Capt. Elmer A. Ingham
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WAR DEPARTMENT

TECHNICAL MANUAL

CELESTIAL AIR NAVIGATION

March 4, 1941

(2) *Averaging device.*—To test averaging device for proper totalizing without first removing index or bubble error, the procedure for determining bubble error by the third method described in paragraph 61*b* (2)(*c*) is recommended. A precomputed altitude curve of the body for the position at which observations are being made is virtually necessary for this check (see sec. XI). If the plotted observation (average of the eight sights corrected for refraction and/or parallax) does not agree with the computed altitude, the totalizing mechanism requires adjustment. To make this adjustment, loosen screw which locks the knurled adjusting screw and rotate adjusting screw upward to increase magnitude of average altitude and downward to decrease it. After adjusting, lock knurled nut and check correctness of adjustment by comparing additional observations against computed altitudes. This adjustment allows for bubble error and observer's personal error only when using the totalizer.

(3) *Index and/or bubble error.*—If it is desired to determine index error or bubble error by checking against a leveled datum line or against the natural horizon as outlined in paragraph 61*b*(2)(*a*) and (*b*), extreme caution must be exercised when rotating the micrometer drum in a direction to decrease altitude setting when near the zero altitude position. To avoid danger of damaging the instrument, the knurled adjusting screw should be backed off several turns, that is, moved upward, before the errors are determined. It may be reset by setting the instrument for 90° altitude and adjusting the mechanism to total 90° (in which case bubble and observer's personal error must be applied to future observations) or adjusted in the manner described in (2) above, in which case the two errors are corrected for in subsequent observation.

65. Octant, A–6 (figs. 43 and 44① and ②).—*a. General.*—(1) The A–6 octant is a light, compact, handy instrument. It may be used either day or night and as a bubble sextant or horizon sextant. Outstanding features are—

(*a*) It contains a semipermanent bubble which requires no adjustment in flight, but which may be enlarged or reduced as desired. It will remain as adjusted for a period of time.

(*b*) Interior of bubble is transparent so that collimation may be effected easily by centering the observed body at center of bubble.

(*c*) It has a direct reading index to 1 minute of arc.

(*d*) Stars may be observed by direct vision, thus facilitating star identification.

(2) Complete discription, operation, and maintenance instructions pertaining to the A–6 octant are contained in Air Corps Technical Order 05–35–7, December 10, 1935.

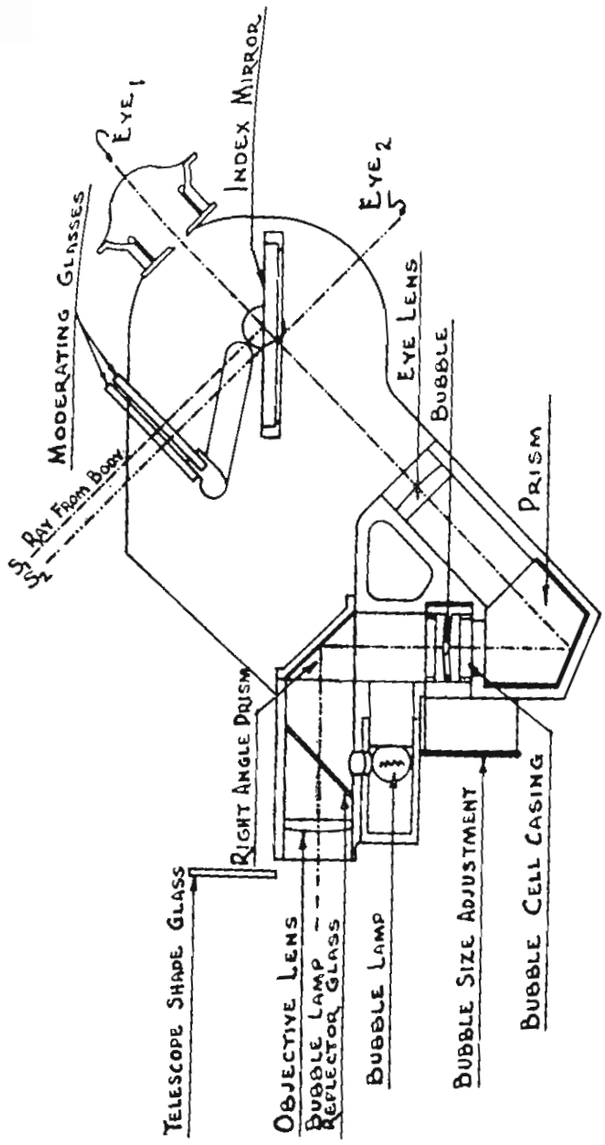

FIGURE 44.—Diagram of optical parts, A-6 octant.

b. Description.—(1) *Optical part*
of observer's eye when heavenly boc
or the moon.

