Description and

Instructions for the Use

of

THE BALL RECORDING SEXTANT

Mark 1 Mod. 0

Restricted

BUREAU OF SHIPS

NAVY DEPARTMENT WASHINGTON, D. C.

MARCH 1944

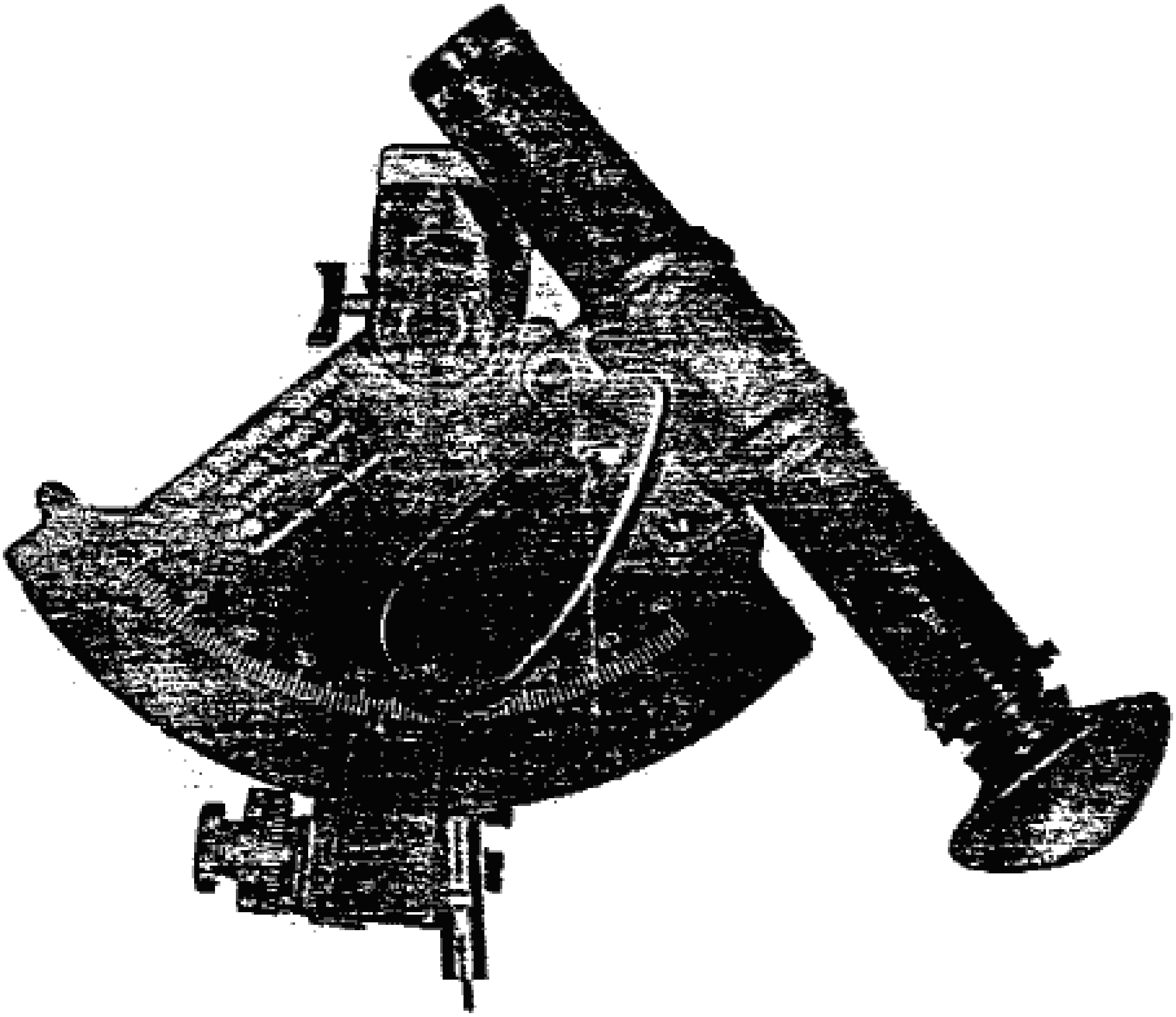


Figure 1.—The Ball Recording Sextant – front view

THE BALL RECORDING SEXTANT

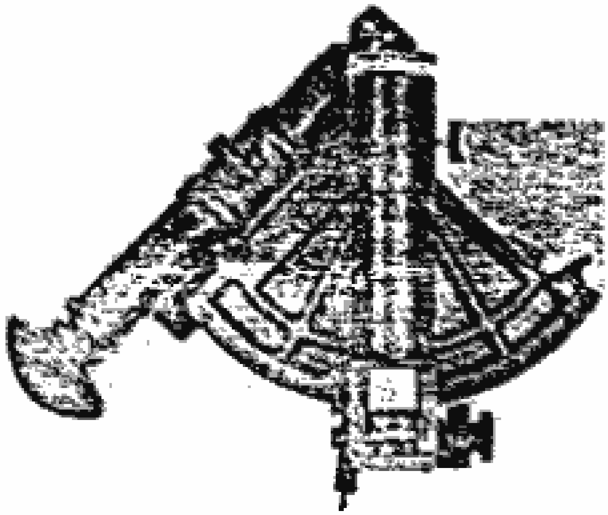


Figure 2.—The Ball Recording Sextant—back view.

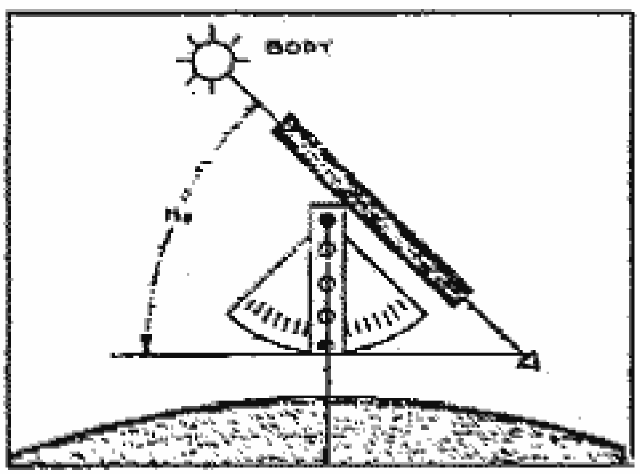


Figure 3.—Schematic diagram of the principle of the Ball Recording Sextant.

