INSTRUCTIONS FOR USE, ADJUSTMENT, AND CARE OF SHIPBOARD THEODOLITE. TYPE: AERO, 1928, U. S. N. (*)

(Extracted from Instructions for Making Pilot Balloon Observations at Sea, issued by the *U.S. Bureau of Aeronautics, Navy Department. — Pilot Chart of the Upper Air, North Atlantic Ocean,* U.S. Hydrographic Office, Washington, November 1940).

GENERAL.

The essential difference between this shipboard theodolite and the ordinary shore theodolite is that the elevation angle of the pilot balloon is obtained by measuring the angle through which a reflecting prism must be turned in order to bring the image of the balloon into coincidence with the image of the horizon. In this respect its operating principle is the same as that of a sextant. With the ordinary shore theodolite the instrument is leveled and clamped and the elevation angle obtained by bringing the balloon into coincidence with the cross hairs of the telescope and reading the angle through which the telescope must be turned from the horizontal to accomplish this. The great advantage of the sextant principle in a theodolite for ship use is that when the vessel rolls and pitches, *the reference point, or zero elevation plane, has the same apparent motion as the balloon.* Thus, as long as the images of the two are in coincidence, the correct elevation angle is shown on the scale. It is therefore unnecessary to turn the elevation screw when, due to motion of the ship, the balloon and horizon shift together in the field of view, or even pass entirely out of sight. They usually automatically come into view again through action of the counterbalance device.

For use at night, or when the horizon is otherwise invisible or indistinct, an artificial horizon is provided in some of these theodolites in the form of a doubled bubble image. When the bubble is thrown "in", the midpoint between the centers of the two images of the bubble replaces the horizon as a reference point.

The appearance of the field in this instrument differs strikingly from that of the ordinary sextant in that there are two vertical strips, one on each side, in which the horizon is viewed. But when the bubble is in use, only one strip shows the bubble images.

DESCRIPTION.

General. — The appearance of the instrument is shown in Figures 1 and 2. A few minor changes will be found in the theodolite issued to the service. The mounting is the familiar tripod (not shown), between the legs of which is suspended from gimbals a rod carrying a movable weight which serves to counterbalance the theodolite. The motion of the counterbalance may be damped by attaching it to the tripod legs by means of the three springs provided.

Figure 1 shows a view of the left side of the instrument. The optical system, with the exception of the index prism "A", ray filters, and eyepiece, is housed in the showerproof case "B", the left side of which is removable. The movable arc "C" carries the index prism "A" and is graduated in even degrees from $-5°$ to $95°$. This scale may be read to tenths of degrees by means of numerals expressing tenths on the micrometer drum

(*) See : *Hydrographic Review,* Vol. XVI, N° 2, Monaco, November 1939, page 162.

