to combine the horizon with the sextant into one instrument. Various forms of artificial horizons will be described in connection with the sextants on which they are used.

SEXTANTS

The term "sextant" is here used to include all instruments which are intended for the measurement of altitudes, regardless of the form of the instrument or the optical principle upon which it is based. In general, only sextants which are available at the present time are described. One or two instruments are mentioned, however, either because they are convenient illustrations of certain types or because they incorporate some novel features which may prove to be useful.

NATURAL HORIZON SEXTANTS

The theory, construction, and operation of the marine sextant are so well known that it is unnecessary to describe the instrument here. If the marine sextant is to be used on board aircraft, it is desirable that it be rather small and light in weight. The angular field of view included in the index glass should be as large as possible, and the telescope should be of low power and large field. It may be advisable when the visibility is poor to dispense with a telescope and observe with the naked eye. The arc should be clearly graduated with rather heavy lines and large figures. A tangent micrometer screw with a drum indicating minutes of arc and a simple, easily operated clamp are preferable to the usual vernier with its clamping and slow-motion screws. The adjustment of the instrument should be checked at frequent intervals.

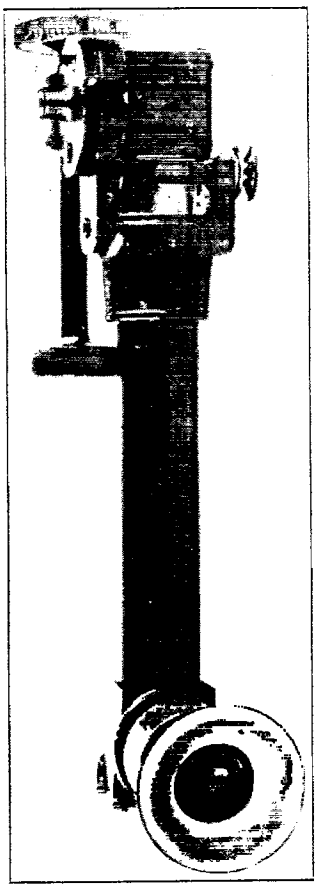

FIG. 3.—Baker aircraft sextant

The Baker aircraft sextant, an English instrument, is shown in Figure 3. This sextant was designed with a view to eliminating the necessity for making the dip and semidiameter corrections. This object is achieved by bringing into view the horizon in front of and in back of the observer simultaneously, one image being erect and one inverted. The two images are separated by a distance depending on the sum of the dips in each direction. In making an observation the image of the star is set to bisect the space between the horizons and thus the correction for semidiameter is also obviated. The sextant consists of a periscopic telescope. In front of the objective are two fixed prisms, the horizon mirrors, and one rotating prism, the index mirror. The index mirror is turned by means of a worm gear and worm. The worm gear carries a scale reading to tens of degrees, while the worm bears a divided drum graduated in degrees and tenths of degrees. By estimation angles may be read to within one or two minutes. The instrument is simple and convenient.

It is assumed that the dips to the front and back horizons are equal. In the case of cloud or haze horizons this is frequently not the fact, and considerable errors may result. The observer, having no means for judging the accuracy of the horizon, must always regard his position lines as being subject to large errors. If the true sea horizon be used, these considerations do not apply.

The Douglas-Appleyard arcless sextant is an English instrument designed for use in surveying and in aerial navigation. The sextant has the usual index and horizon mirrors and telescope. The index arm and graduated arc of the marine sextant are discarded, and the index mirror is operated by a worm gear and worm. The worm carries a micrometer drum and a counter, the counter showing tens of degrees and the micrometer a graduated scale divided to intervals

of 10 minutes. A small magnifying glass is provided which is mounted in such a way that the instrument may be read without removing the eye from the telescope. Electric illumination is furnished. It is claimed that fair accuracy is obtainable in a very short space of time and that the instrument is well suited for aerial navigation.