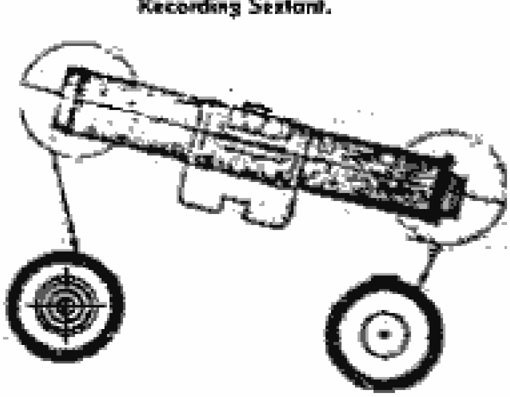


Figure 4.—The sighting tube for day use.

The *Ball Recording Sextant* (figs. 1, 2) is used without a visible horizon to obtain the altitude of a celestial body by determining the angle between the axis of a sighting tube directed at the body and the line of fall of metal balls toward the center of the earth (fig. 3). The angle actually determined is the zenith distance, but the scale is so graduated that the reading obtained from it is the complement of the zenith distance—i.e., the altitude.

The principal parts of this sextant are the sighting tubes, one for day and one for night, the frame, and the index arm, which contains the ball-releasing mechanism and the devices for recording and reading the results of observations.

DESCRIPTION

Both sighting tubes are equipped with an eyepiece mounted in one end and a reticle or objective target mounted in the other end.

In the day tube (fig. 4) the eyepiece consists of a peep-sight and a variable density arrangement for regulating the amount of light which reaches the eye. The variable density arrangement consists of a pair of polarizing filters operated by means of the knurled slide on the top side of the tube.

The reticle at the other end of the tube (figs. 4 and 5) consists of a transparent disk etched with suitably arranged horizontal and vertical lines and concentric circles. The black dot at the center of the reticle is slightly smaller than the apparent disk of the sun or moon so that, when taking a sight, a small ring of light is seen around the edge of the dot. The vertical and horizontal lines aid in minimizing the tilt of the instrument during observations

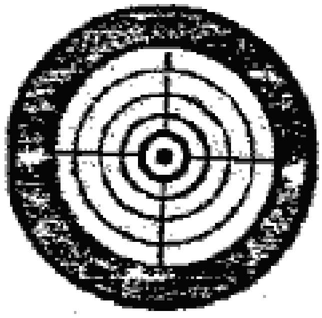


Figure 5.—Photograph of the reticle in the day tube.

In the night tube (fig. 6), the eyepiece is provided with a rotating diaphragm with four sizes of apertures for observations in twilight, moonlight, and various degrees of darkness. To obtain the greatest accuracy, the smallest suitable aperture should always be used

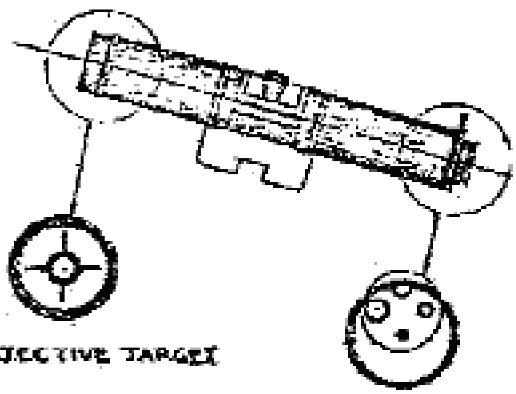
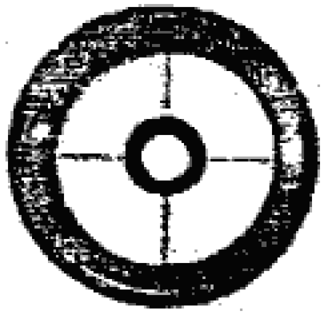


Figure 6.—The sighting tube for night use.

In the center of the night reticle (fig. 7) is a clear round hole which is defined by a black ring and from which diverge four luminous lines. The star or planet to be observed must be centered in this ring. The luminous lines will help in doing this and also, as with the day reticle, will help in reducing the tilt of the instrument.



An eye-centering device, mounted inside the sighting tube, contains a luminous ring and four luminous marks equidistantly spaced about the inner circumference of the tube. It is important that the eye be centered with respect

Figure 7.—Photograph of the reticle in the night tube.

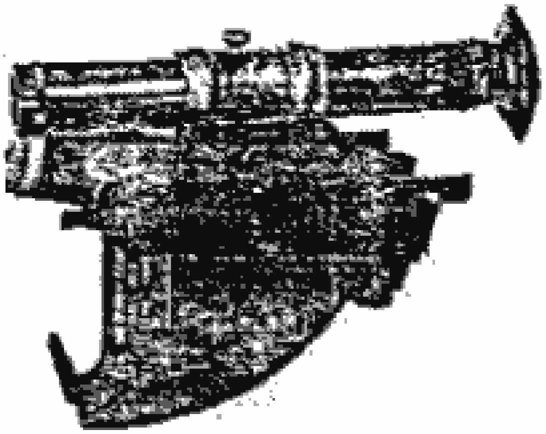


Figure 8.—Position of the sighting tubes on the Ball Recording Sextant.