(*b*) *Eye*$_2$ is the position of observe
a faint one.

(*c*) The index mirror is a glass pla
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(*d*) The pair of moderating glasses
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(*e*) The bubble cell is filled with xyl
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upper and lower surfaces of the bubble
bubble are curved, concave downwar
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image and bubble remain in coincidence

(*f*) The telescope shade glass may be p
when it is desired to exclude terrestrial o

(2) *Path of light through optical syste*
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When the bubble lamp is used, the light is
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(*b*) When coincidence of bubble and body
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viewed through the index glass. With the e
as a mirror now reflects the bubble image, w
through the index glass. Advantage is take
view the less brilliant object whether it is
direct, and to reflect the more brilliant obje

(3) *Operating parts* (fig. 44① and ②).—
tumbler switch is in the central position it is
it illuminates the scale and glass record slate
it illuminates the bubble.

b. Description.—(1) *Optical parts* (fig. 43).—(*a*) Eye_1 is position of observer's eye when heavenly body is a bright one, that is, the sun or the moon.

(*b*) Eye_2 is the position of observer's eye when the heavenly body is a faint one.

(*c*) The index mirror is a glass plate, surfaces of which are optically plane and very accurately parallel to each other. This mirror rotates about an axis perpendicular to the paper. The rotation is caused by operation of the control nut and it, at the same time, operates the micrometer drum from which the altitude is read.

(*d*) The pair of moderating glasses are of different densities. One or both may be introduced into the position shown if the heavenly body is too bright for comfortable observation.

(*e*) The bubble cell is filled with xylol except for a small bubble at the top. The bubble appears as a black circle in a bright field. The upper and lower surfaces of the bubble cell glasses which confine the bubble are curved, concave downward. The radius of the upper curve is equal to the principal focal lengths of the objective lens and eye lens. This condition makes it possible to make an accurate reading any place within the approximately 9° field so long as reflected image and bubble remain in coincidence with bubble clear of the rim.

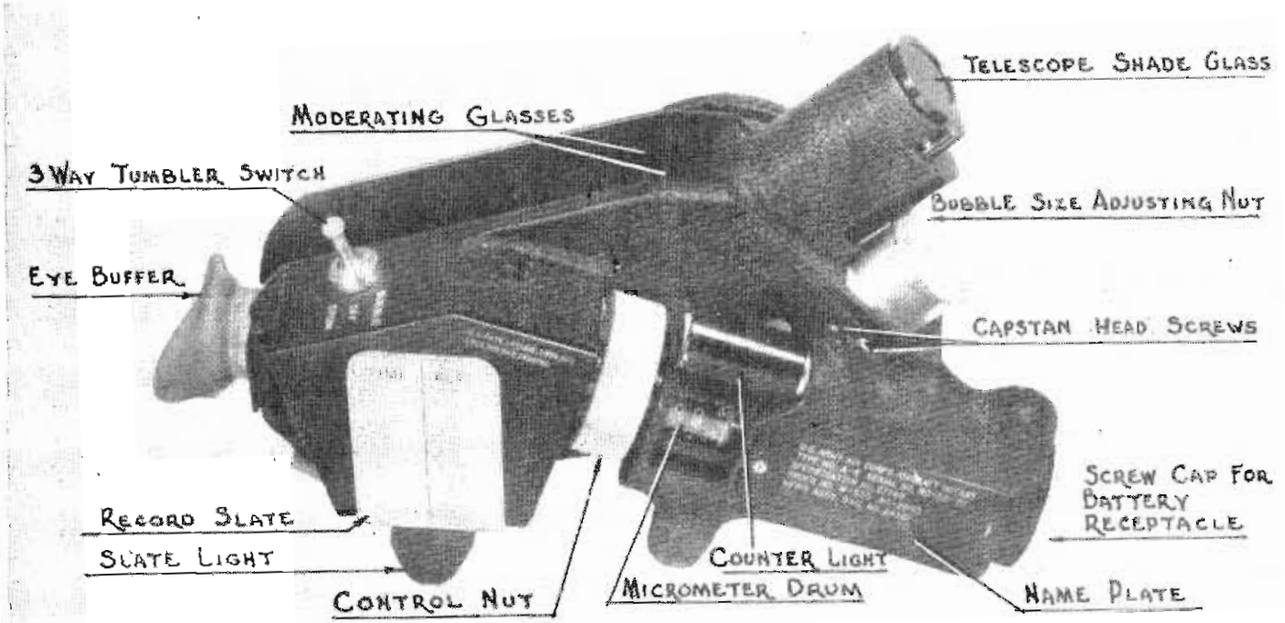
(*f*) The telescope shade glass may be placed over the objective lens when it is desired to exclude terrestrial objects.

