will cold press the wax to shape, and it will easily be seen from the appearance of the squares when the mirror is touching them all over and they are to shape. A supply of rouge and water is then put on the tool and the polishing proceeded with as before.

As will be seen this polisher is more trouble to make than the paper one, but it is very good to polish with. In my next paper I will describe how to test the mirror when the polish has reached the stage described above.

The Erection of an Observatory.

BY

REV. J. MITCHELL, M.A., F.R.A.S.

WHILST in London last year I saw advertised for £35 in the *English Mechanic*—a weekly paper, price 2*d*., every amateur astronomer should take—a 5″ Cooke Equatorial with Declination and Right Ascension Circles, verniers and slow motions but without "Driving Clock." This I at once saw was a bargain. So I wrote to the owner, soon came to terms and purchased the same, first taking the precaution to have it examined and tested optically by a practical astronomer, even though it was a Cooke.

The question of mounting the instrument arose as soon as I returned to India. There are a good many trees outside the College compound, and it was therefore necessary that the telescope should be well elevated to command a good horizon. To have built the observatory directly on the ground would have meant expense beyond my means, so I decided to build on the roof of my bungalow. It is well in this country to be as near as possible to one's hobby. I might have found a higher building than the bungalow but that would have been at a little distance, and further it would have meant that many a night now given to the telescope would have been lost owing to lack of desire on account of sheer weariness of body to go even across the College compound. In this enervating climate one must accommodate oneself to the prevailing conditions, otherwise nothing will be done. Having fixed upon the site, I decided to put up a substantial round brick building and dome with an annexe for a small Transit Instrument and Sidereal Clock.

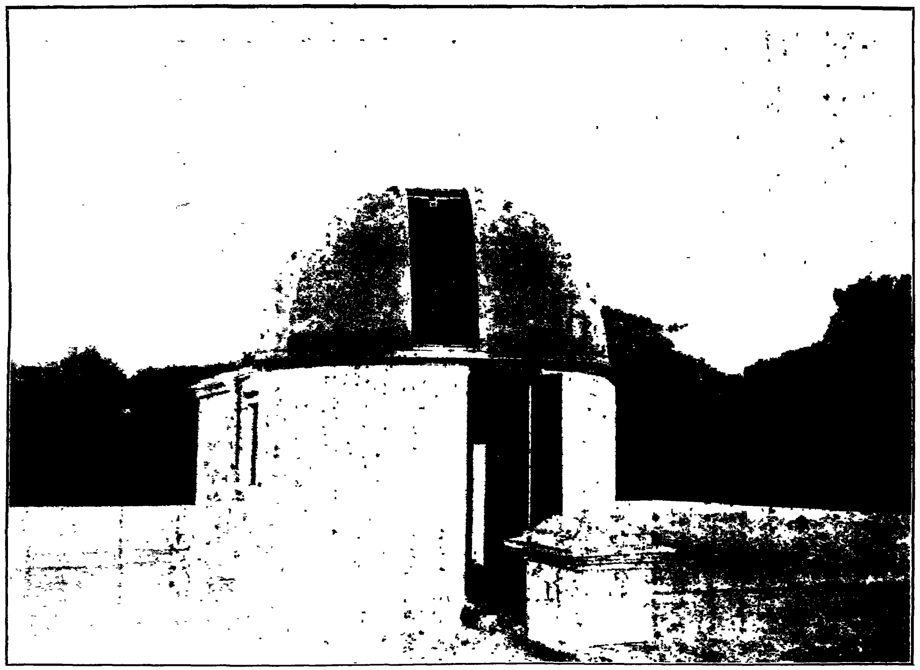

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1913

PHOTOGRAPH OF OBSERVATORY, SHEWING DOME.

BY REVD. J. MITCHELL, M.A., F.R.A.S., BANKURA.