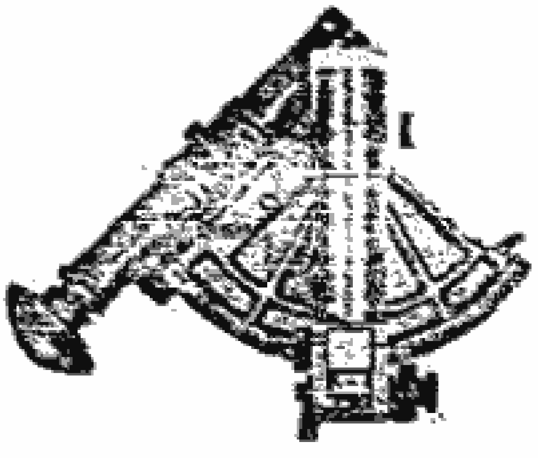


Figure 9.—Index arm and pendulum unit.

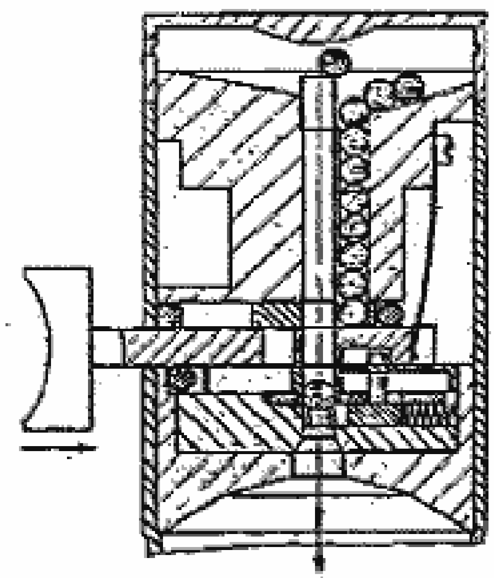


Figure 10.—Schematic diagram of the ball-releasing mechanism.

to the eyepiece aperture. When all of the luminous marks are visible, the eye is correctly centered.

The sighting tubes are in their proper position when they are clamped into the holder which is attached to the instrument frame (fig. 8). When the small screw on the top of the tube fits snugly into a notch in the holder, the sighting elements are correctly aligned.

Upon the frame of the instrument are marked graduations from 0° to 90°, and the index arm (fig. 9) is movable through the entire range of this graduated arc. When a plunger, operated by the release lever, is disengaged from the frame, the index arm swings freely as a pendulum around its pivot point at the axis of the frame.

A cylindrical chamber forms the major part of the index arm. At the top of this chamber is a magazine which may be loaded with a number (usually nine) of five thirty-seconds-inch balls (fig. 10). At the lower end of the magazine is a well which receives a ball between supporting arcs. Squeezing the trigger releases the pressure on the supporting arcs and allows the ball to fall through the chamber to the target below. Each time a ball is released another takes its place between the supporting arcs as the trigger returns to its normal position.

The target on which the balls fall is a recording unit (fig. 11), the two main parts of which are a piece of carbon cloth and a frosted glass drum with four recording surfaces. The point of impact of the falling ball on the carbon cloth is recorded on the uppermost surface as a small black dot. The position of the dot, or of a group of dots (fig. 12), may be seen by turning the knob attached to the four-sided drum through ninety degrees in a clockwise direction.

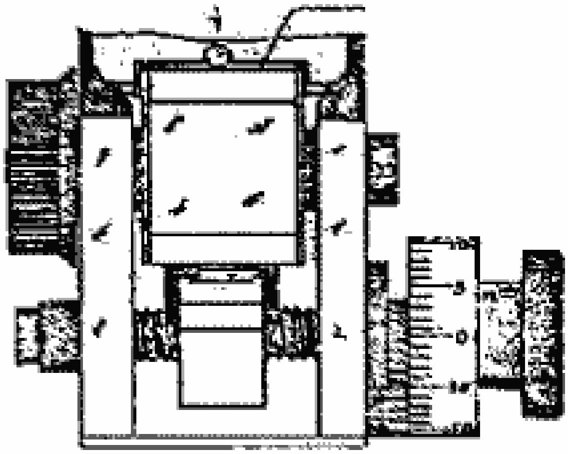


Figure 11.—Schematic diagram of the recording unit.

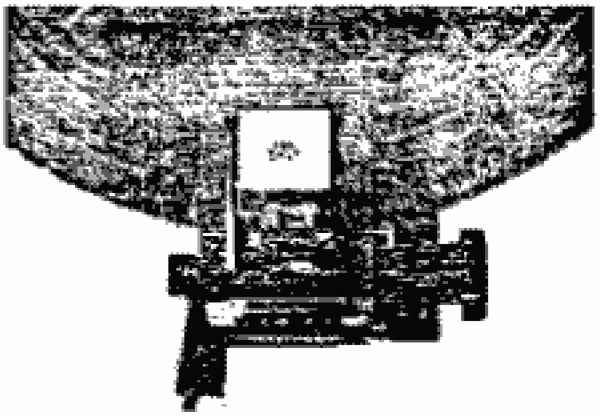


Figure 12.—Sample pattern made by nine balls.

When the recording block is turned through an additional ninety degrees the target pattern is under the reading glass (fig. 13). This glass is etched with a longitudinal black line to be set on the *mean point of impact* of the balls by turning the micrometer screw. The degrees are read from the graduated arc on the frame; the minutes and tenths of minutes are read from the drum and its vernier. The transverse etched lines on the reading glass furnish a means of measuring the amount of tilt of the instrument during the observation, the center line being the line of zero tilt and each graduation indicating an interval of one degree.

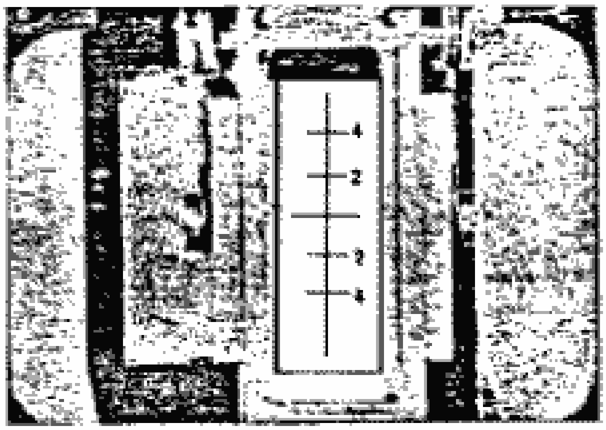


Figure 13.—The reading glass.