(2) *Path of light through optical system* (fig. 43).—(*a*) Light for the bubble enters either through the objective lens or is artificially produced by the bubble lamp. When natural light is used it follows the dotted and dashed path shown in the diagram to Eye_1 or Eye_2. When the bubble lamp is used, the light is reflected by the plane glass reflector and then follows the path as shown. The optics are so arranged as to make the bubble appear at infinity.

(*b*) When coincidence of bubble and body has been effected with the eye at Eye_1, the index glass as a mirror reflects the body S_1, while at the same time the bubble projected through the optical system is viewed through the index glass. With the eye at Eye_2, the index glass as a mirror now reflects the bubble image, while the body S_2 is viewed through the index glass. Advantage is taken of this arrangement to view the less brilliant object whether it is the bubble or a dim star direct, and to reflect the more brilliant object.

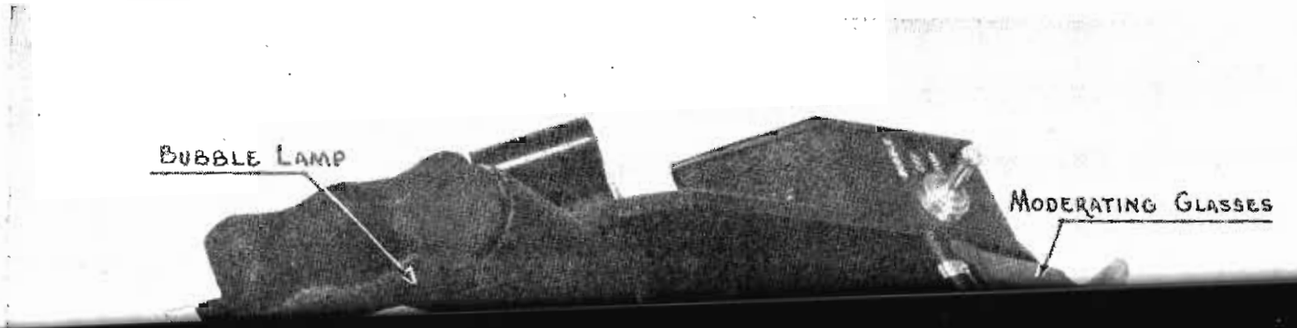
(3) *Operating parts* (fig. 44① and ②).—(*a*) When the three-way tumbler switch is in the central position it is off. Toward the eyecap it illuminates the scale and glass record slate. Away from the eyecap it illuminates the bubble.

FIGURE 43.—Diagram of optical parts, A-6 octant.