Sketch 1.—The first problem to solve was how to get over the difficulty of building so that there would be little or no pressure on the roof proper. We proceeded thus. We selected a point where two walls crossed. Then we put up low curved arches from wall to wall. Next we put two swinging beams 6″ × 3″ across the wall for the Transit House about 5¼′ apart and built arches from the ends of one beam to the ends of the other beam and then on to the wall. Thus the entire house really rests on the cross walls of the bungalow. The inside measure of the house carrying the dome is 10 feet, and the small Transit Room is 6′ × 11′. The walls are 10″ in thickness and 7′ high. The photograph shows the general appearance of the Observatory, both of the dome and the Transit Annexe.

Dome, Sketch 2.—The skeleton framework of the dome is built up of 2″ × ¼″ angle iron, but the angle iron forming the basis of the framework is a little stronger, *viz.*, 2¼″ × ¼″. Here it may be asked "Why put up such a heavy dome? Would not a very much lighter one have served your purpose and been much cheaper?" My answer is this: "Here in Bankura we have in the hot weather, especially in May, very violent wind storms; a light dome would be in danger of being torn to pieces or blown away; and even with this heavier dome special precautions have had to be taken to prevent the dome from being lifted off the wheels." This point will be referred to later.

On the top of the wall, which tapers up at this point, rests a beam, 5″ × 3″ bent round and bolted down by means of four bolts built into the wall. This beam forms the roof of the entrance doorway, the two windows of the Observatory and partly of the roof of the doorway leading into the Transit Annexe. On the top of this is riveted a 2″ trolley rail bent round to fit the beam. The bending of the beam, trolley rail and angle iron was done on the spot as follows: There happened to be standing near the workshop a tree which forked about 4 feet from the ground. At this junction we cut out a grove first to fit the beam. Into this hole we inserted the end of the beam, and with the help of half a dozen coolies we bent it cold a little way. Then we pushed it in a little farther and bent it again, and this we continued until the beam approached the size of the templet which we had accurately prepared. We next withdrew it from the tree and worked it up to its true curve on the anvil. We bent and worked up the trolley rail in the same way. The beam was made of one piece, but such a long length of trolley rail we could not get. The ends of the beam and the ends of the sections of the rail were bolted together by means of plates one on each side of each joining.

The bending of the angle iron was a harder matter, especially the lower 2¼″ circular portion. This gave us a great deal of trouble. Angle iron has a habit of twisting up like a corkscrew when bent according to this primitive method, but eventually we got it near the size by a considerable use of the heavy hammer on the anvil. We cannot, however, claim that the curved angle iron approaches the accuracy of the beam or rail. All the portions of angle iron forming the framework of the dome were bent in this way, and we rejoiced when this part of the work was over. The boring and fitting up of the portions were all done on the spot. This was a big piece of work, for we had over 500 holes to bore through the ¼″ metal. The part of the framework reserved for the shutter consists of two unbroken semi-circular bars of angle iron 2 feet apart. To collect the ends of the other swinging bars we prepared a circular plate of iron 3/16″ thick and cut this into four sections. These plates slightly hollowed rest on and are bolted to the top of the angle iron on each side of the shutter and receive the ends of the bars. The figure will make this clear.

Over the angle iron we bolted battens of teakwood 3½″ × ½″ with rabbet joints, and over this we nailed a covering of sheet zinc which was afterwards given two coats of paint. We might have put canvas instead of zinc but in the long run we shall gain by having put down zinc. The reason we have put battens of wood on the angle iron is because of the heat in April, May and June. The temperature often rises to 115° F. in the shade.

Shutter.—The shutter was a great problem for some time. I discussed the matter with several well-known engineers in Calcutta, and they deprecated the fixing of a sliding arrangement. They advised me to make the shutter in three parts to open outwards like doors. This appeared to me to have one advantage only. It would be water-tight, but on the other hand it appeared a clumsy arrangement as it would necessitate a number of levers along with probably three pairs of ropes. So I determined to try something simpler. We have adopted the following plan, we fixed small brass rollers 1″ × ¾″ on the inner sides of the two angle iron bars right round about 1 ft. apart. These rollers revolve on ¼″ bolts screwed into tapped holes in the iron. The slide is made of ¼″ iron, 1½″ broad with a piece of iron the same size riveted on at the ends and covered with battens and zinc sheeting. The shutter rolls round the inside of the dome. The Calcutta engineers said such a shutter would not work as no arrangement could be devised for lifting it. A rope over a pulley at the top of the dome would pull the shutter inwards instead of upwards, and so it proved at first, but we got over this difficulty by fixing a roller across the shutter about 15″ from the bottom on each side. In the case of the "open" side of the shutter this roller is moveable and can be "unhooked," but it is fixed on the other side.

