The Construction of a Cheap Telescope.

BY

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PAPER VI.

IF the workman who is making this telescope has carefully read what was said in my two previous papers and has experimented with his mirror and testing apparatus as recommended in my last, he ought now to be in a position to make a careful test of the surface of his mirror and to have no difficulty in getting the latter and the testing apparatus in the correct positions for the purpose. He will also have become accustomed to the appearance of the face of the mirror and the general peculiarities and behaviour of the shadings which are produced by passing the knife edge across the cone of rays. We will now, therefore, proceed to test the mirror in a practical way relying on the instructions and principles already given.

The mirror and apparatus having been set up as required, put on the outside zone disc (No. 1) and having first set the pointer of the testing apparatus to zero on the scale, without touching this again, get the knife edge into the centre of curvature of the outside zone, moving only the base screws for this purpose, until the shadow comes on equally from each side of the mirror.

Now take off the disc and observe the shadows on the whole mirror as you pass the knife edge across, remembering that a shadow on the right means that the focus of that part is shorter than the one you have set the apparatus to, *i.e.*, the outside zone, and on the right the reverse: also remembering that at this stage the best result would be for the mirror to darken all over equally without any unequal rings or patches. This will give you a general idea of the mirror, but you should now also test it zone by zone by means of the scale. For this you must know the amount of aberration of each of the inner zones from zone 1. I gave the formula for this in my last paper, and for our 8-inch mirror the distances are:—

Zone.	Dia. of zone.	Aberration.	Distance from zero.
1	7″	·076″	0″
2	5″	·039″	·037″
3	3″	·014″	·062″
4	1″	·001″	·075″

A very useful table for other sizes is to be found in a paper by the Rev. P. C. Davies, F.R.A.S., in the monthly notices of the Royal Astronomical Society, Vol. LXIX ; indeed I would recommend this paper to the attention of members as one of the most complete on the subject of testing mirrors ever published.

Having done with zone 1 as above and having recorded the shadows in a note-book (these notes are most important) proceed with zone 2, but to get the knife edge into the centre of this zone be careful *only to move the index screw on the scale*, and do not move either the testing apparatus or the base screws. The best result will be of course to find that your shadows in this zone come on equally when the index reads ·037″ inwards, but it is very unlikely that you will get this the first time, and a satisfactory result would be to find the index still at zero or near it as this will indicate a spherical curve. Now remove the disc and again observe the shadows on the whole mirror and note as before. These shadows should be carefully studied, their courses being thought out in conjunction with the zonal tests and the hints I have already given above. Treat the other zones the same way.

Now if all the zones read somewhere near zero and the shading of the mirror comes on equally all over at each stage, the figure is spherical and very satisfactory. If the distances actually measured between the zones are less than those given above, the figure is an oblate spheroid and the mirror wants deepening. If they exceed those in the table the figure is hyperbolic and this is a bad business. In the last case if the differences are not great, try the mirror again on the polisher for a time with a very short stroke and then re-test. If it is not improved or if the differences are considerable, you will save time and trouble if you go back to the last stage of the fine grinding and use a fairly short stroke : also be careful not to put pressure on the mirror. In the second case, go on with the polishing and if the polish is well up, use a rather longer stroke than before, but do not polish for more than half an hour without testing again to see how you get on. Several hours should elapse between the polishing and testing to allow the mirror to cool down. In the case of a spherical mirror little more remains to be done. Polish for about ten minutes with a longer stroke and then test. You will soon approach the zonal distances required and the shading will then indicate a surface with a figure slightly deeper than a sphere, *i.e.*, you will get the first shading as a delicate patch on the right-hand half of the mirror. Your mirror is now finished and with the flat mirror (which I recommend you to buy) can be

silvered. This process is not difficult and success depends almost entirely on cleanliness in all the operations. The first thing to be done is to get absolutely pure chemicals. You will for your 8-inch mirror and flat require the following quantities, but it will be as well to get a little extra :—

Nitrate of silver 180 grains in 3 ounces of distilled water.

Caustic potash (pure by alcohol) 150 grains in $2\frac{1}{2}$ ounces of distilled water.

Liq. Ammonia (·880) 4 ounces.

If you can get it absolutely pure, then also glucose 75 grains in $2\frac{1}{2}$ ounces of distilled water. But I fear this cannot be got really pure in India, and even in England I have had trouble. It is better therefore to make some sugar-candy into a reducing solution as follows :—

Put into a graduated measure 5 ounces of sugar-candy in 5 ounces of distilled water ; add $\frac{1}{2}$ an ounce of tartaric acid, and after noting the height of the liquid in the measure, boil in a clean enamel saucepan until the candy has all dissolved and about 5 minutes longer. Then carefully return the stuff to the measure and fill up with distilled water to the original quantity noted. Mix well and add 5 ounces of absolute alcohol and again mix thoroughly. Now put it in a stoppered bottle and let it stand for a week before using.