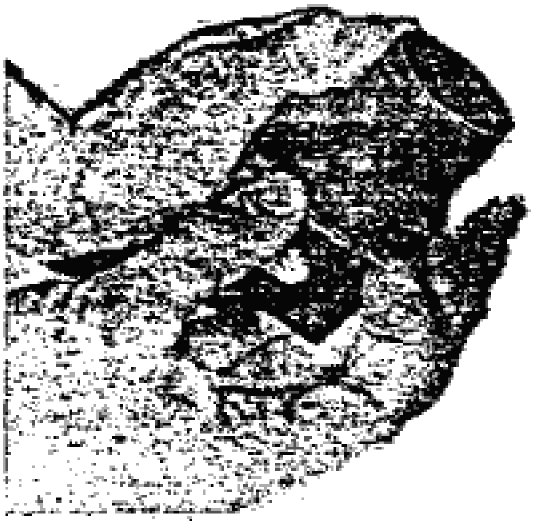


Figure 14.—The carbon-cloth holder.

If the impression made by the balls is not dark enough a new carbon-cloth holder should be inserted. This is easily done. The ribbon holder is held in place by means of a small metal retainer plate which is fastened to the pendulous unit by two screws. When the plate has been removed, a slight tilt of the instrument and a turn of the recording drum will release the old carbon-cloth holder. The new one may be inserted by reversing the process. Figure 14 shows, with a section model of the recording unit of the index arm, how the parts fit together.

NECESSARY CORRECTIONS TO SEXTANT ALTITUDES

Altitudes obtained with the Ball Recording Sextant should be corrected for tilt, refraction, parallax (in the case of the moon and sun), eccentricity of the graduated arc (if any), and index error and personal equation (if any). Since a visible horizon has not been used, the correction for dip is not necessary. Also since the centers of the sun and moon are being observed directly, no correction for semidiameter is necessary.

On page 15 of this booklet is a table which lists the Sextant Tilt Corrections.

Tables E and F in the Nautical Almanac supply the corrections for refraction and parallax for the sun, moon and stars. The values given for stars should also be used for the planets.

It is expected that errors due to eccentricity will be negligible. However, a table of any such errors will be found attached on the inside of the carrying case cover.

It is also expected that no index error will develop. Nevertheless, it should be checked, when a sharp horizon is available, as follows: Aim the sighting tube for day use at the horizon and make several careful observations After correction for dip and eccentricity, the altitude reading should be 0°. (See fig. 15.) A small part of any error found in this way may be due to personal equation. The corrections should be applied to sextant altitudes in the same way as an index correction. If the index error is found to be large, the instrument should be sent as soon as possible to the Naval Observatory for resetting of the screw and recollimation to eliminate the index error. Personal equation cannot be eliminated but may be corrected for.

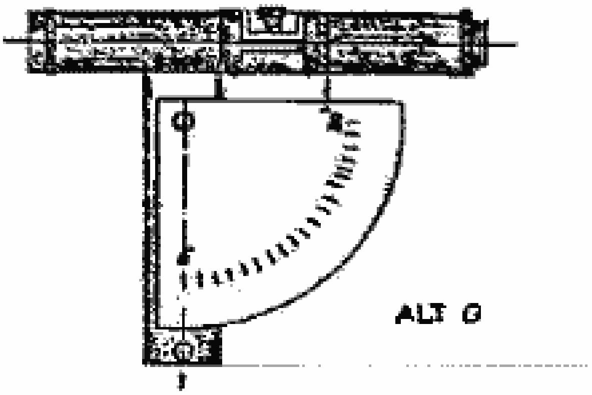


Figure 15.—Schematic diagram of check for index error and personal equation.

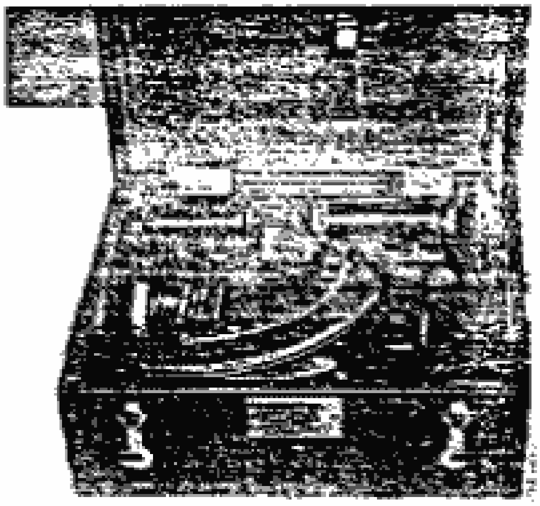


Figure 16.—The Ball Recording Sextant in its carrying case.

METHOD OF USE

Now, let us follow through the entire procedure in making an observation with the Ball Recording Sextant.

Remove the instrument from its case (fig. 16) by grasping its handle with the left hand. Never lift it out by any other part. (See fig. 17.)

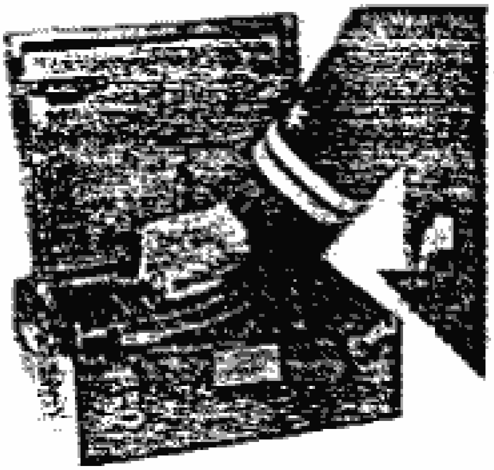


Figure 17.—Removing the sextant from its case.

