cylinder (shown at P^1) it is restored to its original position by moving it in the direction of the arrow A^1 . The valve F opens, and the glycerin passes through the holes h, h . The packing glands prevent any escape of the glycerin around the piston rod R and valve spindle r .

A PHOTOGRAPHIC TELESCOPE.

BY NORMAN EARDEN.

It is possible to do good work in celestial photography with simple home-constructed appliances. The constructing, however, of an instrument together with its mounting, suitable for the purpose of celestial photography, requires good workmanship. The guiding of a photographic telescope requires good eyesight, steady nerves, and most of all, patience. The accompanying figures are taken from a photographic telescope which is now in use by the writer, and has been found to be satisfactory for photographing stars, comets, nebulae, and the sun and moon.

Fig. 1 is a side view of the mounting, showing nearly all the principal parts, and gives a general idea of the appearance of an equatorial mounting. The standard is made from a well-seasoned 2x4 foot plank of suitable length. The surfaces are all well dressed, but surfaces 1 and 2 are made perfectly flat and at right angles to each other. The line BB is drawn perpendicular to the side 1. Then the line AA is drawn to make an angle with BB , that is equal to the latitude of the observer's station. The plank is now cut off along AA , care being taken to have the new surface perpendicular to the side 2. It will now be seen that when the sides 1 and 2 have been put in a vertical position, the line BB becomes level, and the

Fig. 1.—SIMPLE EQUATORIAL MOUNTING.

line AA is elevated at an angle equal to that of the north pole. All that is now necessary to put the standard in a correct position, is to place the surface 2 in the plane of the north and south meridian. Then the surface through which AA passes lies parallel to the earth's axis. The standard must be rigidly fastened in this position.

The next part of the mounting to be placed is the polar axis. The bearing of a bicycle wheel is very well suited for this, as it turns readily and smoothly. This axis must be fastened securely to the elevated surface, and must lie parallel to side 2 as well as the surface on which it is fastened. To the threaded north end of the axle, a bearing for the declination axis must be affixed. This can be made from a piece of stout oak of about 1x2x3 inches. For tapping the oak to fit the threads of the axle, drill a hole in the oak the size of the root of the threaded part of the axle. The oak piece may then be screwed on the axle, and a tight fit obtained. Through this oak piece drill a hole the size of the rod to be used as the declination axis, as shown in Fig. 1. Quarter-inch gas pipe is suitable for this axis, as it is strong and light, and can be easily threaded with standard dies. Each end of the pipe must be threaded, one end being threaded for about four inches. The length of this pipe depends upon the weight of the telescope, as this pipe will hold the weights for balancing the telescope. A 14-inch piece of pipe is usually long enough. This axis may be fastened to the telescope in the same manner as the polar axis was fastened to the declination axis bearing. However, the declination axis must be perpendicular to the polar axis, and the telescope perpendicular to the declination axis.

In order to give long exposures upon stars, comets,

and nebulae, the telescope must be made to follow the heavens in its diurnal motion. This is done by using a clockwork to drive the polar axis from east to west. The telescope can be made to follow the stars very well in the following manner: Procure the bare works of an alarm clock. Find the circumference of the minute-hand shaft. Then make a wooden pulley the circumference of which is twenty-four times that of the minute-hand shaft. Fasten this pulley to the

Fig. 2.—DIAGRAM OF TELESCOPIC CAMERA.

lower end of the polar axis. Then fasten the clockwork to the standard, so that the shaft projects out on the west side of the mounting. Fig. 1 gives a clear idea of the arrangement. Now attach a stout, well-resined cord to the pulley, wrap it around from east to west a few times, then stretch it to the shaft on the clock and wind it around about three times, and let it dangle with a weight of about half a pound attached to it. The cord must be wound around the shaft, so that when the shaft turns, the polar axis will turn from east to west. It will now be seen that when the shaft turns twenty-four times, as it would in a day, the polar axis will turn around once, just as the stars seem to make one revolution about the earth in twenty-four hours.

The constructing of the photographic telescope will come next. Fig. 2 shows the general shape and plan of the instrument. The object glass is the first essential to be considered. An achromatic lens, the focal length of which is less than forty inches, will be fit to use, but lenses of greater focal lengths, and not corrected for the actinic rays, are incapable of producing good negatives. The tube of the telescope should next be made. Tin tubing painted black or red on the inside will make a good tube for the telescope. The tube should be large enough to allow the lens to slip into it, and long enough to allow the lens to be slipped in or out, so that a sharp image may be projected upon the plate. As for the plate holders, it is best to buy them ready made. A simple device for holding the plate holder is shown in Fig. 2.

