Astronomy

Astronomical Photography.

(By Rev. Dr. Kennedy, Hawkes Bay.)

Astronomical telescopes are of two kinds, reflectors and refractors. A reflecting telescope consists essentially of a concave reflector usually made of silvered glass, which reflects the rays of light from the object observed so as to form an image of it in the principal focus of the mirror. In a refracting telescope the rays pass through a lens which refracts or bends them in such a way as to produce an image of the object in the principal focus of the lens. In both cases this primary image is magnified and observed by means of an eye-piece.

A very important difference between a reflector and a refractor, especially when used for photography, is that a reflector brings to the same focus the various coloured rays which make up white light: whereas an ordinary refractor does not bring the rays of all colours to the same focus, on account of the unequal refrangibility of the different coloured rays which constitute white light. An object glass which is intended for visual purposes is made to focus as many as possible of the bright rays which are most effective to the human eye, namely, the green, yellow and red rays. The blue and violet rays do not come to a focus at the same point as the green and yellow rays, and, consequently, there is usually a blue or purple halo round the image of a bright object when observed through an ordinary refracting telescope. Now, it happens that a photographic plate is more sensitive to the blue and violet rays, than to the green, yellow, and red rays, and on that account a lens which is intended for photographic purposes must be made to bring the blue and violet rays to the same focus. An object glass which is made for visual purposes is, therefore, not suitable for photography; and *vice versa*, an object glass which has been specially corrected for the photographic rays is not suitable for direct eye observation. Hence, many astronomers prefer to use a reflector which can be used for both purposes, and many of the best astronomical photographs, especially of nebulæ, have been taken with reflecting telescopes. But as a refractor has other advantages over a reflector, various plans have been devised to make a refractor equally available for the two kinds of work. One way is to separate the lenses of the object-glass a little, until the violet rays come to a focus. The object glass can be used further for eye observation by bringing the lenses together again. This plan has been adopted with great success by M Janssen at Meudon, in France, for his photographs of the sun. Another method, which has been adopted at the Lick observatory, is to use a third lens which, when placed in front of the object glass, brings to a focus the photographic rays. The latest method is that employed by Messrs. Cooke and Sons, of York, who have succeeded in making an object glass which is as achromatic as a reflector, and can therefore be used for photographic as well as visual purposes, without any alteration in the lenses. This photo-visual objective, as it is called, consists of three lenses formed of three different kinds of glass, and it serves to illustrate the perfection which the optician's art has now attained. Six surfaces of glass are so accurately figured that every ray of light falling upon the objective passes through the finest pinhole, at a distance of seventeen or eighteen times the diameter of the lens. Objectives of this kind have been thoroughly tested by Sir Norman Lockyer, Sir. David Gill and other eminent astronomers, who speak of their performance in terms of the highest praise. A Cooke photo-visual objective, 9 inches in diameter and 12 feet 6 inches focal length, is in use at the Meanee observatory, and gives complete satisfaction, both as a visual and as a photographic telescope.