BUBBLE SEXTANTS

Figures 4, 5, and 6 show three German bubble sextants of a very simple form. The essential parts of each instrument are a graduated quadrant with a telescope along one radius, an index arm pivoted at the center of the arc, and a bubble tube mounted on the index arm. The bubble tube is so mounted that the bubble in its central position will be exactly over the pivot center. Thus a fixed mirror can be used in the telescope to reflect an image of the bubble to the eyepiece. The bubble image appears foreshortened in all positions but one. This, however, is not serious except near the upper and lower limits of the scale, which are rarely used in practice.

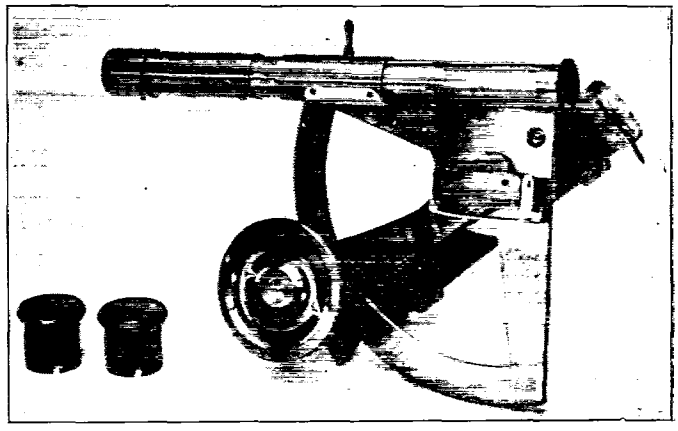

FIG. 4.—Marcuse (Butenschön) sextant

The Marcuse[5] sextant (fig. 4) manufactured by Butenschön, of Hamburg, is poor in design and construction compared with the other two. The scale is on the back or handle side of the arc and is read by means of a vernier to single minutes. The field of the telescope shows the entire bubble tube and in the center a circular opening about the size of the bubble image, through which the star or sun may be seen, and also a reticule consisting of three vertical and three horizontal lines. In making an observation, the telescope is pointed at the star, which is centered by means of the reticule. Then the index arm is adjusted until the bubble image is hidden by the circular opening in the field.

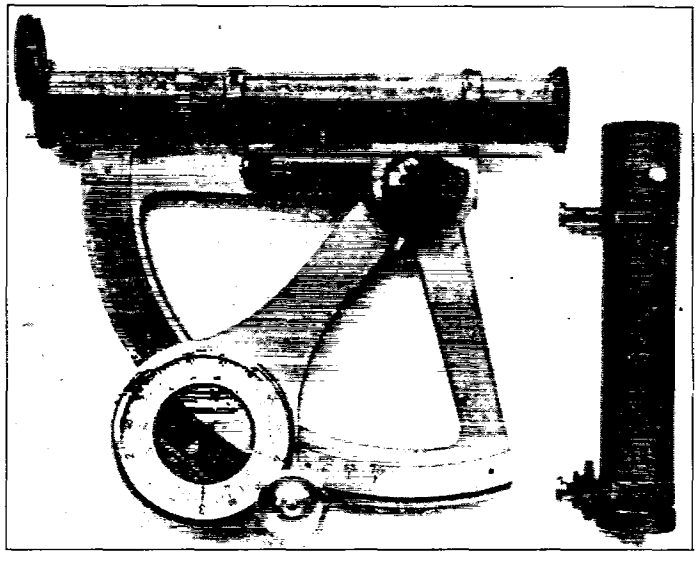

FIG. 5.—Hartmann sextant

The Hartmann sextant[6] (fig. 5) made by Hartmann and Braun, of Frankfort, incorporates several novel features. The bubble tube may be used in either of two positions, one for altitudes and the other for dip angles. The arc and dial carry corresponding sets of numbers, black for altitudes and red for dip angles. The arc is graduated at 5° intervals only. The index arm carries an index for reading the arc and also a pointer geared to a rack on the arc. This pointer travels over a dial graduated in 5° at 5-minute intervals. A small thumb nut geared to the arc is used to set the index arm. The field in the telescope consists of two parts. One, slightly more than half

[5] Illustrierte Aeronautische Mitteilungen, Vol. IX, No. 4, 1905.

[6] Deutsche Luftfahrer Zeitschrift, Vol. XVI, No. 20, Oct. 2, 1912. "Ein Libellenquadrant in neuer Form," by Doctor Hartmann.