this period is large compared with the oscillation periods of the airplane, the chances of progressively building up a large oscillation of the gyroscope from the oscillations of the airship are minimized. The spin axis of the gyroscope thus tends to hold a vertical position in straightaway flight, even though the airplane is constantly oscillating. The system containing the gyroscope is then said to be stabilized.

Careful piloting is an absolute necessity if an artificial horizon is used. If this condition is met, the errors of observation will be found to average from 10 to 20 minutes of arc, while with careless piloting the errors become so great as to make the results useless.

The development of a satisfactory artificial horizon has proceeded along two general lines: First, the attempt to build an auxiliary horizon to be used with a marine type of sextant much as the mercury horizon has been used, and second, to attach the artificial horizon to the sextant.

Pendulum artificial horizon.—A horizon of this type was designed and used by H. N. Russell (loc. cit.) in connection with his investigation of the navigation of aircraft by sextant observations. It consists of a pendulum about 10 inches long mounted in gimbals and having a speculum mirror set horizontally on top of it. The bob is arranged to swing in a pot containing a viscous liquid for damping vibrations. The whole is protected from the wind by a case.

Satisfactory observations upon both the sun and the moon were secured with the aid of this instrument, while provisional tests at night indicated that it could be used for star observations.

Engine vibration caused little trouble when the instrument was mounted upon a suitable shock-absorbing substance. Probably the most serious objection to an artificial horizon of this type, whether gravitational or gyroscopic in its nature, is that it is heavy and cumbersome and has to be moved to different positions for different bodies.

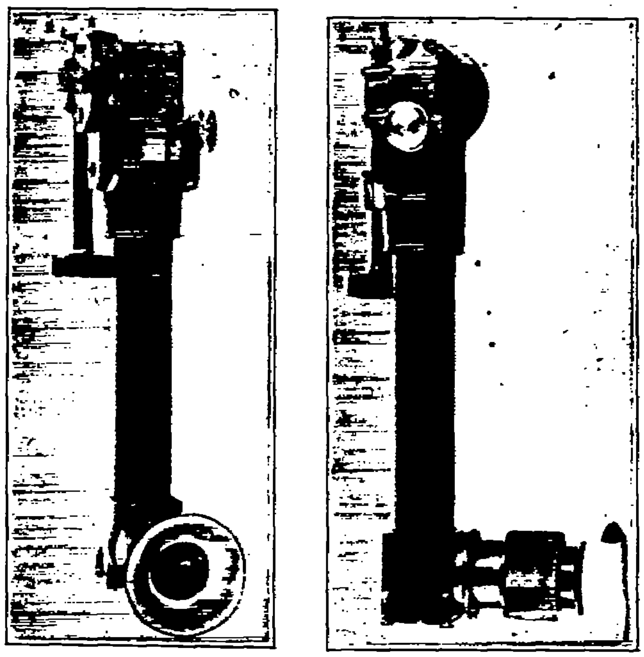

FIG. 14.—Baker sextant.

SEXTANTS USING NATURAL HORIZONS.

In the following description of sextants it will be assumed that the reader is familiar with the principle and the operation of the ordinary sextant. Only the sextants which are particularly adapted to aerial work will be described.

Marine sextants.—These are of the ordinary type used in marine navigation and will not be described here. For aerial use a telescope of low power and large field should be used. The graduations on the arc should be heavy and the vernier should be easily read without the aid of a reading glass.

The Baker sextant.—This instrument (figs. 14 and 15) possesses the unique feature that it eliminates both the correction for the dip of the horizon (when the horizon is level) and for the semidiameter of the body. This not only adds to the rapidity of obtaining the altitude, but it removes the uncertainty due to the lack of knowledge as to the actual height of the aircraft above the horizon used.

The elimination of these two corrections is accomplished by reflecting into the field with the image of the sun the image of the horizon directly under the sun and that of the horizon opposite it. The observer sees the two horizons, one of which is inverted, with an open space between, the width of this space depending on the sum of the dips of the two horizons. Now, if he bisects the space between the two horizons with the image of the sun, he eliminates the dip and semidiameter corrections.