It is absolutely necessary to have a finder and a following telescope on a photographic telescope, where long exposures are to be made. A small telescope, magnifying from ten to twenty diameters, will suffice for both of these requirements. These telescopes can be obtained at a small expense at any optician's. To be able to keep the star in the same position in the finder, two wires crossing each other at right angles are placed in the focus of the eye lens of the eyepiece. The wires must cross at the center of the field of view. (See Fig. 3.) The position in which the star is placed and kept is also shown in the same figure. The following telescope must be firmly attached to the large telescope and parallel to it. If this is done, the object appearing on the cross wires will be projected upon the center of the plate. The whole telescope should now be weighed, and a weight of about one half the telescope's weight constructed. Tap the weight in the center to fit the threads on the declination axis. Now the telescope is made to balance on the declination axis, and is fastened to it as shown in Fig. 1, and the telescope and weights are made to balance on the polar axis. When the photographic telescope is completed, it should meet with the following requirements:

Fig. 3.—CROSS HAIRS IN THE EYEPIECE.

1. That the polar axis is elevated to an angle equal to the latitude of the observer's station.
2. That the polar axis lies in the plane of the meridian.
3. That the declination axis is perpendicular to the polar axis.
4. That the telescope is perpendicular to the declination axis.
5. That the polar axis can be made to turn from east to west once in twenty-four hours.
6. That the plate is placed in the proper focus of the objective.

To try out the instrument, place the plate holder with a plate in place. Get a bright star in the finder; and place it as shown in Fig. 3. Start the clockwork, draw the dark slide of the plate holder, and expose for about ten minutes. With but a trifle variation in the

speed of the clock, the star should be made to keep the same position in the finder. Develop the plate, and if the plate has been in the focal plane of the objective, and the telescope has been guided correctly, the star will appear as a sharp, round dot. A few trials of this sort will bring out the defects of the instrument, which must be corrected before good results can be expected.

In regard to the length of exposures to be given, only a few suggestions can be given. The moon can be successfully photographed in one or two seconds. The sun requires a shorter exposure of about one-quarter second, with the aperture reduced to about one-half inch. Stars, comets, and nebulae require long exposures and careful guiding. Exposures of one hour generally give good results. A fast plate is used to advantage in photographing stars, comets, and nebulae, but for the sun and moon a slow plate is required. Celestial photography will be found to be a pleasure, as well as instructing, by all those who try it. The celestial photographer will never lack for subjects, as there is always some interesting object in the heavens that is willing to impress its image upon the sensitive plate.

A CHEAP HYDRO-COMPARATOR.

BY GEORGE N. WILCOX.

Having a pair of cheap balances, and finding that the weights did not agree, I made a one-grain weight by cutting a piece of No. 23 copper wire (as nearly as possible) 1.113703 inch long. I used a steel scale graduated to hundredths, and a microscope; but if you make it $1\frac{1}{8}$ inches by a yardstick, and file off a hundredth as near as you can guess, and trust the diameter of the wire to be accurate (0.022571 inch) you will probably come nearer than some weights you might buy. For other sizes of wire (if you have no table giving length per pound) multiply the length of each smaller size (larger number) by $\frac{1}{2} = 1.26$, and for a larger size divide. A No. 24 should be 1.113703 inches by 1.26 inches long, and a No. 26 should be twice as long as a No. 23.

Now, to compare weights of other kinds, I split a

HOME-MADE HYDRO-COMPARATOR.

cork half through, as the boys do for a fishing float (though I used a somewhat smaller one) and put it on a piece of the No. 23 wire, twisting it around a couple of nails below the cork to keep it right side up. About an inch above the cork the wire was coiled and then stitched into a piece of paper the size of a quarter to form a scale pan.

This float may be placed in a glass of alcohol, weighting it down after putting on say the one-grain wire weight, until the cork is completely submerged. After this it will be found that a very small bit of paper will sink it considerably lower, in fact it will probably go down and wet the paper scale pan as mine did many times, unless you put a piece of pasteboard over the glass with a hole in it for the wire, but not large enough to let the pan through.

Now see how far the cork is below the surface, and take off the one-grain weight and put on the weight you wish to compare, and see if the cork is higher or lower. If allowed to stand a few minutes, the position of the cork may change for some reason which I cannot explain; but allowing only time enough to come to rest, and changing your weights several times, you can probably get them nearer alike than by any other method which is as cheap.

Perhaps I should explain that when weight is added, enough extra wire is submerged to displace liquid equal in weight to the weight added, so a larger wire would give less motion, though a smaller one seems to be more affected by uncertain conditions.

With water instead of alcohol, it acts as if there were more friction, the cork staying in the position placed to a certain extent.

According to George S. Bliss, chief of the United States Weather Bureau of Philadelphia, J. Armstrong Drexel rose to a height of 9,897 feet in his flight to make a new world's altitude record for aeroplanes in Philadelphia on November 23d. Johnstone's record was 9,714 feet. It is not likely that Drexel's record will be accepted, because it has been decided to record only those which exceed previous records by 100 meters.