COMPASS FOR MEASURING VARIATION AT SEA

by

REAR-ADMIRAL L. TONTA, DIRECTOR.

1. We propose to give here a brief description of a type of liquid compass which is particularly suitable for accurate measurements and which has been used by the Italian Hydrographic Office for the determination of variation at sea.

The compass was constructed in the instrument works of the *Istituto Idrografico* at Genoa.

We will confine ourselves to a description of the principal organ of the compass, *i. e.*, the *magnetic card* and give a brief account of the telescopic azimuth circle.

The essential characteristics of the card are the method of construction of the float and its system of suspension.

2. *THE CARD FLOAT.*

This is derived from the original type developed by MAGNAGHI and adopted as the standard in the Royal Italian Navy in about 1882. The float in its original shape, that is, as proposed by MAGNAGHI, is shown in fig. 1. It is in the form of an ellipsoid of revolution of which the minor axis is vertical, and is constructed of two cups made of thin sheet copper, joined together by means of two rings held by screws. A sort of ferrule or central cone of turned brass passes through the float along its vertical axis and is connected to the cups by rings and screws. The cone forms the passage for the pivot-pin and has a cap at its apex. The system of magnetic needles consists of six bundles of lamellae, contained inside the float, which are secured to the central cone by means of a light armature. The magnetic moment of the system is about 3.200 C. G. S. units. The compass card, which is graduated in degrees and thirds of a degree (20'), has a diameter of 194 mm. (7.64 ins.) and is engraved on a copper ring secured by screws to the upper cup of the float. This graduated circle is obtained by *galvano-plastic reproduction* of a model engraved by hand. This method of construction ensures great accuracy without requiring long and costly manual work.

