A Cheap Telescope.

PAPER I.—BY H. G. TOMKINS, C.I.E., F.R.A.S.

IT has occurred to me that some members who may not perhaps be able to afford an expensive instrument might be inclined to do what I myself did in similar circumstances some years ago—namely, make one. This is by no means either difficult or expensive and only requires a very ordinary amount of ability to use one's hands and a small amount of trouble. In return for this there is no reason why any member of our Society should not, in about two months' time or much less if he can devote all his day to the work, possess a very passable instrument of his own make which will show satisfactorily a great deal more than he could see with a three or four-inch telescope costing probably £30 or £40. I propose then to contribute six short papers on the way to go about this task—I may say a most pleasing one, and I hope several of our members will make use of them and construct their own telescopes. The kind of instrument I have in mind is a silver on glass reflecting telescope—a rough design of which I give below in Fig. 1.

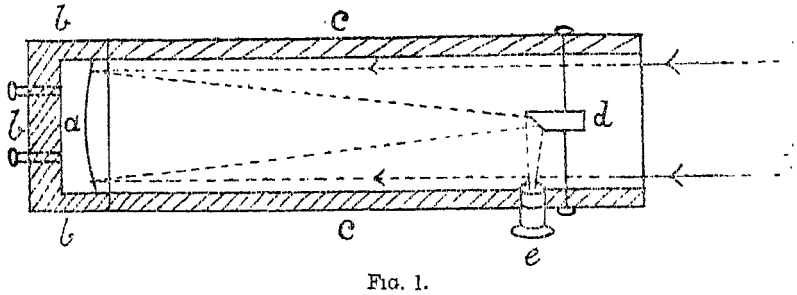

FIG. 1.

Here the parabolic glass mirror with silver surface is at 'A' resting in its cell 'B' on three screws for adjustment. The tube is at 'C,' a small plane mirror at an angle of 45° to the axis of the tube at 'D' and the eye-piece at 'E.' The image of the object enters the end of the tube in the direction of the arrows, falls on the silver mirror at the bottom of the tube and is reflected, to the diagonal mirror 'D,' and then to the eye-piece where it is viewed. A telescope of this kind is known as a reflecting telescope and is cheap and simple to make and powerful for viewing the heavenly bodies. The sketch shows the tube unmounted. The mounting, however, is not a difficult matter, and we may leave this until the end of our description. It will be cheapest to buy outright the

eye-piece and the small diagonal mirror. The latter can, of course, be made at home, but it is some trouble to get accurate and is hardly worth while. I will, however, include a short description later on. First as to the size of a telescope. I would not suggest anything very small or, on the other hand, very large, and I think a beginner will find that a diameter of 6 or 8 inches for his telescope sufficient. I recommend the 8-inch as being equally easy and cheap as a 6-inch and much more powerful. Both have the advantage of materials being got cheaply in India.

We will decide on a diameter of 8 inches. As to length, this depends on the focus of the mirror and as a very sort focus is attended with difficulties in making, I would suggest 10 diameters as a suitable length. This will make a focus of 6 feet 8 inches and the tube about 7 feet 6 inches long. If it is desired to adopt a 6-inch mirror then the focus should be 5 feet and the tube about 6 feet.

These dimensions will give us a basis to work on until the mirror—the most important part of the telescope—has been made. Next as to cost. The following will be wanted :—

	Rs.
Two glass discs, 8″ diameter	
Emery powder, coarse	
,, ,, fine	
Pitch—2 lbs.	
Chemicals for silvering mirror	
Jewellers' rouge for polishing	
Eye-piece	6
Flat Mirror	15
2 lbs. carborundum No. 40 and 100 for edging discs	
Wood for tube	
Total ...	

The whole therefore should not cost more than about Rs. 25 or Rs. 30, and if a member makes his own flat mirror the cost would be about half this amount. The discs, emery powder, carborundum and pitch can be had from Messrs. Ahmuty & Co., Calcutta, at the prices above ; the chemicals can be had from Messrs. Smith, Stanistreet & Co., Calcutta, and the Jewellers' rouge from Messrs. Bathgate & Co., Calcutta. For the eye-piece and the flat mirror, the best place would be Messrs. Broadhurst, Clarkson & Co., 63, Farringdon Street, London, as advertised in our JOURNAL. The power of the eye-piece should, of course, be given and the focus of the mirror in ordering. I would suggest a power of 80 to 100 diameters

as being useful if only one eye-piece is obtained. If more than one, then useful powers are 60, 100, 150, 250. The first gives a wide field and low power. The last a small field and high power. They should be of the ordinary Hu pattern.

Let us now begin with the making of the mirror. First of all two discs of wood should be cut each 8 inches in diameter and 1 inch thick. It is better to true them up in a lathe if possible, and I have no doubt members will be able to get this done by a friend easily enough. Each glass disc should then be warmed by boiling it in water from cold. Hot pitch is then spread on the face of each glass disc and the wooden discs are stuck one on each, care being taken to get them central. The wood disc will, of course, be slightly smaller than the glass with its rough edges. A small piece of wood should similarly be stuck on the other face of each glass disc, and when the pitch has cooled the edges of the disc may be ground smooth. This is simply done by mounting them in a lathe and grinding the edges with a piece of hoop iron mounted on a piece of wood to fit the edge of the mirror. Revolving the disc against this and using carborundum and water, the edge will very quickly become smooth and the disc should then be the same size as the wood, namely, 8 inches. The carborundum should be rough, say No. 40 to begin with, and finish off with No. 100 and flour emery. A slight bevel, say 1-16 inch, should be ground on the edge of the face of each disc. If a lathe is not available, the best way will to order the discs ready edged or if the member wishes to try for himself, he could mount the disc between two centres and get a man to revolve it by means of a strap or he could work the edge of the disc by hand in a curved iron strip with carborundum and water as in Fig. 2.