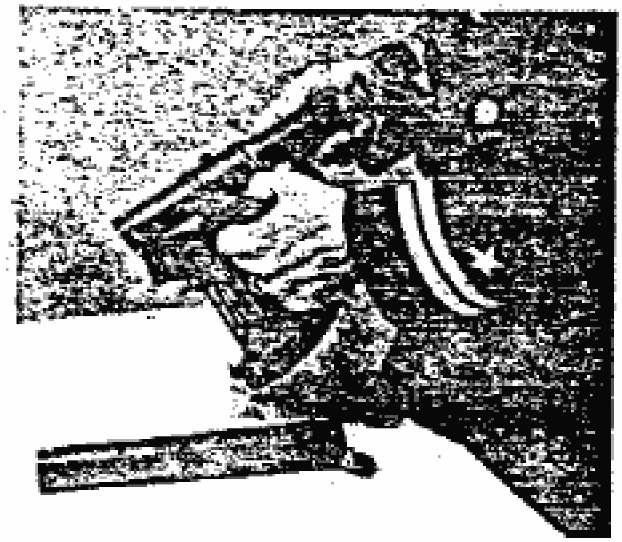


Figure 18.—Inserting the proper sighting tube

If the proper sighting tube is not already in place, release the clamping screw, remove the tube, and insert the other one. Be sure that the small positioning screw on the top of the tube fits properly and completely into the notch in the holder. Then tighten the clamping screw again. The navigator in figure 18 is fitting the day tube into the tube holder for an observation of the sun or moon.

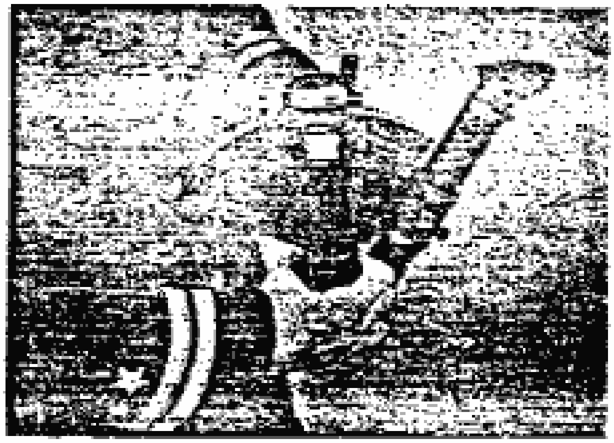


Figure 19.—Loading the magazine.

To load the magazine with balls, invert the sextant with the index arm still engaged to the frame, depress the trigger (fig. 19), and rock the inverted instrument gently until all the balls return to the magazine. Release the trigger and bring the sextant to an upright position.

Now, disengage the pendulous unit by pulling down with the index finger on the knob on the lower left side of the plunger. The thumb may be pressed against the metal catch on the right for increased leverage. (See figs. 20 and 21.)

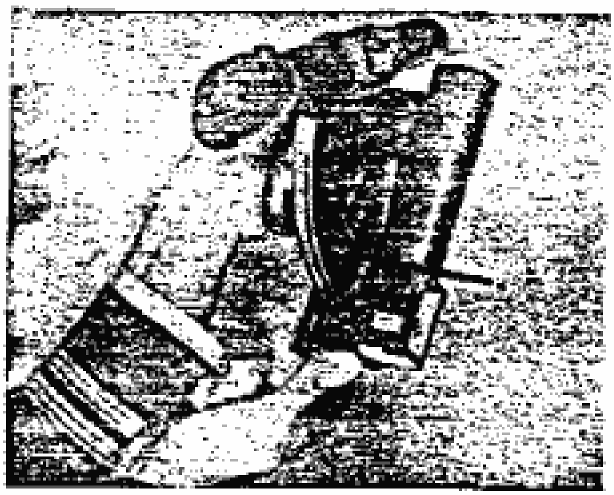


Figure 20.—Disengaging the pendulous unit.

At this time, for an observation of the sun, adjust the filter for density. For observations of the moon the maximum amount of light will probably be wanted, whereas a minimum of light will be required for observations of the sun.

Figure 22 illustrates the next step in the procedure. Face squarely toward the object to be observed and aim the sighting tube. When the pendulous unit has come to a vertical position, release the plunger by a slight pressure on the lever to engage the unit to the frame. Be sure that the plunger actually enters one of the holes in the frame (they are two degrees apart) and does not rest on the frame between the holes, as might occasionally happen (see fig. 23).

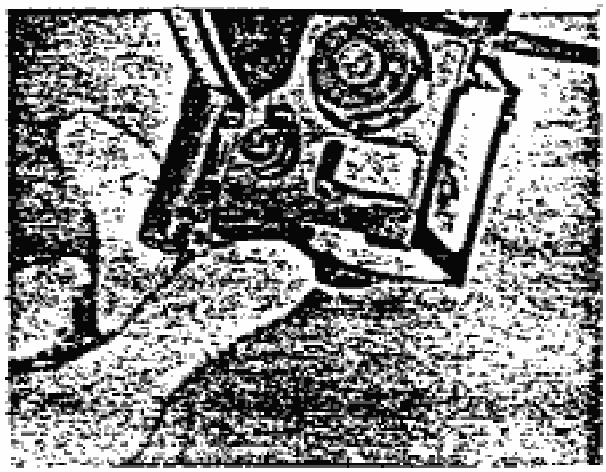


Figure 21.—Close-up of disengaging the pendulous unit.

Note that the navigator in figure 22 has found a place on which to rest his elbows. This is a desirable feature in using this instrument, since holding it steady will help to keep the pattern of dots made by the balls small in size and the mean position will be relatively easy to determine.