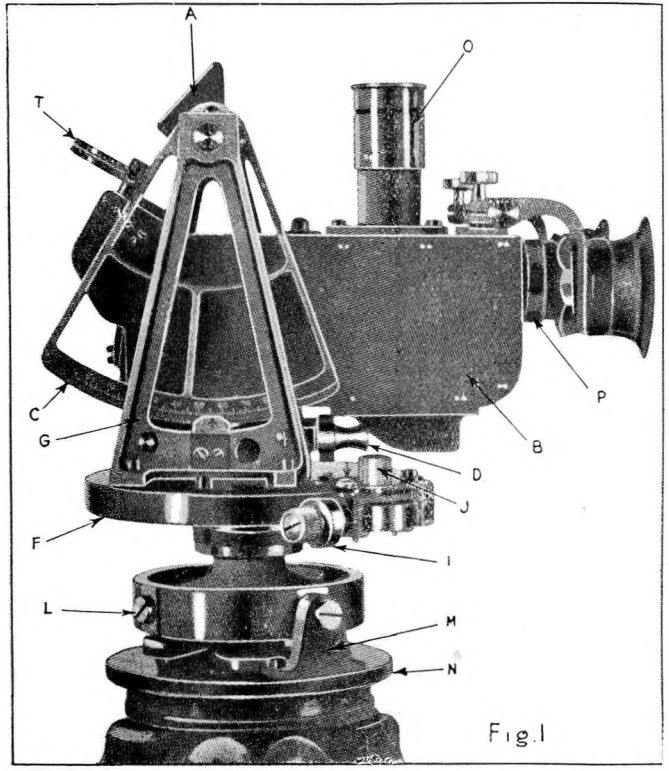

Fig.1

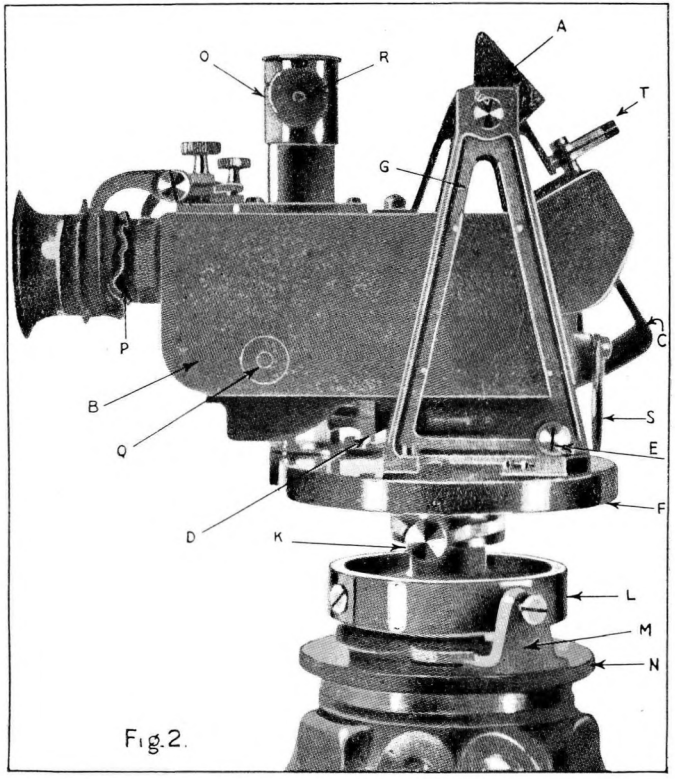

Fig.2.

"D". For rapid adjustment, as when picking up the balloon, the micrometer worm can be thrown out of gear by pressing "D" down until it is held in disengagement. Slow motion in elevation is obtained by turning the milled knob "E" (fig. 2) on the right side of the instrument. One revolution shifts the line of sight 1°. The optical system is supported over the center of the horizontal azimuth top plate "F" by the standards "G", which are bolted to this plate. This top plate, standards, and optical system may be turned in azimuth, since they are carried by the horizontal azimuth plate (concealed in figs. 1 and 2) which is pivoted in the base plate (also concealed in figs. 1 and 2). The azimuth angle to the even degree is read through a horizontal window "H" (just visible in fig. 1). Tenths of degrees are read on the azimuth micrometer drum "I" (fig. 1). Slow motion in azimuth is obtained by turning the milled knob on the end of the micrometer drum. One revolution shifts the line of sight 1°. For rapid adjustment, as when picking up balloon, the azimuth micrometer worm may be thrown out of engagement by turning the knob "J" (fig. 1).

In the instrument as issued to the service there is a spring closing catch (not shown on sketches) located opposite "K", and secured to the base plate. This catch automatically secures the theodolite in the inner gimbal when mounting, but must be released by hand in dismounting. To permit orientation of theodolite without shifting the tripod legs, the base plate is pivoted in the inner gimbal axis and may be locked in any azimuth position by the clamp screw "K" (fig. 2). It should be noted that clamp "K" must be slacked off when dismounting or mounting the theodolite. The gimbal ring "L" is supported by the standards "M", which are bolted to the plate "N". This plate screws on to the threaded edge of the top plate of the tripod.

Optical system (figs. 1, 2, and 3). — Figure 3 is largely self-explanatory. In addition to depicting the optical system, it indicates the path of rays of light traversing the optical system.

