THE MODERN TELESCOPE[1]

IV.

THE next point to which Mr. Grubb refers is one to which much interest attaches. It is now a long time ago since Sir J. Herschel investigated the effects of differently shaped apertures upon the images of stars. The figure shows the effects they produce due to diffraction.

An effect is also produced on the image if a round, or triangular, or square patch is placed in the centre of the object-glass. With the former the discs of the stars are smaller, and the position of the diffraction rings is changed, so that double stars can thus be measured, while in ordinary circumstances the companion is hidden by one of the rings.

Now in a reflector, unless, indeed, we use the front view, the central patch is always present, and it is to this and to the arm which supports it that the peculiar look of a star in a reflector is due. Mr. Grubb does not hesitate to ascribe to this the great difference of opinion that exists as to the performance of the two classes of instruments, and adds :—

"A veteran and well-known worker with refractors declared 'he never looked into a reflector without drawing away his eye in disgust;' and workers with reflectors cannot understand how the refractor workers can bear that dreadful fringe of colour from the secondary spectrum. The same applies to other matters. Newtonian observers cannot understand how those who observe with refractors or Cassegrain reflectors can bear to strain their neck so in looking up through the tube; while the refractor and Cassegrain workers cannot understand how the Newtonian workers will break their backs sitting or standing bolt upright when they might be reclining comfortably on an easy chair as they do. After all, when this comes to be investigated it resolves itself into but little more than a question of to which telescope the observer has been most accustomed. Each observer becomes in time *wedded to his own instrument;* he has done his work with it, the credit of his discoveries is due to it, and he naturally falls into the idea that no other can be as good."

We next come to those points in which the reflector is stated to be superior to the refractor. These are absence of secondary spectrum, superior applicability for physical work, possibility of supporting mirrors irrespective of size, and handiness of reflectors due to their short focal length, and especially if the Cassegrain form be employed. With regard to the first point, the experiments of Mr. Vernon Harcourt and Prof. Stokes, in which they attempted to produce two kinds of stars with rational or nearly rational spectra, have failed to lead to any great hopes being formed as to ultimate success, and the superior advantage

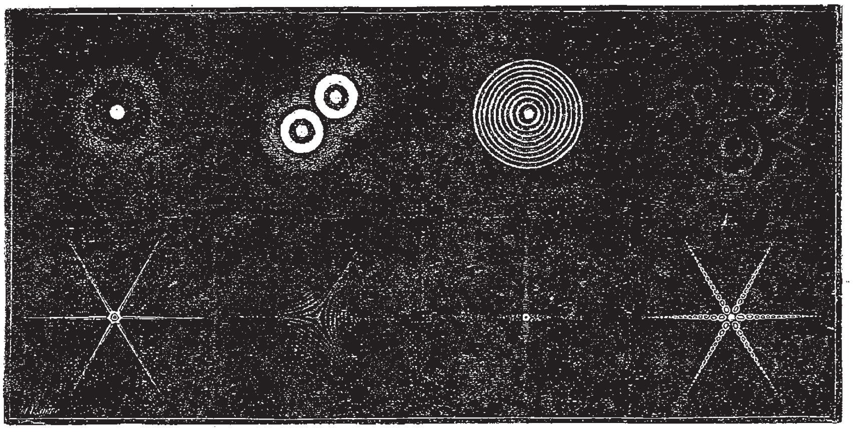

FIG. 10.—Diffraction effects produced by apertures and stops of different shapes (Herschel).

of the reflector in the fact that there is no colour will doubtless long remain. The superior applicability for physical work is much more doubtful. At present we know too little about reflection from metals and many other points to lay down the law with certainty, and in my own opinion Mr. Grubb's dictum is far too absolute with regard to spectroscopic work.