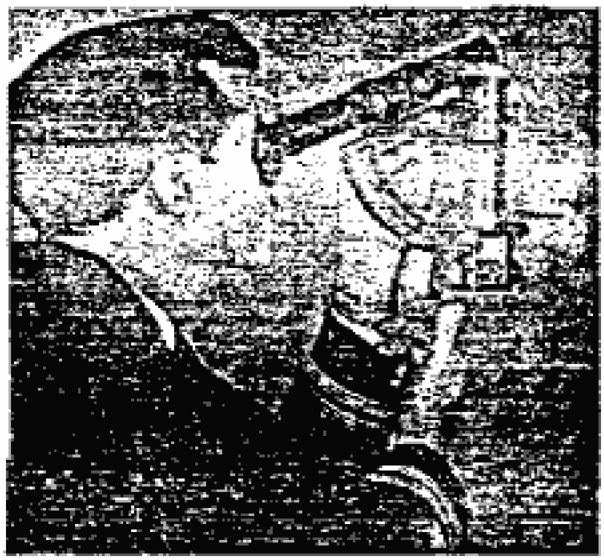


Figure 22—Locking the pendulous unit

With the right hand grasping the pendulous unit and the ball of the forefinger on the trigger, carefully center the black spot on the image of the sun, keeping the cross lines of the reticle as nearly horizontal and vertical as conditions permit. Squeeze the trigger once to load the ball-releasing mechanism. The weight of the instrument is now being held by both hands and if additional support can be found for the elbows as noted above, muscular strain will be reduced to a minimum.

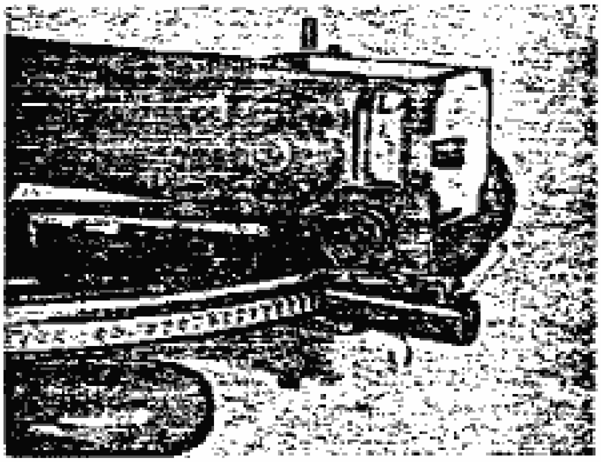


Figure 23.—Proper position of the plunger.

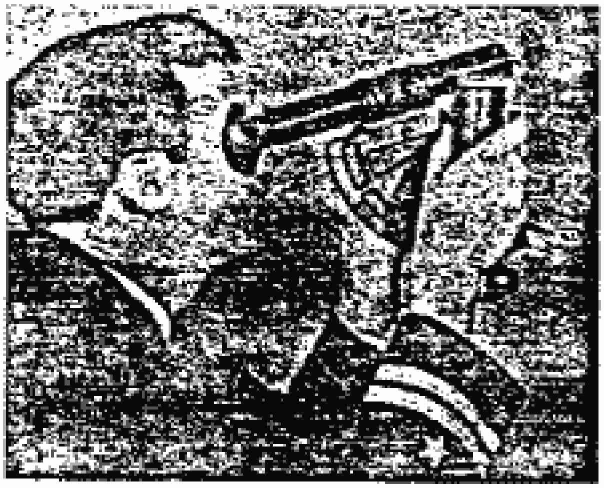


Figure 24.—Squeezing the trigger.

Keeping a steady aim on the sun, squeeze the trigger carefully, in the same manner as you would squeeze the trigger of a rifle, which will release a ball for the first observation (fig. 24). Make a number of observations in reasonably rapid succession in each case taking care to *squeeze* the trigger, not pull it. The average time at which the balls were dropped may be determined by calling "Mark" to the quartermaster as the first and last balls fall or at the time of fall of the middle ball.

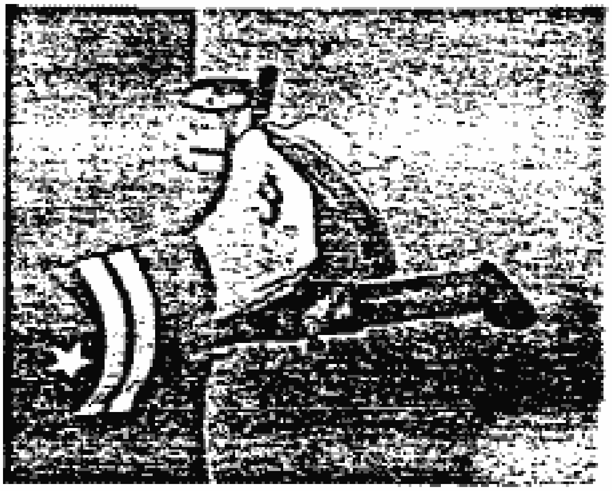


Figure 25.—Turning the drum.

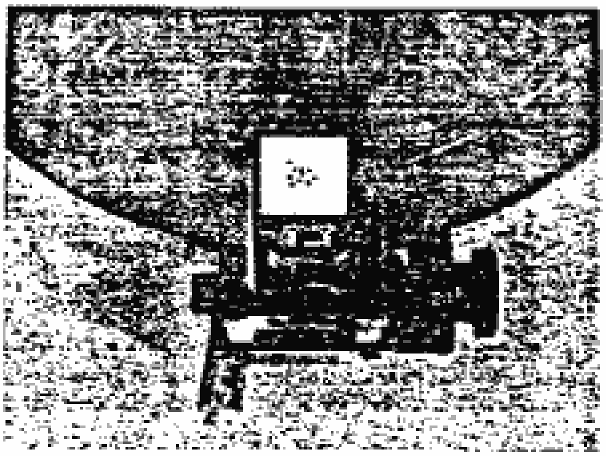


Figure 26.—Target seen for one observation (nine balls dropped)

When all the balls have been dropped, invert the instrument again. Turn the recording drum through ninety degrees (fig. 25), and look at the pattern of the dots (fig. 26). In the example shown, the shot was particularly good, since most of the balls fell on the same spot. Wild shots (dots widely isolated from the general pattern) should not be considered. Of the pattern shown in figure 26 all of the shots should be taken into account for the reading.