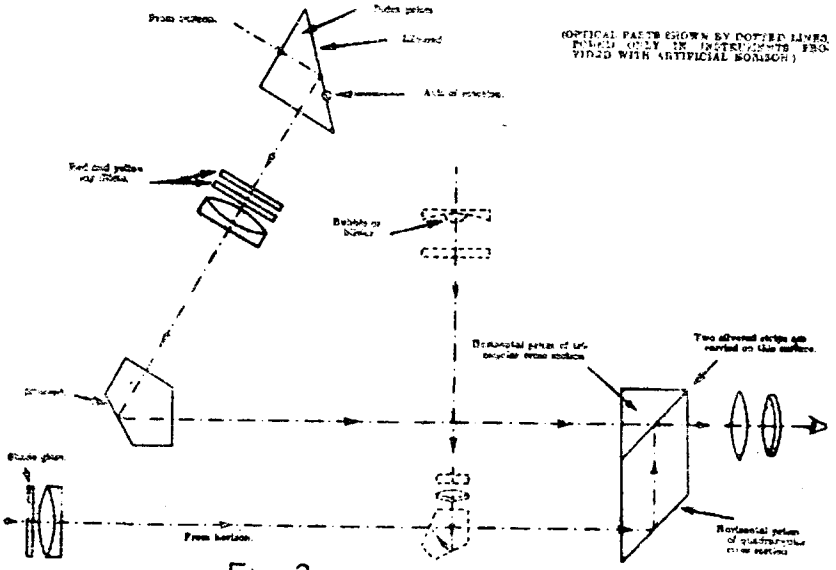

Fig. 3

The magnification of the system is 8-power and the field is 6°.* Focus is obtained by turning the knurled ring "P" on the eyepiece.

On those instruments which are equipped with artificial horizon (as is the one shown in figs. 1 and 2), the bubble or blister, located in the projecting cylindrical case "O" at

(*) *Theodolites Aero,* 1928, U. S. N., N° 1-30, 2-30, 3-30, to 10-30, *inclusive, have a field of* 3°.

the top, is thrown "in" by turning the knob "Q" (fig. 2). The two images may be brought closer together, or moved farther apart, by means of the thumb screw "R" (fig. 2). These two knobs are on the right-hand side of the theodolite. Night illumination of the bubble is provided by means of a self-luminous substance painted on the inside of the cylindrical case. If this gives insufficient light, a flashlight may be used.

A neutral shade glass is fitted at "S" (fig. 2) to reduce horizon glare when necessary. Two ray filters, one yellow and one red, are provided at "T" for improving the visibility of the balloon on hazy days. For preventing optical fatigue, an eye blinder is furnished as a cover for the eye not in use.

A geared peep-sight device (not shown in illustrations) is provided on the instrument issued to the service. This sight is for use in rapid picking up of the balloon.

OPERATION.

To take an observation when horizon is visible. — Set up tripod. Chains are provided from leg to leg so that this may be done quickly with an equal spread of the legs. Secure the gimbals to the top plate of the tripod by screwing the plate "N" on to the threaded edge of the top plate of the tripod. Attach counterbalance rod and weight to the bottom of the inner gimbal. The tripod may be stowed with these parts attached. Slip theodolite into inner gimbal, making sure that catch engages. If theodolite swings excessively due to roll and pitch of the vessel, try to dampen swinging by attaching springs from the counterbalance rod to each leg of the tripod. Stability may be improved by shifting counterweight up or down on the rod.

Set azimuth circle to read same as ship's course and make sure azimuth micrometer worm is engaged. With clamp "K" loose, line up telescope on fore-and-aft bench mark. When line of sight is parallel to keel of ship looking forward, set up on "K" until horizontal azimuth plate is clamped in inner gimbal.

Note. — When line between bench mark and center of theodolite is not parallel to centerline of ship, but instead is inclined to it at an angle, the course of the ship plus or minus this angle must be set on the azimuth circle. In this connection it should be mentioned that upon receipt of the theodolite a number of suitable locations for taking observations under various wind conditions should be selected and orientation angles determined. In order to make sure that the orientation is correct and has not been accidentally changed during observation, check should always be made at *beginning* and *ending* of observation. A satisfactory check can usually be made by sighting the theodolite in the direction dead ahead, estimated by eye, and noting if azimuth reading is same as ship's heading.

