

ELEMENTARY EXPERIMENTS
IN
OBSERVATIONAL ASTRONOMY.

BY GEORGE W. MYERS.

(Continued from page 491, Vol. I.)

Let the bolt at C be provided with a long, pointed head and fit a notched sight at A . Attach a plumb-line to the head, C , and allow it to hang freely in a vessel of water (battery cell or tin cup) supported by a stand, S , on the post, EF . Placing a carpenter's level on the top of AC , hold the quadrant so that the bubble will play, and start the graduations with the point which then falls just beneath the line near B , the graduations rising to 90 deg. at A .

If desired, a circular board, graduated and fixed horizontally to the post, EF , just below the stand, may be added, from which, by the aid of a pointer fixed to the post, OM or PN , horizontal angles, or azimuths, may be read. All measurements of altitude and azimuth which are made with a universal instrument may be roughly made by this apparatus, if the objects used are bright.

EXPERIMENT XXIV.

To make a wooden quadrant for hand use.

Join two $\frac{3}{4}$ -inch surfaced boards together, reinforcing them by cleats, if necessary, and cut from them a quadrant of radius 18 inches, as suggested by the accompanying figure. Graduate it, and provide it with a plumb-line, as shown. By means of a handle attached as represented in the edge view, altitudes of naked-eye objects may be measured by hand, much after the fashion of the simplest forms of the sextant. The sight-line, SC , is determined by a notched sight at S , and a pin or nail at C . The graduation lying just beneath the cord at D , when the sight-line is directed to the object, furnishes the angular elevation of the object above the

*For the convenience of those who may desire to use these experiments (there are forty-four of them) in their classes, they may be obtained in pamphlet form from "The School Science Press," Ravenswood, Chicago, at 25 cents a copy, and \$2.50 a dozen.

horizon. The reading may be very much facilitated by an assistant. Altitudes of the moon, of the brighter stars, and with the use of colored glasses to protect the eyes, of the sun may be

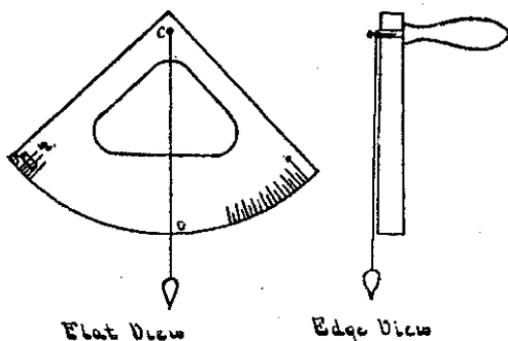


Fig. 24.

measured with rather surprising accuracy with this device, after a little practice.

EXPERIMENT XXV.

Construct a Tycho's quadrant.

If the quadrant, $ACBD$, of the last experiment be made smaller and lighter, and a pin be inserted at C to serve for a handle, the quadrant may be supported by hand. In this case an assistant observer will note the reading which falls under the plumb-line.

EXPERIMENT XXVI.

Construct a plumb-line gnomon.

Surface a board (DE , Fig. XXI), 2 feet by 3 feet, and fix two uprights, A and B , vertically upon it. Tie the uprights with a cross-piece, C , at the top, and suspend a plumb-line, provided with a sliding bead, from the middle of C . Varnish or paint the surface, and with thin wedges at G and H level the board carefully with a spirit level and mark the point just beneath the lower tip

of the bob. Hereafter the board may be leveled by sliding the wedges in and out until the bob hangs just over the designated point. With this point as a center, describe a series of concentric circles with radii varying by one inch (or by $\frac{1}{2}$ inch). By noting the instant when the forenoon shadow of the bead crosses (or touches) any circumferences and the instant when the afternoon shadow crosses the same circumference, the time of apparent noon is given by taking one-half the sum (the mean) of the times of the two suggested instants.

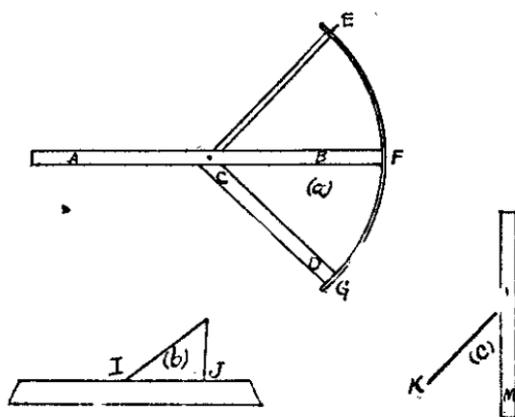
To find the meridian, see Experiment XX, (a), (2).

EXPERIMENT XXVII.

Construct a horizontal sun-dial.

Apparatus for graduating a horizontal dial.

Cut out and surface two wooden circles of 12 inches diameter and fit the half of one to the other at an angle of 48° (the



(a) = Graduating Apparatus,
 (b) = Horizontal Dial,
 (c) = Vertical Dial.

Fig. 25.

colatitude of Chicago). Erect at the common center of the circles a wooden or iron rod, making an angle of 42° (the latitude)

to the whole circle, and on the side opposite to the one on which the half-circle is fitted, as indicated in the figure. Cut the rod off to a length equal to the radius of the circles. Fasten one end of a flexible strip of copper, EFG , the length of which equals a quadrant of a circumference whose radius equals the radius of a circle, to the top end, E , of the rod, leaving it free to turn.

Graduate the circle, CD , whose plane is perpendicular to the rod, CE , 5° or 10° , then by putting the end, G , of the copper strip, EFG (free to turn about E), at the successive points of graduation of the circle, CD , corresponding points may be transferred to the circumference of the full circle, AB , which, being connected with bottom of the rod, will indicate the consecutive positions of the shadow of the rod for twenty and forty minute intervals of time. This completes the apparatus for graduating the dial.