Now, turn the drum through another ninety degrees to bring the record of the observation under the reading glass. With the micrometer screw, set the longitudinal black line on the glass over the mid-point of the dots (fig. 27).

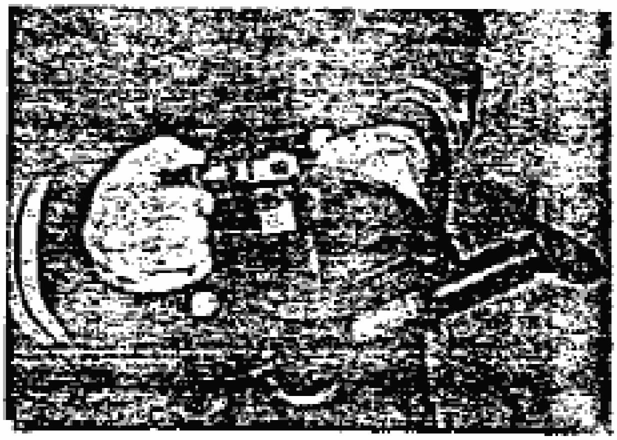


Figure 27.—Setting the reading glass.

The index arm indicator now points to a little more than 32° on the graduated arc. (See fig. 28.) Read the micrometer head and vernier—16'.4 (fig. 29). The uncorrected, sextant altitude, therefore, is 32°16'.4.

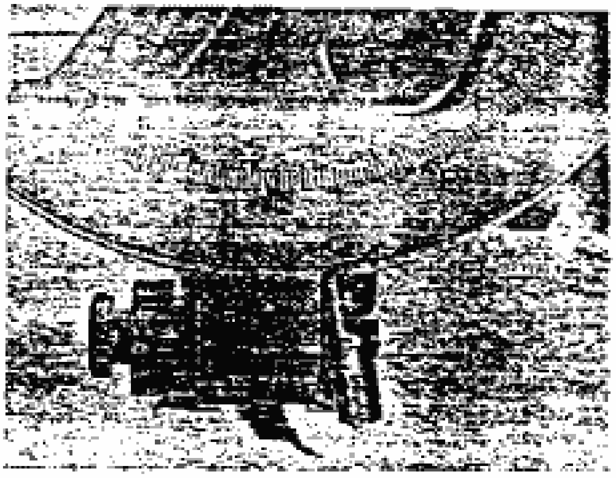


Figure 28.—Reading the degrees of arc.

Note in figure 15, which is enlarged from figure 29, that the mid-point of the pattern is 1°.1 away from the line of zero tilt, indicating that the sextant was not exactly vertical while the observation was being made. From the sextant tilt correction table on page 15, interpolate between 1°.0 and 1°.5 of tilt and between 30° and 35° of sextant altitude to get 0'.4 (always subtracted from the altitude reading). The refraction and parallax correction from table E of the Nautical Almanac (assuming that our observation was one of the sun) is also to be subtracted from the altitude reading. This value is 1'.4. If the other corrections, those for eccentricity and index error, are negligible (and they usually are, or should be), the observed altitude from this observation would be 32°14'.6.

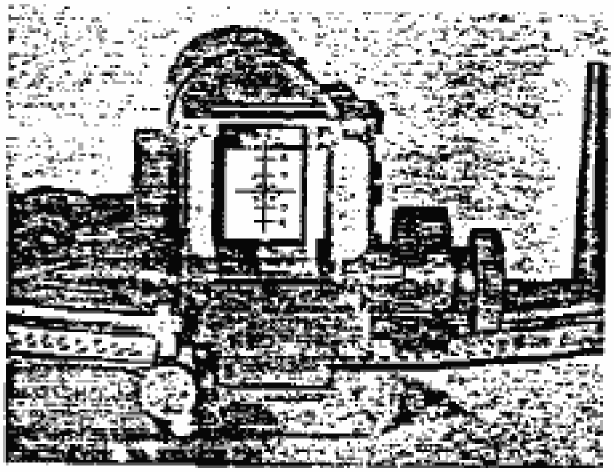


Figure 29.—Reading the micrometer screw and vernier.

NOTES

1. The BALL RECORDING SEXTANT is not intended to replace the Endless-Tangent-Screw Sextant. It is recommended, rather, as a supplementary instrument, for use chiefly when the horizon is obscured for some reason, or at night, when the horizon is not visible.

2. At the present time it is impossible to state with certainty the errors of this instrument under various conditions of use. With regular practice, as in gunnery, the skill of the observer will increase, and it is believed that in competent hands this sextant will produce serviceable navigational results under various light and weather conditions. However, until a thorough study has been made of numerous reports on continued use of this sextant, *IN ANY CASE IN WHICH THE SAFETY OF THE SHIP IS INVOLVED, SOLE RELIANCE SHOULD NOT BE PLACED ON DATA FROM OBSERVATIONS WITH THIS INSTRUMENT.*

3. It is emphasized again that the instrument is more accurately operated from a braced or seated position, when the increased comfort should eliminate strain during the observing procedure.

4. The sighting tube may be readily pointed at a selected star if the observer keeps both eyes open while bringing the star into the field of the tube.

5. Note that because the recording drum has four sides, four observations may be made in rapid succession, provided that a note is made of the position of the pendulous unit each time and a record is kept of which target area was used. The reading glass should be in a middle position *before* each set of observations is made. In this way any ambiguity in resetting the index arm for reading the sextant altitude will be avoided.