Disengage elevation and azimuth worms (by means of "D" and "J"). Release balloon. To pick up balloon use external sighting device until the balloon is sighted in field of telescope. As soon as balloon "settles down", engage the azimuth and elevation screws and follow balloon as usual.

Keep image of balloon in line with the *vertical* cross hair between the strips and level with the image of the horizon showing in the vertical strips. The horizontal cross hair is only a convenient reference line for indicating the center of the field and aligning balloon with horizon. No attempt should be made to keep the balloon on the horizontal cross hair. The correct elevation angle is obtained by keeping image of balloon on a line with horizon image seen in strips.

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To take an observation with artificial horizon (bubble or blister). — When the horizon is indistinct or invisible, the bubble is used in its place. Set up and orient as before. Throw bubble "in" by means of thumb screw "Q". (fig. 2). This produces greenish light in one of the vertical strips. If the theodolite is approximately level, two images of the bubble will be seen in the right. hand strip. These images are large and only a vertical section is visible — that is, right and left sides of the images are cut off and cannot be seen. The thumb screw "R" (fig. 2) is used to adjust the closeness of the bubble images. Adjustment should be made until the overlap of the images has a lenticular appearance (the shape of a

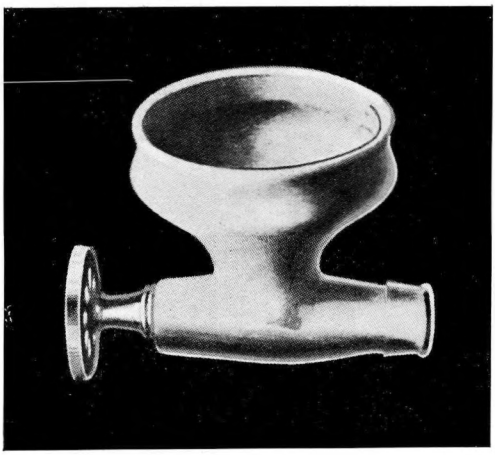

FIG. 4 — *Inflation Valve — Type: Aero 1930.*

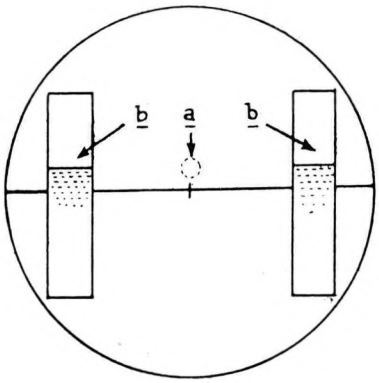

Fig. 5. — *Field when taking observations using horizon.*

a) *Image of balloon on a line with horizon and in line with the vertical cross hair.*

b) *Horizon shown in strips on each side.*

Note. — *Balloon should be aligned with horizon as shown, and* not *with horizontal cross hair.*

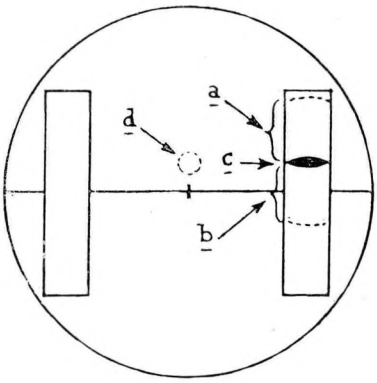

Fig. 6. — *Observation using bubble instead of horizon.*

a) *Upper image of bubble.*

b) *Lower image of bubble.*

c) *Bubble overlap (cigar-shaped).*

d) *Balloon kept in line with dark cigar shape made by bubble overlap as shown, and* not *with horizontal cross hair.*

Note. — *Bubble image appears only in one strip.*

cigar with pointed ends). This overlapped portion will appear darker in color and its horizontal axis is used as the horizon. The image of the balloon should be kept in line with this axis as when using the real horizon.

Important Note. — The field of view of this theodolite is much larger than that of the ordinary shore theodolite. Therefore much greater care must be taken in aligning balloon with horizon and vertical hair. With this new type the same *apparent* error results in far greater *real* error than is the case with the shore type.