In another part of his valuable paper Mr. Grubb measures the advantage of the reflector with regard to the question of support; he shows that an object-glass may be supported by a central arm without loss of definition. and even that the tube may be filled with compressed air. He says: "The pressure required would be very small. Suppose the objective to be forty inches aperture, and 600 lbs. weight, and that it was purposed to lift $\frac{2}{3}$ of its weight on the air cushion, a pressure of about $\frac{1}{3}$ of a pound to the square inch, or say $\frac{1}{60}$ of atmosphere would suffice, even when the telescope is at its maximum elevation."

The remarks of Mr. Grubb on the practical difficulties which supervene when increased aperture is required, are best given in his own words :—

"It may be said that the difficulty of manufacture is a question for the instrument-maker alone, and not to be discussed by those whose business it is to decide on the form of instrument employed; but it should be remembered that any advance in the size of telescopes, refractors, or reflectors, over those at present in existence, must be considered to be to a certain extent, an experiment, and the nature of the difficulties which will be encountered can at present only be speculated upon, even by the most experienced; and therefore it behoves those whose province it is to decide on the matter to inquire diligently into the relative practicability of the various forms of telescopes in order that they may not decide on a form which might be, if ever accomplished, of great usefulness, but which on trial would be found to be, in the present state of art, impossible to manufacture.

"With respect to refractors, the first great difficulty to be met with is that of procuring suitable discs of glass. Of our glass manufacturers only two firms seem to possess the secret of manipulation of optical glass, viz., Messrs. Chance, Brothers and Company, of Birmingham, and M. Feil, of Paris, a descendant of the celebrated Guinand. Of these one at least speaks confidently of producing discs up to one metre in diameter; but when I consider the difficulty which I know was experienced in moulding the 27-inch discs for the Vienna objective I cannot say that I feel the same confidence. These 40-inch discs would require to be obtained in one single

[1] Continued from p. 189.

piece, just three times the quantity of homogeneous glass that the Vienna discs required, and though I am not of course in the secrets of the glass manufacturers, it appears to me that the chances of obtaining 40-inch discs in the present state of the art are remote.

"The other difficulties of manufacture of refractors consist in the nicety of the operation connected with the calculations of the curves, the manipulation of such extremely costly material, and the enormous labour and trouble of the figuring and perfecting of the objective. All these, however, I have no doubt will be overcome by the optician for any size which the glass-maker is at all likely to produce.

"Now, as to the difficulties connected with the manufacture of reflectors, whether metallic or silver on glass.

"First, as to the difficulty of producing the metallic or glass disc to work upon.

"Lord Rosse has succeeded years since in casting, annealing, and perfecting discs of six feet in diameter, and any difficulties he met with were not such as to lead me to the belief that the limit of possible size has been by any means reached. As regards glass mirrors, the question has never been discussed, for in any sizes that have been made up to the present time, it was only necessary to go to the plate-glass manufacturers and say, 'I want a disc of crown glass of such a diameter and such a thickness,' and forthwith the glass disc was delivered without any trouble; but, when we come to these extraordinary sizes, it is quite a different matter. For the 4-foot disc of glass for the Paris reflector, in place of that which has so recently resulted in failure, the St. Gobain Glass Company require twelve months' time to perfect (although, be it remembered, the quality of the glass is here of no consequence whatever); and I have been myself in correspondence with the principal glass manufacturers here and on the Continent, and not one of them is willing to undertake even a 6-foot glass disc; so that it would appear that, above that size, the silver-on-glass mirrors are out of the question.

"This much, however, is to be said: If anyone were to go to a brass- or bell-founder's and ask them to undertake a speculum of six feet in diameter, he would almost certainly be met with a refusal; and yet Lord Rosse has proved the feasibility of it. And so, reasoning by analogy, might the manufacture of a six- or eight-foot glass mirror be possible, if undertaken in the same scientific spirit in which Lord Rosse undertook his. I answer to this—Yes; perfectly true; but this is too purely a speculative matter to be considered at the present day in the choice of telescopes.