Sketch 3.—The rope fixed to the bottom of the shutter now passes over this roller, and thus the direction of the lifting force is almost vertically upwards. This has solved the problem. The shutter lifts easily. Two pulleys have been fixed at the top of the dome under the shutter, and two ropes pass over these pulleys—one for lifting and the other for lifting when on the other side. One lifts and the other steadies and then reversed. We use strong leather punkah ropes for this purpose. The shutter works quite easily and gives no trouble.

Sketch 4.—The dome rests on four trolley wheels. We made a pattern of a wheel 9″ in diameter and had them cast and turned in Calcutta. Two of these wheels (opposite to each other) work loose on their axles, but in the case of the other two the wheels are fixed on the axles which project into the room. At the end of each of these axles is fixed a large but light wheel, just low enough to be reached by the observer. By turning one or both of these wheels the dome is revolved. Fears were expressed that the wheels would slip, that a rack and pinion arrangement would be necessary. Occasionally the wheels do slip, but a twist on the wheel opposite is always sufficient to start the dome again. The dome revolves so lightly that it can easily be pushed by hand without touching the wheel. The arrangement is quite a success.

The shutter for the Transit consists of two windows at the sides, four folding doors above resting, when closed, on the windows.

To prevent the dome from being blown off the rail eight clips (angle iron 6″ × 2″ × ¼″) are bolted to the main angle bar forming the basis of the dome. These project under but do not touch the edge of the beam on which rests the trolley rail. The dome is thus absolutely secured against the worst storm. (Fig. 4.)

Apart from the instruments the observatory has cost Rs. 780.

Bankura. J. MITCHELL.

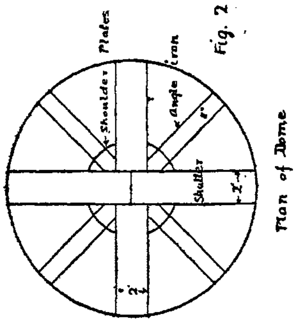

Fig. 2

Plan of Dome

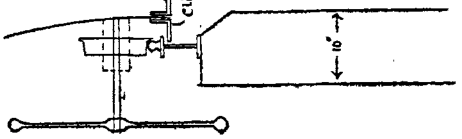

Fig. 4.

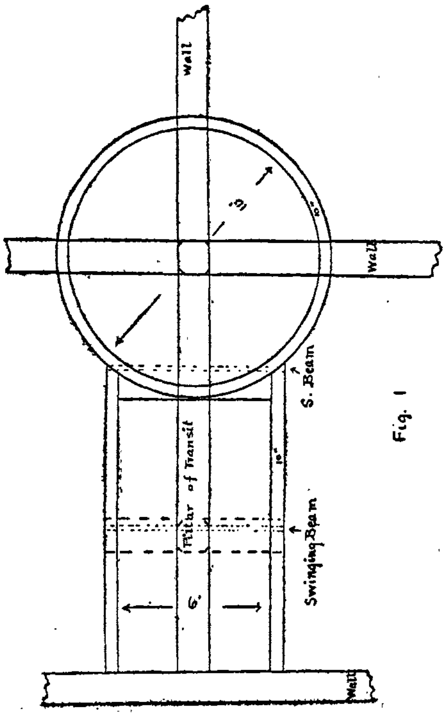

Fig. 1

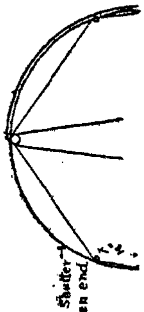

Fig. 3.