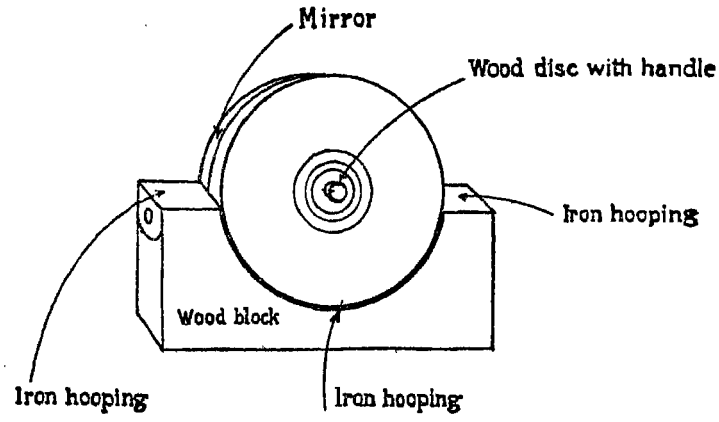

FIG. 2.

This being done, the next step is to grind the curve. With a sharp blow with a wooden mallet knock off the smaller pieces of wood from the face of each disc and now select the better of the discs for the mirror. Fasten the other disc down by the wooden back of the top of a tube or box of such a height from the floor as to allow of the workman conveniently grinding the mirror over it as described below. We now make use of a curious property of two discs ground together face to face. When two discs are ground together one over the other with straight strokes across their diameters, one of them being at the same time revolved, the result is two curved surfaces, and the upper disc becomes concave and the lower one convex. Now mix some rough emery with plenty of water in a pan. An enameled pail and good sized sponge should also be at hand, and it will save trouble if the top of the box is covered with a piece of white American cloth, a hole just large enough to let the disc through being cut in the middle. The part where the American cloth touches the disc can be made water-tight by sticking a strip of adhesive bandage, such as is sold by all chemists round it. Now put a supply of emery on the disc (which we will henceforth call the tool) and taking the mirror in both hands, put it on the tool and grind it face downwards, backwards and forwards over the tool at the same time moving slowly round the tub. A slight side motion should also be given—that is to say, the mirror should not always pass over the centre of the tool, but slightly on one side of it and then on the other. The mirror should also be revolved in the hands about $\frac{1}{3}$ of revolution each time the workman gets round the tub, so that he may not always be grinding with the same part of the mirror in front of the stroke. The stroke should be from $\frac{1}{3}$ to $\frac{1}{2}$ the diameter of the mirror and the side stroke $\frac{1}{8}$ the diameter. Little or no weight should be put on the mirror and in the fine grinding and polishing certainly none at all. Fig. 3 will illustrate all this.

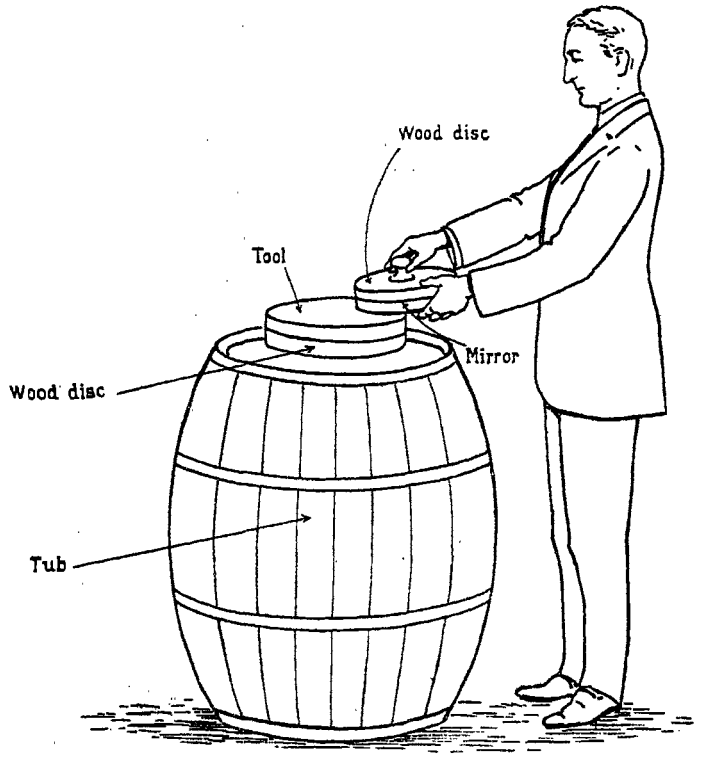

FIG. 3.

When the emery begins to wear down, which will be in about ten minutes or perhaps less, wash off with the sponge into the enamel pail and put on a fresh lot. Care should be taken to collect all the washings in the pail, as these will be wanted later on.

After half an hour's work it will be as well to examine the curve, as when this begins, it deepens rapidly, and it is important not to get it too deep. A simple way of ascertaining this is to leave the face of the mirror wet, and then to reflect the image of the Sun on to a wall as nearly as possible back towards the Sun. The distance of the mirror to the reflected spot on the wall is the focal length and should finally be 6 feet 8 inches, when the mirror is complete. The spot should then be a sharply defined image of the Sun. The rough grinding can go on until the focus is about 10 feet and then a finer grade of emery should be used.

Enough, however, has now been said for the member to make a start with his work, and I will deal with the fine grinding in my next paper. I hope that anyone who takes up the work and has any difficulty will write to me at once.