"The other great difficulty in the manufacture of reflectors is the annealing of the disc, and I believe it is this difficulty which limits to so narrow an extent the production of glass discs for silver-on-glass mirrors."

We can abundantly gather from this paper of Mr. Grubb's that our opticians are doing all that lies in their power to give us increased power in the future. The fact that in the last few years one refractor of 25 inches, and two of 26 inches, have been acquired to science, leads us to hope that for the present progress will lie in increasing the dimensions of that instrument. Mr. Grubb, indeed, has already in hand one of 27 inches for the Austrian Government. The *contretemps* to the four-foot Foucault in Paris will also help to set the tide in the same direction.

From what has preceded it will be seen that each increase in the power of the telescope is of little avail unless we use it in purer and purer air. It is quite true that in the telescope much of the injury to definition arising from currents in the tube may be got rid of by the employment of lattice-work; but this, of course, will not lessen the atmospheric effects of the column of air ever increasing in diameter between the telescope and the object.

Prof. Piazzi Smyth's astronomical experiences on Teneriffe will still be in the minds of many of our readers. He showed that an enormous advantage was secured from observations so soon as half the atmosphere was below the observer. A more recent experiment by Dr. Draper, however, has shown that it will not do to go blindly and put the telescope on any high mountain. The conditions of each place from this single point of view must be carefully studied. Summing up his experiences of the Rocky Mountains up to heights of 10,000 feet, Dr. Draper says:—

"On the whole, it may be remarked of this mountain region that the astronomical conditions, especially for photographic researches, is unpromising. In only one place were steadiness and transparency combined, and only two nights out of fifteen at the best season of the year were exceptionally fine. The transparency was almost always much more marked than at the sea-level, but the tremulousness was as great or even greater than near New York. It is certain that during more than half the year no work of a delicate character could be done. . . . Apparently therefore, judging from present information, it would not be judicious to move a large telescope and physical observatory into these mountains with the hope of doing continuous work under the most favourable circumstances." J. NORMAN LOCKYER

(*To be continued.*)

ELECTRICAL ANALOGIES WITH NATURAL PHENOMENA

WITHIN the last few years M. Gaston Planté has at intervals described a series of very curious phenomena produced by electric currents of high tension, and has pointed out numerous analogies which they present with several atmospheric and cosmical phenomena. Without committing ourselves to the belief that these analogies are real, the phenomena described are so interesting that we are glad to be able, by the kindness of M. Planté, to reproduce some illustrations of them.

To obtain electric currents of high tension M. Planté has employed secondary batteries of sheets of lead, which, as is known, constitute powerful accumulators of voltaic electricity. By associating a very great number of batteries uniting from 400 to 800 of these secondary couples, a discharge is obtained equivalent, according to M. Planté, to that of from 600 to 1,200 Bunsen couples arranged in tension.

Fig. 1 represents the arrangement of 400 secondary elements divided into ten batteries. This is the source of electricity employed for some of the earlier experiments which we are about to describe. The more recent ones have been made with 800 secondary elements arranged in twenty batteries of forty couples. A second series of batteries similar to the first is arranged in another room, and the current which it furnishes is joined to that of the first series by conducting wires suitably adjusted. These batteries, associated at first in simple circuit by means of commutators, do not require to be charged all at once like two Grove or Bunsen couples. When they have not been out of use for too long a time a few hours suffice to charge them. We may then, by turning the commutators, unite all the secondary elements in tension and use at will, either in a few seconds or in a longer time, the enormous quantity of electricity resulting from the chemical work accumulated during two hours by Grove or Bunsen batteries.

Such was the powerful means adopted by M. Planté in making his late experiments. In his earlier experiments he used a much simpler apparatus.

The gyratory movements accompanied with luminous effects which M. Planté had observed with a powerful current of electricity, and the spherical and annular forms manifested by bodies submitted to that action, suggested to M. Planté the probability of the electric origin of the forms of some of the nebulous masses of matter which