This reducing agent is recommended by the Rev. W. Ellison and I have found it work well in India instead of the glucose. It has the advantage of being easy to obtain. For use take 8 drams of the solution and fill it up to $2\frac{1}{2}$ ounces with distilled water. The other things required will be a glass funnel, a good supply of pure cotton wool, a glass stirring rod, 8 ounces of nitric acid (strong), a couple of glass test tubes not too large and a good supply of distilled water.

Don't stint the last but get several gallons so as to have plenty handy. All these can be got from your chemist.

The nitrate of silver and the caustic potash can be got pure from Messrs. Smith, Stanistreet of Calcutta, and in ordering them care should be taken to explain that purity is a necessity.

In silvering operations the first process is cleanliness in everything that is used. First, however, place the mirror face down and hanging by its support in the silvering dish so that the face of the mirror is about half an inch from the bottom of the

dish. Now fill up with water until the face of the mirror is about ⅛ of an inch below the surface of the water. Remove the mirror from the dish, measure the quantity of water and note the amount. Now to clean the mirror pour a few drops of nitric acid on the surface, and with a plug of cotton wool fixed in the end of the test tube go carefully all over it and then swill it with water. Do this several times and then wash with distilled water and hold it up on edge. If the water clings evenly to the surface the mirror is clean, but if dry spots, etc. appear, it wants more attention. When quite clean put the mirror face down in some distilled water until it is wanted. Now clean the silvering dish and all the glasses, measures, etc., in the same way. Too much care cannot be given to this business for if everything is not chemically clean, troubles will be certain to arise. This having been done take 2½ ounces of the nitrate of silver solution and put it in a clean glass. Now drop ammonia into this until the precipitate which forms at first is cleared up and the solution is again like clear water. Next drop some of the spare nitrate of silver solution one drop at a time into the liquid and keep stirring until the liquid becomes a pale yellow colour when held up to the light. Care must be taken over this. Next add the whole of the caustic potash solution and stir. It will turn quite black in colour. Drop ammonia into this drop by drop until it shows signs of clearing and the liquid is full of black particles. Be careful not to go too far and stir well after each dropping. Filter the liquid into a clean glass. You can do this through a plug of cotton wool pushed into the glass funnel. Now you are ready to silver. Take the dish and pour into it a quantity of distilled water equal to the water you noted as first directed less 7½ ounces. Now add the silver solution and stir well. Next add the reducing solution, quickly stir and then suspend the mirror in it face down. Put the mirror into the liquid slant-wise so that air-bubbles may not form under it. Leave it for about 10 minutes and then very carefully break the silver film that will have risen at the margin of the dish and see what the liquid looks like. If it is clear with a muddy-looking deposit at the bottom the silvering is done. Now lift the mirror out of the dish and well swill it with distilled water and after that with ordinary water. Do not on any account touch the film with anything. Place the mirror on edge on a piece of blotting paper to dry. The flat can be silvered in the same way and I generally do it at the same time as the mirror, mixing a little extra solution for the purpose sufficient for a small cup or jar in which it can be conveniently done. Now throw away the used solution and wash the dishes and put them away. Do not keep the solution as it is liable

to form a fulminate of silver if kept, and this is very dangerous and liable to cause an explosion. When the mirror is dry make a soft small pad of leather filled with cotton. The inside of a lady's old suede glove is best. Now go gently over the silver film with this and a dust of rouge. The film will quickly take a beautiful black polish and your mirror will be done.

To suspend the mirror in the dish a strip of wood must be fastened to the back and the arrangement made as in Fig. 16.

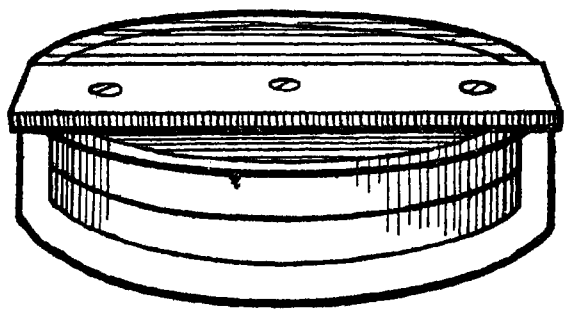

Fig. 16.

The strip can be fastened to the wooden back by three small screws and the whole can afterwards be removed from the mirror by a sharp knock on the wood with a mallet. This will crack the pitch and the supports will come clear away from the glass.

In my next and last paper I will describe how to mount the mirror for use.

A Note on the Discovery of the Martian Canals.

BY

MR. D. N. DUTT.

IN the collection of Professor Lowell's lectures on Mars first published in book form in 1908, the chapter on the Canals and Oases of Mars opens with the following remarks :—

" Thirty years ago what were taken for the continents of Mars seemed, as one would expect continents seen at such a distance to appear, virtually featureless.