To make the dial:

(a) Insert a smooth stick in a surfaced board at an angle with the surface equal to the latitude of the place. Describe about the foot of the stick a circle of radius of six inches and transfer to this circle, from the point directly under the end of the stick, the graduations of the full circle of the graduating apparatus described above.

(b) Instead of the inclined stick the edge of a triangle may be used, whose angle, HII , is the latitude.

EXPERIMENT XXVIII.

To make and graduate a vertical dial.

On the south side of a vertical surface attach a triangle (or a rod, KL , foregoing cut) so that its plane shall be perpendicular to the vertical surface, LM , and its hypotenuse, KL , shall make an angle equal to the co-latitude ($90 \text{ deg.} - \text{latitude}$) with this surface.

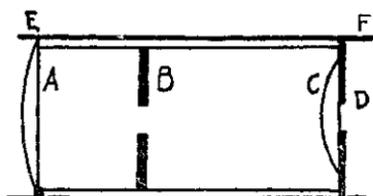
To graduate the circle LM , an apparatus like the one for the horizontal dial may be used, save that here the angle ECF must be the *co-latitude* ($90 \text{ deg.} - \text{latitude}$), and the angle FCG must here be equal to the *latitude* of the place.

EXPERIMENT XXIX.

To construct a negative, or Huyghenian, eye-piece.

Procure two plano-convex lenses, one of $\frac{3}{4}$ -inch diameter and 2 inches focal length, and the other of $\frac{3}{4}$ -inch diameter and $\frac{3}{4}$ -inch focal length. Roll up around a cylindrical stick, 5-8 inch diameter, heavy manila paper, using 6 or 7 ply, a cylindrical tube. The successive layers of paper may be stuck with library paste.

When the cylinder dries, cut off a piece of $1\frac{3}{8}$ inches, square the ends, and fit the lenses as suggested by the figure. Before attaching the lenses to the tube, cut from the center of two circular pieces of pasteboard a smooth hole $\frac{1}{4}$ -inch in diameter, as at *B* and *D*. After pasting the edges of the first disk, stick it in the tube $\frac{3}{4}$ inch from one end, *D*, where the 2-inch focal lens is to be attached. The edges of the lenses may be stuck to the paper by means of gold-size. Complete the eye-piece as suggested by the cut. The completed eye-piece should be covered with a layer of tissue paper, the edges of which are allowed to extend beyond the ends of the tube, as shown at *E* and *F*. The ends should then be



Eye-piece.

Fig. 26.

stuck down around the edges of the lens, *A*, and of the pasteboard disk, *D F*.

(N. B.—This exercise is due to Dr. George Pyburn, and was published in *Popular Science Monthly*, Vol. XXIV., No. 1. The article is also reproduced as *Appendix A* in Miss Byrd's *Laboratory Manual*.)

School Science.

EXPERIMENT XXX.

To make a telescope.

Obtain a $1\frac{1}{2}$ -inch x 30-inch achromatic object-glass, *O*, and roll up tubes of manila paper, stick with glue or library paste, and make a cell (as *c*) around it. Then roll up a tube, *T*, 30 inches long, and a draw tube, such as *D*, some 15 inches long. Provide the back end of the draw-tube with cardboard flange, *F*, and roll up smaller tubes to fit, as indicated in the figure. The collars, *G G* and *H H*, may be made by rolling narrow strips of manila paper about the tube, *A*, until they just fit inside *D*. A strip of broadcloth, just wide enough to wrap once around the outside of *a*, should be glued to the outer surface of *a* to insure smooth sliding of *a* within *A*. The eye piece was fully explained in Experiment XXVIII.

(See Appendix A of Miss Byrd's *Laboratory Manual*.)

(See Fig 27, next page.)

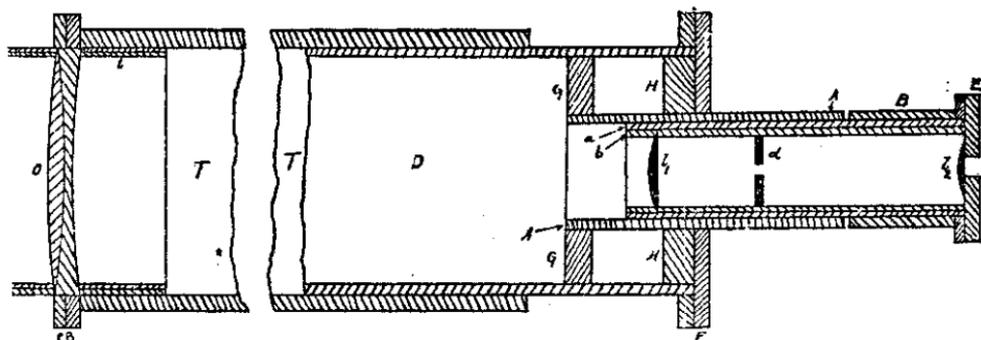


Fig. 27.

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|------------|--------------------------|--------------------------|-------------------------|
| <i>O</i> . | Objective. | <i>B</i> . | Covering for eye-piece. |
| <i>c</i> . | Cell and cap. | <i>C B</i> . | Flange of Pasteboard. |
| <i>i</i> . | Inner tube to hold cell. | <i>F</i> . | Flange. |
| <i>T</i> . | Main tube. | <i>l</i> and <i>l2</i> . | Eye-piece lenses. |
| <i>D</i> . | Drawtube. | <i>d</i> . | Shoulders. |
| <i>a</i> . | Eye-piece adapter. | <i>G</i> and <i>H</i> . | Perforated diaphragm. |

(To be continued.)