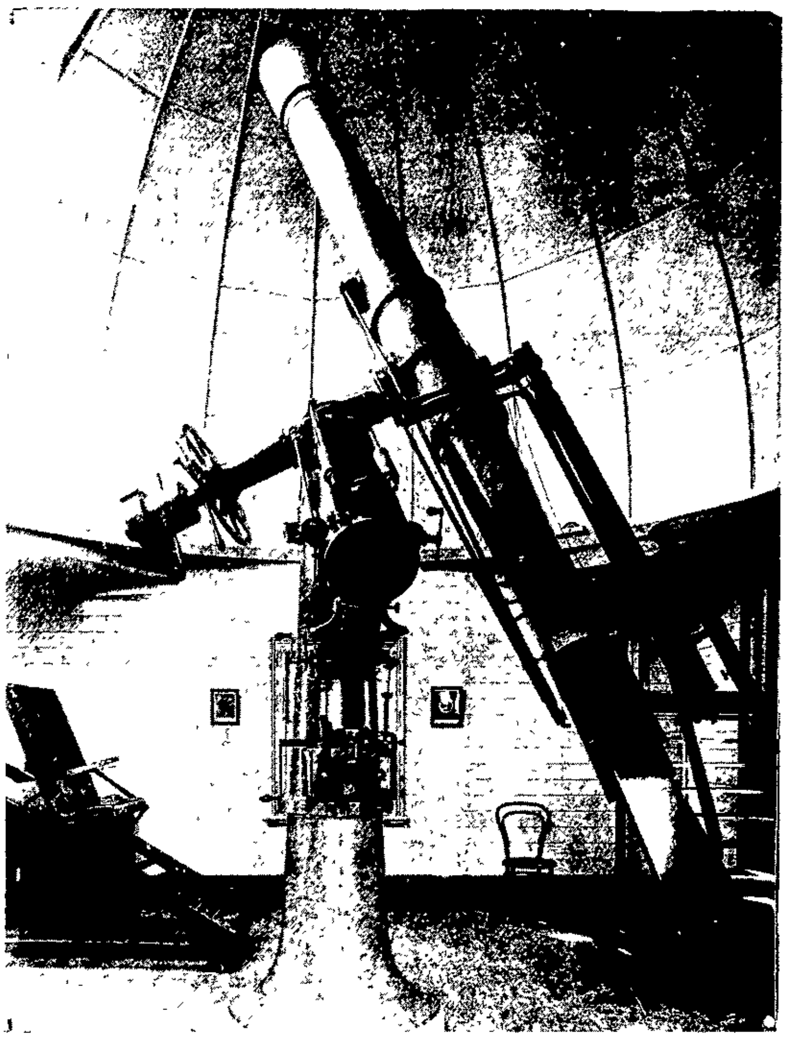

FIG I.—MEANEE OBSERVATORY TELESCOPE USED AS A PHOTO-HELIOGRAPH.

The first celestial object photographed with anything like a useful, practical result following from the picture, was the sun. As early as 1845 Fireau and Foucault succeeded in taking Daguerreotype photographs of the sun, and in 1851 Berowski photographed the solar prominences during a total solar eclipse. In 1857 De la Rue designed the Kew photo-heliograph, which consisted of a telescope with an object glass of $3\frac{1}{2}$ inches aperture and about 5 feet focal length, and corrected for the photographic rays. The eye-end was furnished with a camera and enlarging lens, which magnified the image of the sun to about 4 inches. In 1873 the Kew photo-heliograph was transferred to the Royal observatory, Greenwich; but it has been since superseded by a photographic refractor of 9 inches aperture and nearly nine feet focal length. With this instrument a photograph of the sun 8 inches in diameter is taken every fine day at Greenwich.

Fig. 1 is a photograph of the Meanee observatory telescope used as a photo-heliograph. The image of the sun in the principal focus of the 9-inch photo-visual objective is $1\frac{1}{3}$ inches in diameter. This is enlarged in the attached camera, by means of a magnifying lens, to $5\frac{1}{3}$ inches in diameter. The full aperture of the object glass is not used when photographing the sun, but it is stopped down three or four inches. The light of the sun is so intense that a very slow photographic plate and a very rapid shutter have to be used. Generally, very slow lantern plates (whole-plate size) are used, and developed with hydroquinone. The shutter (see Fig. 2) consists of an aluminium disc 6 inches in diameter, with an adjustable slit, and rotating round a centre eccentric to the enlarging lens. When the shutter is released, the slit flies rapidly across the image of the sun at the principal focus, giving an exposure to the plate for a very small fraction of a second. It is possible to give with this shutter any exposure from one twentieth to one five-thousandth of a second. The duration of the exposure generally varies from one three-hundredth of a second in winter, to one three-thousandth of a second in summer, with a 3-inch stop, which is equivalent to working the lens at f/50.

When the photograph of the sun has been taken it has to be measured, the four following particulars being determined for each spot: First, its distance from the centre of the sun; second, the angle between it and the north point; third, the size of the whole spot; and fourth, the size of the umbra of the spot, that is to say, of its dark central position. The area of a spot is measured by placing a thin piece of glass on which a number of cross lines have been ruled one hundredth of an inch apart, in contact with the negative. These cross lines make up a number of small squares, each the ten-thousandth part of a square inch in area. The negative is then examined with a magnifying glass, and the number of little squares covered by each spot is counted. Some idea of the gigantic size of the sun can be formed from the fact that a spot which would cover only one of these little squares would be $2\frac{1}{2}$ million square miles in area, and yet would be only between two and three millionths of the visible hemisphere of the sun.

Fig. 3 is a photograph of a group of sun spots taken at the Meanee observatory last June, as seen through the measuring glass ruled into small squares. The area of the whole group is about 1000 million square miles. The size of the earth on the same scale would be the circle E in one corner of the square.

Fig. 4 is an enlarged photograph of a sun spot also taken in June. The length of the group is 120,000 miles, and the total area is 1250 million square miles.

Fig. 5 is a photograph of the sun taken on the 17th July. The spots belong to the same group as that in Fig. 4, returning after a revolution of the sun. The large spot