It has already been pointed out that this sextant can be used only when the horizon is level. This fact makes it useful in only a few cases when the ordinary type of sextant can not be used.

Fig. 15 illustrates the principle of the Baker sextant. The fixed horizon prisms (H) are set at the top of a vertical tube (V) high enough to reach above the observer's head as he looks into the eyepiece (E). This is done so that both back and front horizons may be visible simultaneously. These prisms reflect rays of light from the horizons down through the vertical tube (V) to the prism (P), where they are reflected horizontally to the eye at (E). An index prism (I), rotating about a horizontal axis perpendicular to the plane of the paper, is controlled by a knurled thumbscrew carrying a micrometer head, which operates the altitude scale as well. This index prism catches rays of light from the celestial body, reflects them through a small circular hole drilled vertically through the joint between the prisms (H) down parallel to the rays from the horizons until they are reflected by the prism (P) to the eye. The sextant itself is shown in figure 14.

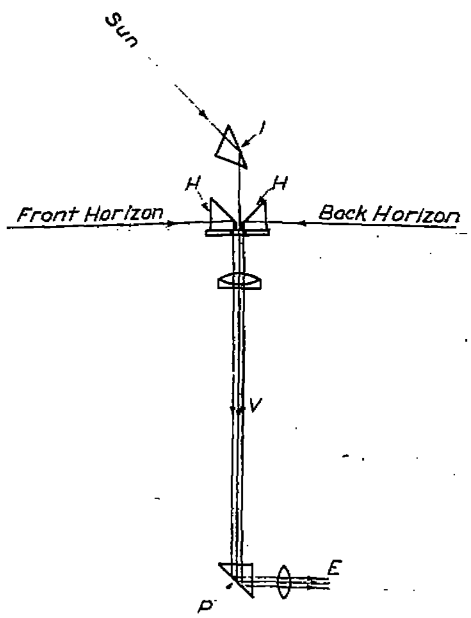

FIG. 15.—Principle of Baker sextant.

BUBBLE SEXTANTS.

The artificial horizon sextants most commonly used are of the bubble type (fig. 16). A bubble tube of the ordinary type or of the circular type is used and the image of the celestial body is brought into coincidence with that of the bubble when the bubble is at the center of the tube.

Byrd bubble sextant.—A sextant of this type (fig. 16A) used considerably in naval aviation has been developed by the United States Navy. This sextant is very similar in appearance to the ordinary marine sextant and can, in fact, be used with a natural horizon by depressing the mirror (M), which reflects the bubble through the horizon glass (H) to the telescope (T).

The bubble is contained in an ordinary spirit-filled tube set into the metal tube (B), which is mounted rigidly to the frame. For day observations, the light entering through the bottom of the tube is sufficient to make the bubble visible to the observer. At night the lamp (L) is used to illuminate the bubble. In order to bring the image of the bubble to a focus at the same point as the image of the celestial body, a half lens is used to focus the rays of the former while the rays from the body pass through the open half.

A convenient means is provided for making the first rough setting of the arm (A). Underneath the arc which carries the scale is a rack into which fits a worm gear operated by the micrometer head (D). By moving the lever (L_1) down, the worm gear is taken out of mesh with the rack and the arm can be set to its approximate position. The lever is then released, the worm gear again meshes with the rack, and the fine adjustment is made with the micrometer head. The head reads directly to the nearest 30 seconds. A lamp (L_2) is used to illuminate the scale at night.

The switch (S) is used for the lamp (L_2), which illuminates the scale, while the lamp (L), illuminating the bubble, is operated by the push button (P). These two switches are located on the handle of the sextant, where they can be operated by the fingers of the hand holding the instrument. The handle contains the battery used for the lamps.

With this instrument, the images of the bubble and the celestial body move in the same direction when the sextant is inclined longitudinally.