6. The marks on the recording drum may be removed by rubbing gently with a moistened finger or dampened cloth. An eraser should *not* be used.

7. In rough weather, a series of observations should be made, to check the constancy of rate of change in altitude of the body.

8. When the pendulous unit is disengaged from the frame, the instrument should be handled with particular care to avoid damage from excessive bumping of the unit against the frame. Rubber bumpers are provided to minimize this danger.

9. As with other sextants, when the Ball Recording Sextant is not in use it should be stored in its carrying case. The index arm should be approximately in an 80° position for proper fit of the instrument in the case.

SEXTANT TILT CORRECTION

To be subtracted from altitude reading

SEXTANT TILT

Sextant altitude reading	0.5°	1.0°	1.5°	2.0°	2.5°	3.0°	3.5°	4.0°	4.5°	5.0°
	′	′	′	′	′	′	′	′	′	′
0°	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.1
10	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.5	1.9	2.3
15	0.0	0.1	0.3	0.6	0.9	1.3	1.7	2.2	2.8	3.5
20	0.0	0.2	0.4	0.8	1.2	1.7	2.3	3.0	3.9	4.8
25	0.1	0.2	0.5	1.0	1.5	2.2	3.0	3.9	4.9	6.1
30	0.1	0.3	0.7	1.2	1.9	2.7	3.7	4.8	6.1	7.5
35	0.1	0.4	0.8	1.5	2.3	3.3	4.5	5.9	7.4	9.2
40	0.1	0.4	1.0	1.8	2.7	4.0	5.4	7.0	8.9	11.0
45	0.1	0.5	1.2	2.1	3.3	4.7	6.4	8.4	10.6	13.1
46	0.1	0.5	1.2	2.2	3.4	4.9	6.6	8.7	11.0	13.5
47	0.1	0.6	1.3	2.2	3.5	5.0	6.9	9.0	11.3	14.0
48	0.1	0.6	1.3	2.3	3.6	5.2	7.1	9.3	11.7	14.5
49	0.2	0.6	1.4	2.4	3.8	5.4	7.4	9.6	12.2	15.0
50	0.2	0.6	1.4	2.5	3.9	5.6	7.6	10.0	12.6	15.5
51	0.2	0.6	1.5	2.6	4.0	5.8	7.9	10.3	13.1	16.1
52	0.2	0.7	1.5	2.7	4.2	6.0	8.2	10.7	13.5	16.7
53	0.2	0.7	1.6	2.8	4.3	6.2	8.5	11.1	14.0	17.3
54	0.2	0.7	1.6	2.9	4.5	6.5	8.8	11.5	14.5	17.9
55	0.2	0.7	1.7	3.0	4.7	6.7	9.1	11.9	15.1	18.6
56	0.2	0.8	1.7	3.1	4.8	7.0	9.5	12.4	15.7	19.3
57	0.2	0.8	1.8	3.2	5.0	7.2	9.9	12.9	16.3	20.1
58	0.2	0.8	1.9	3.3	5.2	7.5	10.2	13.4	16.9	20.8
59	0.2	0.9	2.0	3.5	5.4	7.8	10.6	13.9	17.6	21.7
60	0.2	0.9	2.0	3.6	5.7	8.1	11.1	14.5	18.3	22.5
61	0.2	0.9	2.1	3.8	5.9	8.5	11.5	15.0	19.0	23.5
62	0.2	1.0	2.2	3.9	6.1	8.8	12.0	15.7	19.8	24.4
63	0.3	1.0	2.3	4.1	6.4	9.2	12.5	16.4	20.7	25.5
64	0.3	1.1	2.4	4.3	6.7	9.6	13.1	17.1	21.6	26.6
65	0.3	1.1	2.5	4.5	7.0	10.1	13.7	17.9	22.6	27.8
66	0.3	1.2	2.6	4.7	7.3	10.5	14.3	18.7	23.6	29.1
67	0.3	1.2	2.8	4.9	7.7	11.1	15.0	19.6	24.8	30.5
68	0.3	1.3	2.9	5.2	8.1	11.6	15.8	20.6	26.0	32.0
69	0.3	1.4	3.1	5.4	8.5	12.2	16.6	21.6	27.3	33.7
70	0.4	1.4	3.2	5.7	8.9	12.8	17.5	22.8	28.8	35.4
71	0.4	1.5	3.4	6.1	9.5	13.6	18.5	24.1	30.4	37.4
72	0.4	1.6	3.6	6.4	10.0	14.4	19.6	25.5	32.2	39.6
73	0.4	1.7	3.8	6.8	10.6	15.3	20.8	27.0	34.1	42.0
74	0.5	1.8	4.1	7.3	11.3	16.3	22.1	28.8	36.3	44.6
75	0.5	2.0	4.4	7.8	12.1	17.4	23.6	30.7	38.7	47.6
76	0.5	2.1	4.7	8.4	13.0	18.7	25.3	33.0	41.5	51.0
77	0.6	2.2	5.1	9.0	14.0	20.2	27.3	35.5	44.6	54.8
78	0.6	2.5	5.5	9.8	15.2	21.8	29.6	38.4	48.3	59.2
79	0.7	2.7	6.0	10.7	16.6	23.8	32.2	41.8	52.5	
80	0.7	3.0	6.6	11.8	18.3	26.2	35.3	45.8	57.4	
81	0.8	3.3	7.4	13.1	20.3	29.0	39.1	50.5		
82	0.9	3.7	8.3	14.7	22.7	32.4	43.7	56.3		
83	1.1	4.2	9.5	16.7	25.9	36.8	49.3			
84	1.2	5.0	11.0	19.4	29.9	42.4	56.6			
85	1.5	5.9	13.0	23.0	35.3	49.7				
86	1.9	7.4	16.3	28.3	43.0	59.9				
87	2.5	9.7	21.2	36.3	54.3					
88	3.7	14.2	30.0	48.7						
89	7.1	24.9	48.2							
90	30.0									

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