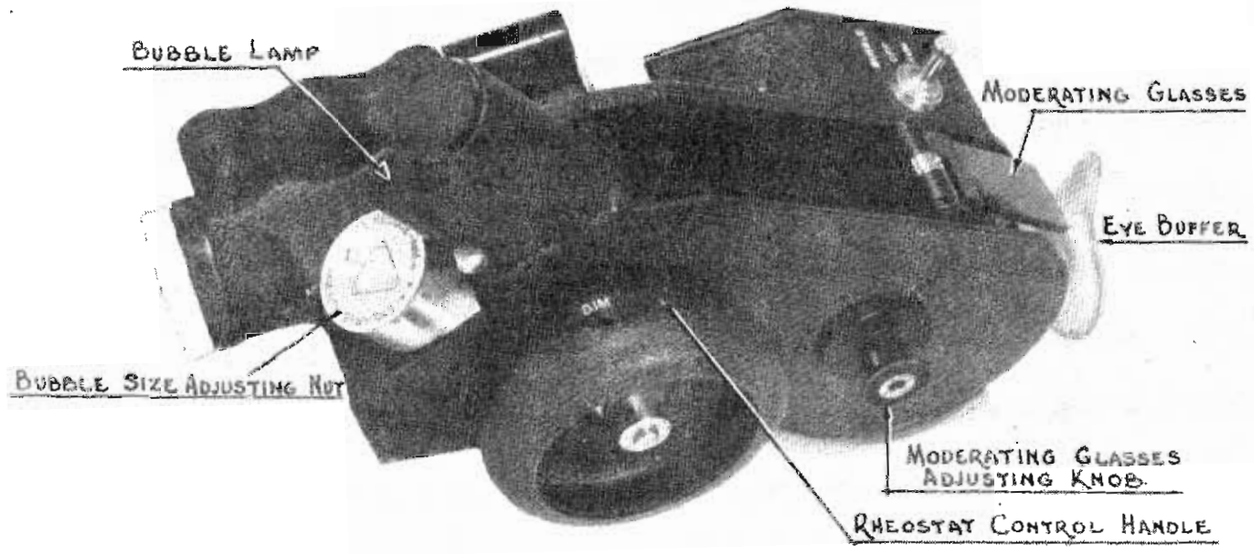
① Right hand view

FIGURE 11.—Octant, A-6.



① Right hand view

FIGURE 44.—Octant, A-6.



② Left hand view

FIGURE 44.—Octant, A-6.—Continued

(*b*) The rheostat handle varies the intensity of illumination of the bubble. The illumination system has not been altogether satisfactory due to the tendency of the rheostat system to get out of order.

(*c*) The control nut rotates the index mirror and micrometer drum. The mirror and drum are geared lower than in the A–5 octant so that movement of control nut does not rotate the mirror and drum so rapidly.

(*d*) The name plate serves as a cover for the counter adjusting nut and lock nut. It is fitted in a dovetail and slides downward away from the eyepiece to make the nuts accessible.

(*e*) The capstan headscrews permit adjustment of bubble to coincidence with natural horizon as described in paragraph 61*b*. An adjustment pin for these screws is carried in the case.

(*f*) Operation of the bubble adjusting nut changes the size of the bubble. See *d* below for method.

(*g*) The filter adjusting knob is the means by which the moderating glasses are introduced or removed. Care must be exercised in operating this knob so as not to injure the teeth of the filter gear. When it is desired to move the filters, pull knob full out and hold it out while rotating until filters are in desired position. Then release knob.

c. Operation.—(1) *To use with bubble horizon in daylight observation.*—(*a*) Place eye at Eye_1 (fig. 43). This is the usual position for observations on sun.

(*b*) Admit light to bubble by rotating telescope shade glass so as not to cover telescope.

(*c*) Adjust moderating filters so as—

1. To intercept sun's rays.

2. Not to intercept moon's rays.

(*d*) Observe, bringing body into coincidence with center of bubble by turning control nut. Have bubble free from rim of chamber, preferably in center.

(2) *To use with bubble horizon in night observation.*—(*a*) Place eye at Eye_2 (usual position for night observation on star), or at Eye_1 if body is a brilliant one.

(*b*) Adjust moderating filters so as not to intercept rays from body.

(*c*) Move three-way light switch to "Bubble."

(*d*) Vary bubble illumination by means of rheostat control.

(*e*) Observe, bringing body into coincidence with center of bubble by turning control nut. Bubble should be free from rim of chamber, preferably in center.

(3) *To use with sea horizon.*—(*a*) Place eye at Eye_1.

(*b*) Remove bubble as described in *d* below.

(*c*) Adjust telescope shade glass to cut out glare of horizon.

(*d*) Adjust moderating filters so as—

1. To intercept sun's rays.

2. Not to intercept moon's rays.

(*e*) Observe, bringing the body to tangency with sea horizon by turning control nut.

(4) *Precautions during operation.*—(*a*) See that filter glasses never interfere with movement of index glass.

(*b*) Keep hands off index glass.

(*c*) Do not allow bubble unit to be struck.

(*d*) Remove battery before putting instrument away.

(*e*) Keep octant in case when not in use.

d. Adjustment.—(1) *Size of bubble.*—(*a*) To increase size of bubble point telescope downward, and turn bubble adjusting nut in the "enlarge" direction as shown by arrow engraved on nut.

(*b*) To decrease size of bubble point telescope upward and turn bubble adjusting nut in the "reduce" direction. It is possible to remove bubble entirely from the field by turning the nut in reduce direction a sufficient number of turns.

(*c*) *If nut is rotated while telescope is held in a horizontal position, size of bubble is not affected.* Therefore if the end of motion of nut is reached before bubble is adjusted to desired size, hold octant so that telescope is horizontal and reverse direction of rotation of the nut as far as it will go. Then return to operation under (*a*) or (*b*) until desired size bubble is attained.

