, complete satisfaction to the Russian authorities. Considerable difficulty was experienced in procuring the necessary disks for the object-glass, but eventually M. Feil, of Paris, supplied both flint and crown. The former appears to have given perfect satisfaction, but in the latter, near to the centre of the disk, there is collected, about a quarter of an inch below the surface, a quantity of small air-bubbles, which cover a space one and a half inch long by one-eighth broad. As in the opinion of the opticians, as well as of Prof. Pickering, this defect would not introduce any inconvenience, it was determined to proceed with the manufacture, rather than to wait for a more satisfactory casting. This defective spot, of elliptical shape, has no bad effect on the images of stars in the general use of the telescope, but bright objects, such as α Lyræ, are accompanied by two streams of false light, some minutes in length, in opposite directions, which appear to be produced by this defect in the crown lens. The position angle of these rays is found to be 114°-294°, and this direction is almost exactly perpendicular to the major axis of the air-bubble, which has been measured 23°-203°. Moreover, as this peculiarity is the more noticeable when the diameter of the object-glass is diminished by diaphragms, there can be no doubt that it is the result of diffraction produced by this spot.

The mounting of the object-glass in its cell differs in two respects from the plan generally adopted. The internal surfaces of the two lenses are separated by about six inches. Though this separation does not render the telescope available for photography, it doubtless tends to improve the achromatism; and, further, since openings are left in the cell for the purpose of cleaning the inner surfaces, currents of air can pass between the lenses and promote an equality of temperature between them and the atmosphere outside. The two lenses are not rigidly mounted in their cell of cast-iron, but, to prevent any risk of pinching or strain that might arise from the unequal expansion of metal and glass, a space of 0·5 mm is left. It was conjectured that a displacement of the lenses, relatively to each other, through this small amount would exercise no bad effect on the quality of the images, and this anticipation has been found correct.

The constants of the object-glass are as follows:—

		m.
Radii of the crown-glass lens	...	− 5·1054 + 5·2831 (computed).
		mm.
Thickness of the crown	... ...	42·42
Thickness of the flint	... ...	26·06
		m.
Radii of the flint ...	... ...	+ 4·8386 − 140·130

The focal lengths computed from these data, one of which, however, has been inferred, give the following results:—

			m.
Red,	$\lambda = 636$	... Focal length	13·892
Yellow,	$\lambda = 589$	... ,, ,,	13·885
Green,	$\lambda = 535$	... ,, ,,	13·884
Blue,	$\lambda = 481$	... ,, ,,	13·892

from which it will be seen that the achromatism is satisfactory for the brighter parts of the visible spectrum, and in fact accords with that part of the spectrum which was originally selected for the minimum focal length, viz. $\lambda = 0{\cdot}00057$.

The relative position at the focus for rays of different refrangibility was more accurately determined by the method of Prof. Vogel with the aid of a small spectroscope, as well as with the great spectroscope attached to the instrument. It was then seen that the part of the spectrum between D and b was so nearly linear that no certain determination of the difference of lengths for the different colours could be effected. For more distant parts of the spectrum the following measures were made of the distances of the three hydrogen lines from the normal position D − b:—

		mm.		
C	df =	3·0	...	$\frac{df}{f}$ = 0·00021
F	=	6·4	...	= 0·00045
H_γ	=	32·9	...	= 0·00233

It is not uninteresting to compare this result with that which Prof. Vogel obtained from measurements on the Vienna refractor of 26 inches, where the general character of the achromatism is very similar to that of the Pulkova refractor, since in both the red images are joined between D and F, and beyond F a rapid increase in the secondary spectrum is exhibited—a defect common to all objectives of silica glass.

In the Vienna object-glass the distances of the focus of the three rays before mentioned from the focal plane D − b are—

		mm.
C	... ...	2·7
F	... ...	6·0
H_γ	... ...	23·5

Consequently the diameters of the circle of chromatic aberration, reckoned on the same plane, are, for the two telescopes, as follows:—

Pulkova.	mm.		Vienna.	mm.	
Aperture	762		Aperture	675	
Focal length	14,120	"	Focal length	10,360	"
Diameter C	0·162	or 2·37	Diameter C	0·176	or 3·51
,, F	0·345	,, 5·05	,, F	0·391	,, 7·81
,, H_γ	1·775	,, 25·95	,, H_γ	1·831	,, 30·48

The advantages of a proportionately greater focal length in the case of the Pulkova instrument are shown by the somewhat smaller values of the angular diameter. This want of perfect achromatism makes itself felt in the Pulkova instrument in the images of stars remote from the optical axis. For a circle about 16′ in diameter, no appreciable effect is noticeable, but outside this radius the image has a tendency to exhibit a red fringe on the side turned towards the optical axis, and a violet on the side more remote.

The parallactic mounting appears to possess and retain a very satisfactory stability. In the case, however, of exceptionally heavy object-glasses, it is of interest to rigidly investigate the flexure of the tube. The total weight of the object-glass and cell is in this case 400 lbs. approximately, and considering the great distance from the centre of the instrument at which it is supported, the coefficient of flexure might be expected to be large. As a

matter of fact, this constant when derived from the observed zenith distances of known stars is 40″, but this amount, of course, refers only to the difference of flexure at the eye and object-glass ends. Direct measurements have, however, been made of the deflection of either end. For this purpose a small telescope was attached to the cradle of the instrument, with which a scale placed at either end could be read, the instrument being in both a vertical and horizontal position. The result was that the object-glass dropped 5·48 mm., and the eye end 3·22 mm.; when all necessary corrections have been made, this gives a flexure of 34″, a satisfactory agreement with that obtained from observations of stars. This deflection from the straight line was observed at eight different angles with reference to the horizon, and the results are fairly represented by supposing the flexure to vary simply as the sine of the zenith distance.

