SCHWARZSCHILD'S AIR NAVIGATION SEXTANT WITH ARTIFICIAL HORIZON

SCHWARZSCHILD'S sextant* (Fig. 1) outwardly resembles an ordinary sextant, permitting the telescope to be held approximately horizontal by means of a handle.

The light of the star penetrates the telescope after having been reflected in the two mirrors of the sextant, of which one is fixed (horizon glass) and the other (index glass) turns on an axis perpendicular to the optical axis. The angular displacements of the mobile mirror are controlled by means of a toothed pinion engaging with a circular rack, concentric with the divided limb. The limb is read by means of a vernier graduated to minutes of arc.

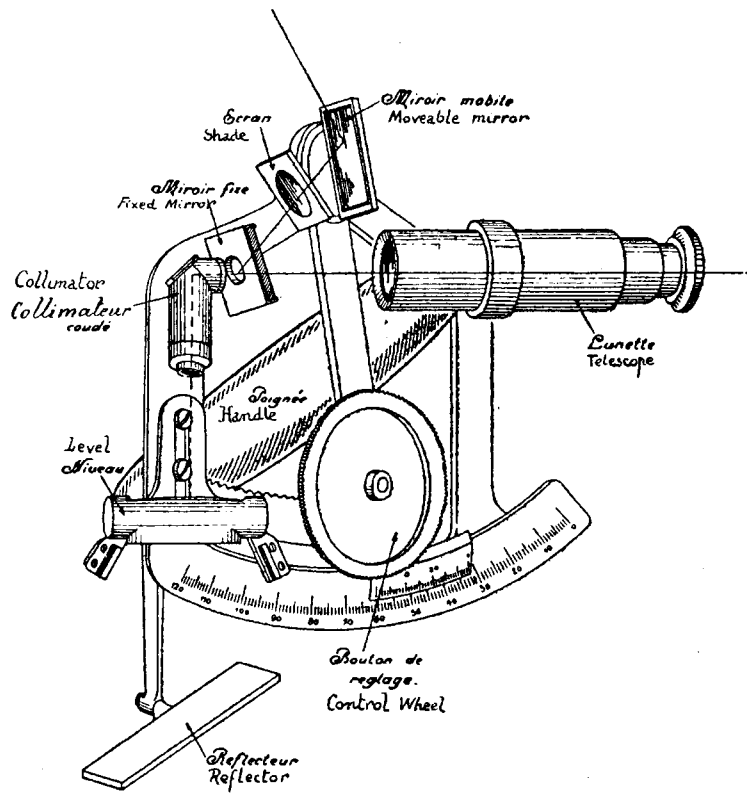

Fig. 1

* Schwarzschild, Dir. of the Observatory, Potsdam. This sextant was much used in German aviation in August 1918; it was made by Spindler & Hoyer, Göttingen.

The fixed mirror, which corresponds to the semi-silvered mirror of ordinary marine sextants, is pierced at the centre, by a small circular hole about 6 to 8 millimetres in diameter, and it is through this hole that the artificial horizon is observed.

The artificial horizon consists of an air bubble level, in an ordinary small torus sided tube, the bubble of which is situated in the focal plane of an elbowed collimator. The object glass of this collimator is centred on the optical axis of the telescope, on the other side of the fixed mirror. The most prominent characteristic of SCHWARZSCHILD'S invention, is that: *the radius of curvature of the level is equal to the focal length of the collimator.*

Thanks to this arrangement, the image of the bubble, reflected by the collimator mirror, is thrown back at infinity, through its object glass, in the direction of the true horizon of the observer, and thus answers the same purpose as the sea horizon in the case of ordinary marine sextants.

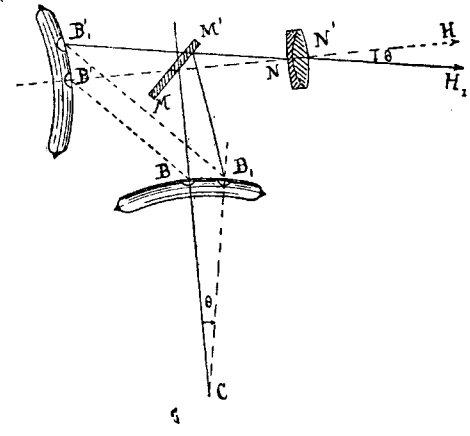

Fig. 2

$B\ B_1$ — Spirit Level.

$B'\ B'_1$ — Image of the Spirit Level reflected by mirror MM'.

In fact, if (Fig. 2) N and N' are the nodal points of the object glass of the collimator; $M\,M'$ the mirror, and B the position of the centre of the bubble when the telescope is horizontal, everything is as if the reflected image B' of the bubble were observed directly.

Suppose the whole instrument to be turned through an angle θ in the vertical plane; the bubble takes up a position at B_1, such that the angle at the centre of curvature of the level $B\,C\,B_1$ is equal to θ; its image appears at B_1'.

In order that it may be still on the horizon of the nodal point of incidence N, it is necessary and it suffices that the angle $B'\,N\,B_1'$ be equal to θ. As $B'\,B_1 = B\,B_1$, it follows that $B'\,N = C\,B$, i.e. that the radius of curvature of the level is equal to the focal length of the collimator.

If, now, the image of the star is made to coincide with the image of the bubble, by rotating the mobile mirror, this coincidence will continue in spite of slow movements of the instrument in the vertical plane; just as the coin-

cidence of the images of the sun's limb and the sea horizon remains, once obtained, in spite of the oscillations of the observer.

These coincidences may be observed in any point whatsoever of the field ; nevertheless, it is always recommended that this coincidence be made as near as possible to the centre of the field, because the quality of the images rapidly becomes worse as the distance from the axis increases, especially as the image and the level have opposed curvatures.

By day the sun is observed through a smoked glass, and the bubble is brought so as to be concentric with the image.

For night observations, a small electric lamp is used fed by a battery on the handle of the instrument ; its luminous intensity is regulated by means of a small rheostat. The lamp produces two luminous reflections at the extremities of the bubble ; the image of the star is brought between these reflections.

The graduated circle is illuminated by the same lamp.

With this sextant the horizon is sighted directly with the telescope : this is an advantage by day. By night, care must be taken not to mistake the star while taking the angle.

Finally, it must be remembered that in these instruments the line of reference is that of the resultant of the centrifugal force and gravity. This line only coincides with the vertical if the movement of the observer is not accelerated in the horizontal plane (1).

(1) See *Notice on Fleuriais' gyroscopic horizon*, Messrs. PONTHUS and TERRODE'S model, by Monsieur FAVÉ, page 49 of the *Annales Hydrographiques*, 1924.