(2) *Index and bubble error.*—The design of this instrument is such that both index error and bubble error may be eliminated with comparative ease. No adjustment of the prisms is necessary. If the observer does not care to eliminate both of these errors, he can determine and eliminate either with even greater facility.

(*a*) *To determine and eliminate index error.*

1. Determination.—Adjust instrument as for daylight observation with sea horizon (no bubble). Set scale near zero and determine index error as described in paragraph 61*a*. During this procedure moderating filters should not intercept rays striking index glass.

2. Elimination.—Rotate control nut until reflected and projected images coincide. Slide name plate downward toward bottom of handle. This will expose counter adjusting nut and counter lock nut. Loosen lock nut (the lower one of the two; it works like any right hand screw). Then turn adjusting nut which will permit scale drum to be turned without rotation of index mirror until scale reads zero. Tighten lock nut. Check reading on

datum point to be sure that image is not doubled when scale reading is zero.

(*b*) *To determine and adjust scales for bubble error.*

1. Determination.—Proceed as outlined in paragraph 61*b*. During this operation bubble must be in the field. Position of moderating filters will depend upon which method of paragraph 61*b*(2) is being employed and what object (terrestrial or celestial) is being sighted. The third method (comparison with computed altitude of a celestial body) is recommended when the observer's purpose is only to determine bubble error and to adjust scales with zero error when bubble and reflected image are centered.

2. Scale adjustment.—Having determined the magnitude of bubble error, the micrometer drum may be adjusted to read zero when the bubble is centered by turning the adjusting nut in the same manner as has been described for obtaining zero index error. It must be remembered that when drum is thus adjusted for zero bubble correction, an index error will be put into instrument.

3. Bubble error may be eliminated without adjusting the scale by turning the capstan head screws. Adjustment of the capstan head screws is generally made only when it is desired to eliminate both index and bubble error as described below.

(*c*) *To eliminate both index and bubble error.*—The octant is in perfect adjustment when no index or bubble error exists. When this adjustment is complete the octant is in condition of adjustment to permit reading altitudes against either the natural horizon or the bubble horizon, and the readings will be accurate and the same for either case. To accomplish this the index error is first determined and scales adjusted for zero index error as described in (2)(*a*) above. Then bubble error is eliminated as follows:

1. Set up octant for sighting on either a leveled datum point or on the sea horizon.

2. Using adjusting pin, turn the two capstan headscrews opposite to each other, observing at the same time. It will be seen that this moves the bubble in the field. Move it until image of datum point bisects it exactly. When finished, these screws should be taut but not under strain.

e. Maintenance.—(1) The octant requires no field lubrication. All necessary lubricants are applied during assembly.

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(4) The lamp sh
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66. Octant, A–6A
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Order 05–35–7.

b. Description.—The
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(2) The adjustable
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(3) The fixed stop scre
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(2) When cleaning optical surfaces the same precautions should be observed as for type A–5 octant.

(3) Three spare bulbs, two of clear glass and one frosted, are provided in the case. The frosted bulb is for bubble illumination and the two clear bulbs for illuminating the scale and the recording slate, respectively.

(4) The lamp shield lock screws should be tested frequently for tightness. Vibration of the airplane frequently loosens these screws with the result that the shields sometimes fall from the octant and are lost.

66. Octant, A–6A (fig. 45).—*a. General.*—The A–6A octant is a type A–6 which has been modified to incorporate a mechanical averaging device. This device operates on the same principle and is practically identical with that incorporated on the type A–5A octant. The description and adjustment are contained in Air Corps Technical Order 05–35–7.

b. Description.—The principal parts of the averaging device are shown in figure 45. Comparison with the A–5A octant (fig. 42) will show the similarity between the two. The principal differences are—

(1) The movable (vernier) scale is the outer of the two scales. Hence degrees are read off the inner scale, minutes off the outer. The reading in figure 45 is 28°40′.

(2) The adjustable resetting stop performs the functions of the zero reset screw on the A–5A.

(3) The fixed stop screw is of slightly different design. This screw is locked in position by a lock screw which must be loosened before the stop screw can be turned.

(4) The position of the operating handle is such that it may be operated in either direction by the index finger.

c. Operation.—(1) Individual sightings with this instrument are made in the same manner as when using the A–6.