As regards the light-collecting capacity, it may be mentioned that the satellite of Neptune can be observed in an illuminated field without difficulty, and that the satellites of Mars were observed on fifteen evenings in 1886, a year in which the opposition fell very unfavourably for their observation. Hyperion is visible on a feebly illuminated red field, while Enceladus and Mimas are visible till quite close to the planet's disk. That there are difficulties in the employment of such large telescopes goes without saying: it is, however, satisfactory to notice that the number of evenings on which the telescope cannot be used from bad definition or adverse meteorological conditions is not larger than in the case of the 15-inch equatorial. W. E. P.

SIR WARINGTON W. SMYTH, F.R.S.

MINING has suffered an irreparable loss by the death of Sir Warington Smyth, which occurred suddenly at his house in Inverness Terrace on the 19th inst. He was the eldest son of Admiral W. H. Smyth, F.R.S., and was born at Naples 73 years ago. He was educated at Westminster and Bedford Schools and at Trinity College, Cambridge, where he exhibited great skill as an oarsman, being one of the winning University crew on the Thames in 1839. In that year he graduated, and obtained a travelling fellowship which enabled him to devote more than four years to a journey through the chief mining districts of Europe, and thus to lay the foundation of that practical knowledge which subsequently made him the greatest British authority on mining matters. Continental travelling in 1839 was by no means the easy matter it is now, and his journey through the Harz, Saxony, Austria, Hungary, Turkey, and Asia Minor, was not devoid of risk and adventure. As a result of his travels through the European and Asiatic dominions of the Sultan, he published in 1854 a work entitled "A Year with the Turks." In subsequent years, he visited during his vacations the more important mines of France, Belgium, Spain, Italy, and Norway. His official career began in 1844, when he was appointed by Sir Henry De la Beche to a post on the Geological Survey, and while holding this position he explored and geologically mapped the metalliferous districts of Devon and Cornwall, North Wales, and Ireland, and the coal-fields of Lancashire and Yorkshire, North Staffordshire and Derbyshire. In 1845 he joined the Geological Society, and in 1866 was elected President of that body. For the last 17 years he has acted as foreign secretary, in which post his rare linguistic powers proved of great service to the Society. On the foundation of the Royal School of Mines in 1851, he was appointed the first lecturer on mining and mineralogy. On the reorganization of the School in 1881, he gave up the Chair of Mineralogy, but acted as Professor of Mining until his death. He held the office of inspector of the mines in the Duchy of Cornwall, and in 1857 he was also appointed comptroller of all the mineral properties belonging to the Crown. It would be tedious to enumerate the long list of Royal Commissions and International Exhibitions with which Sir Warington was prominently associated. His report as Secretary of the Jury on the mining industry at the Exhibition of 1862 is a model of what such a work should be, and to his energy on the Council of the Inventions Exhibition of 1885 the success of the mining section was largely due.

In 1879 a Royal Commission was appointed to inquire into accidents in mines and the possible means of preventing their occurrence and of limiting their disastrous consequences. Mr. Smyth was appointed Chairman, and, in order to secure time to attend to the duties of this arduous and honorary office, he resigned the post of Examiner to the Science and Art Department—an office he had held for several years. The Commission ended its work in 1886, and during the seven years it was in existence some thousands of experiments were made, and the Report, covering 858 pages, definitely settled many important questions bearing upon the diminution of accidents in mines.

To his scientific attainments, Sir Warington added singular literary skill. His early classical training enabled him to write with an elegance and vigour unfortunately rare in technical works. He spared no pains, and neglected no details. As a teacher he was very popular with his pupils, his success as a lecturer being due not only to his finished delivery, but also to his skill as a draughtsman, which enabled him to dispense with the aid of elaborate diagrams, and to rely merely on accurate blackboard sketches, which he drew with great rapidity in the presence of his class. His reputation as Professor attracted to the School of Mines students from all parts of the world, and no better evidence of the excellence of his teaching could be adduced than that afforded by the important positions so many of his pupils occupy in the mining world. Of his literary works, the most important is his "Rudimentary Treatise on Coal-Mining"—a standard work, bearing internal evidence of not being mere extracts of books, written in 1867, and now in its seventh edition. Besides this, he wrote the articles on mining for "Ure's Dictionary" and for Stanford's series of "British Manufacturing Industries," 1876.

For his labours on the Accidents in Mines Commission, and for his other public services, he received the somewhat tardy acknowledgment of knighthood on the occasion of Her Majesty's Jubilee. Throughout his life he refused the great pecuniary rewards offered by the commercial branches of mining, and preferred to devote the half-century during which he was engaged in business connected with mines to the service of science and of the State. Although he had been in ill-health for some time, he never neglected his official duties. He died in harness, with a partially corrected examination paper on the table before him. He was buried yesterday at St. Erth, in Cornwall, not far from his home at Marazion, in the centre of the mining district with which he was so long associated. B. H. B.

NOTES.

WITH the consent of the Prince of Wales, the President, the Council of the Society of Arts has awarded the Albert Medal to Dr. W. H. Perkin, F.R.S., "for his discovery of the method of obtaining colouring matter from coal tar, a discovery which led to the establishment of a new and important industry, and to the utilization of large quantities of a previously worthless material."

THE Essex Field Club and the subscribers to the Gilbert Club will hold a meeting at Colchester on Saturday, July 5, in memory of William Gilbert, the founder of the science of