THE ILLUMINATION OF THE BUBBLE OF A SPHERICAL LEVEL

In *Hydrographic Review*, Vol. V, N° 2 of November 1928 on pages 159-181, there are described the various systems for utilising the bubble of a level in determining the angle a given direction makes with the vertical.

If, instead of the bubble itself, one observes its real image, it is possible to give the spherical level a radius of curvature equal to the focal length of the objective employed; that is the solution employed in certain sextants for the determination of the vertical in aeroplanes. The bubble is projected on the image of the ground in the form of a dark circle at a point which is independent of the direction of the telescope.

But if one wishes to use the bubble for night observations of the heavens, it must be illuminated in order that the luminous points may be brought into line. For the rest, when a star, the moon or the sun is observed, to obtain a certain accuracy of measurement it is necessary to centre the star on the bubble itself. The position of the bubble is then defined by its complete circle.

Messrs. A. DE GRAMMONT and G. MARBOUX, in an article submitted to the Academy of Sciences of Paris in July, 1928, have described a method of applying the system of illuminating employed in ultra microscopes to the illumination of the bubble in a spherical level.

We give below an extract from the article which appeared on this subject in the weekly Proceedings of the Meetings of the Academy of Sciences (N° 4, 23 July 1928, pages 217-219).

"Efforts have been made to illuminate the bubble of a spherical level by a lateral illumination shown in fig. 1 by stopping the direct rays by means of a screen. On a dark background one perceives a thin brilliant circle. In order to apply this arrangement to the determination of the altitude of a star it is necessary to project the image of the bubble on the heavens and one is forced to turn the concave face of the level towards the objective in order that its curvature on the one hand and the curvature of the field of the objective on the other may have the same sign.

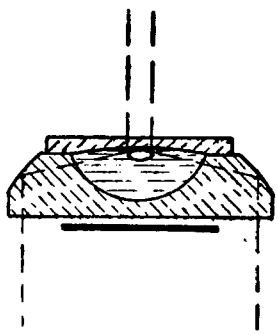

Fig. 1

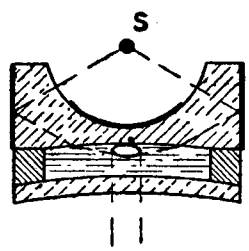

Fig. 2

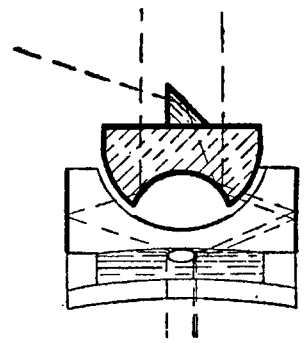

Fig. 3

"The spherical level must therefore always be illuminated on its upper surface; under these conditions the problem is a little more complicated. We have been able to solve this problem by means of the arrangement shown in fig. 2. The source *S*, located in the spherical cavity of a cylindrical glass silvered on its outer surface, illuminates the bubble along a parallel sufficiently fine, while the direct rays are intercepted by a screen.

"The electric lamp may be replaced by direct daylight illumination by means of the arrangement in fig. 3. As long as the sun is high above the horizon the rays totally reflected by the upper part of the spherical calotte strike the silvered surface before returning to the bubble.

"When the altitude of the sun above the horizon is less than 20°, a small totally reflecting prism reflects the rays towards the sides of the cupola.

"This arrangement has been applied to an octant designed for aerial navigation and the accuracy shown is analogous to that of the ordinary sextants. For an observer with a little training the error will not exceed 2 minutes and there need not be any doubt of the choice of the star observed when sighting directly through a transparent glass on which the luminous circle of the bubble is reflected at the same time."