(2) The averaging device gives arithmetical mean of eight sights and is operated in a manner similar to that of the A–5A.

d. Adjustment.—Adjustments for elimination of bubble and index error are the same as for type A–6. If a leveled datum plane or the natural horizon are employed when making these adjustments, extreme caution must be exercised when rotating the control nut in a direction to decrease altitude setting when near the zero altitude position. To avoid danger of damaging the instrument, the fixed stop screw should be backed off two or three turns during the micrometer drum adjustment. After the micrometer drum has been adjusted and locked, the stop screw of the averaging device should be turned clockwise until it presses the arm against the movable stop. The

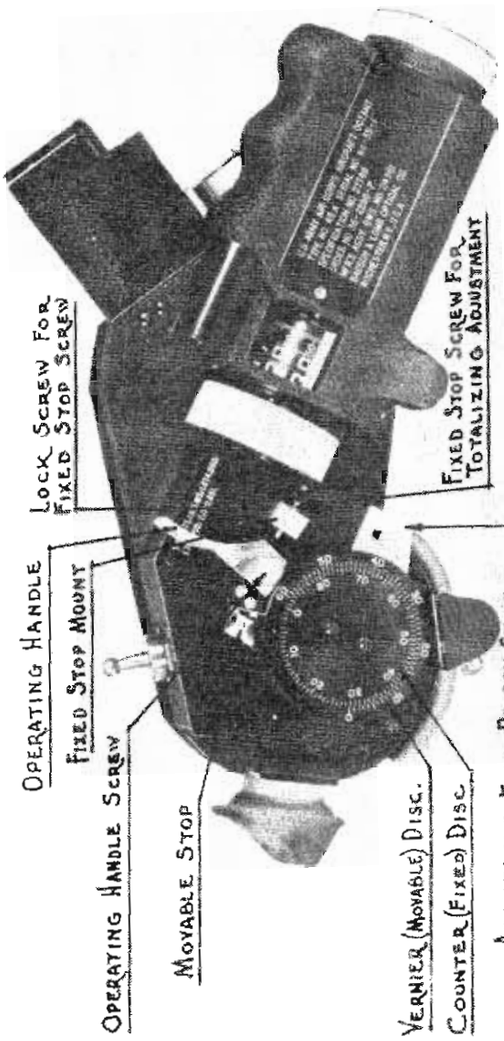

FIGURE 45.—Octant, A-6A.

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following errors are ap

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(2) Bubble.
(3) Coriolis' type ac
(4) Refraction.
(5) Parallax.
(6) Dip.
(7) Semidiameter.

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have been described in p

c. Coriolis' type accele
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been described in paragr
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are index and bubble err

d. Refraction, parallax
result from conditions not
corrections are given in t
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68. Refraction (fig. 46)
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altitude setting should be zero and control nut should be against the zero position stop during this operation. Care must be exercised not to exert any pressure against the movable stop. The stop screw should be tightened only enough to prevent any movement of the arm in the zero altitude position. Since this screw is the acting stop for zero position when the averaging device is being used, it is obvious that its adjustment is very critical. Any error in its position is added eight times so the final reading would be thrown off an amount equal to eight times this error. After setting the adjusting screw it must be firmly locked by the lock screw.

67. Correction of observed altitudes.—*a.* It has been stated in a preceding section that the intercept, or altitude difference, was obtained by comparing the observed and computed altitudes. The observed altitude (H_o) is not the sextant altitude (H_s), but the sextant reading after it has been corrected for several determinate errors of observation. In other words, assuming no acceleration errors, observed altitude is true altitude as measured from the plane perpendicular to the vertical at observer's position. Depending on whether the visible horizon or bubble horizon has been used for leveling and upon the particular body observed, corrections for one or more of the following errors are applied to H_s to obtain H_o:

(1) Index.
(2) Bubble.
(3) Coriolis' type acceleration.
(4) Refraction.
(5) Parallax.
(6) Dip.
(7) Semidiameter.

b. Index error and bubble error, being strictly instrument errors, have been described in paragraph 61.

c. Coriolis' type acceleration error, its determination, and the subsequent adjustment of the plotted line of position to correct for it have been described in paragraph 59. This error is essentially an instrument error but its amount, although determinate, is not constant as are index and bubble errors.

d. Refraction, parallax, dip, and semidiameter are errors which result from conditions not related to the instrument. Values for these corrections are given in the Air Almanac. They are also listed individually and in various convenient combinations in the Nautical Almanac and in many of the tables used for solving the astronomical triangle.

68. Refraction (fig. 46).—*a.* A well-known principle of optics is that a ray of light in passing from one medium into another medium

FIGURE 15.—Octant, A-6A.