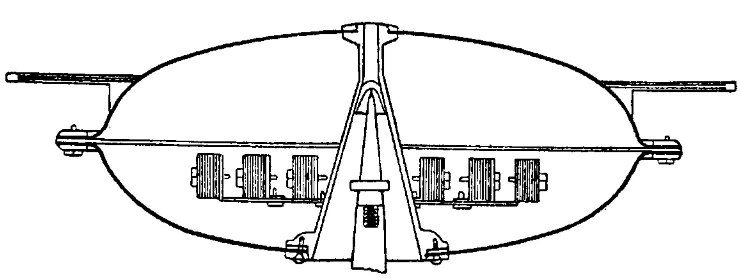

FIG. 1

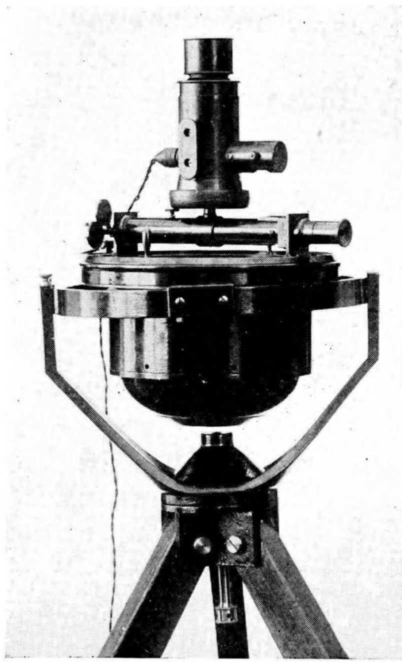

FIG. 5

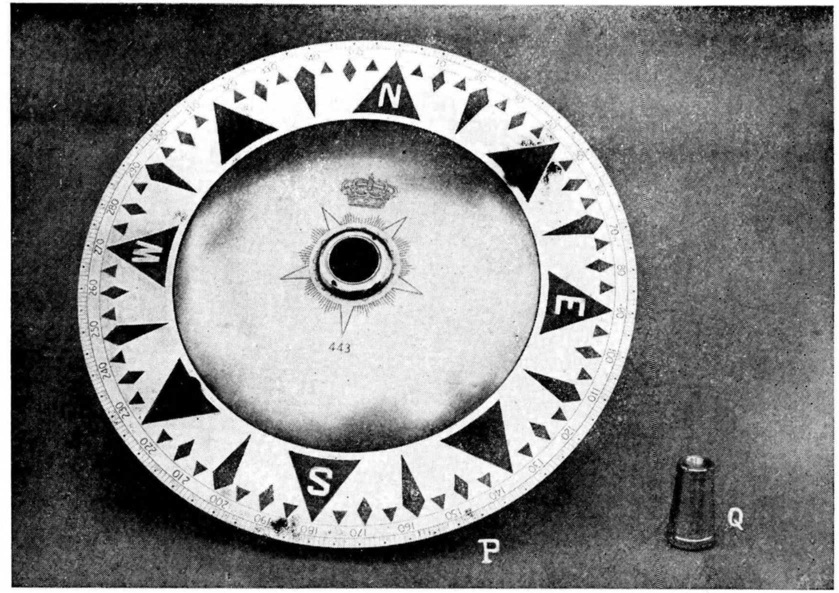

FIG. 3

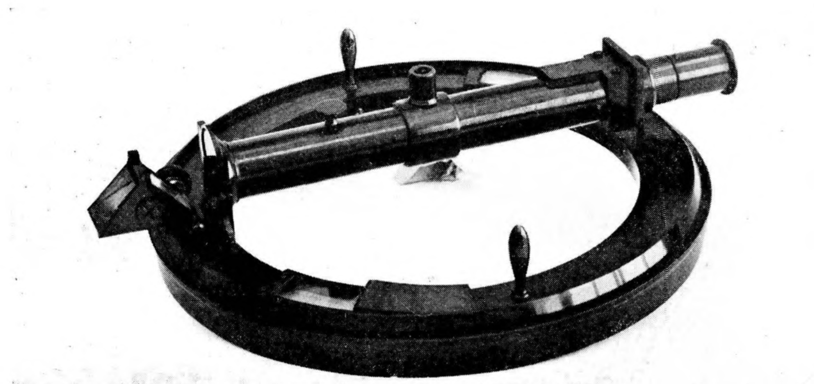

FIG. 4

Every part on the card is silvered.

The compass card, the float and the needles weigh about 750 grams (26.5 ozs) *in air*. The mechanical qualities are excellent as a result of the distribution of the weights and the relative positions of the centres of gravity and displacement and the point of suspension, which are so set as to make the card as insensitive as possible to the disturbing forces to which a compass is always subject on board ship.

The greater part of the weight being distributed about the periphery (the ring bearing the graduations, the rings which seal the float, etc., etc.), the moment of inertia is raised quite high with respect to the vertical axis of rotation and consequently gives a fairly long period of oscillation. Finally, the method of construction confers all the qualities of a true instrument of precision on this type of card.

Only one fault can be found with the original model invented by MAGNAGHI — the impossibility of examining the pivot-pin and the cap rapidly and easily; these are delicate parts which must be kept in perfect condition. This is a fault, it should be noted, which is common to most liquid compasses.

3. *NEW SYSTEM OF SUSPENSION OF THE CARD.*

This inconvenience has been obviated by means of a new system of suspension invented and carried out by the author of this note, and this was adopted in about 1915 as the standard for the compasses in the Royal Italian Navy.

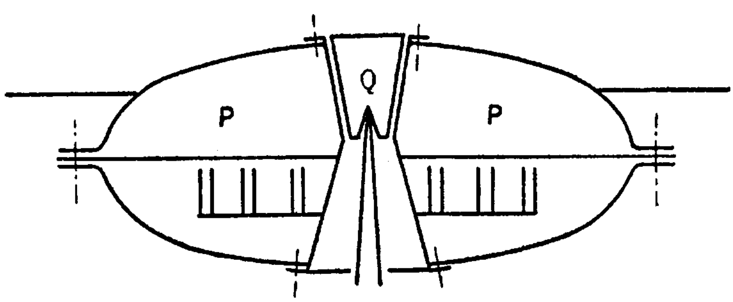

FIG. 2

It is represented diagrammatically in fig. 2 while fig. 3 shows the external appearance. In place of the ferrule or central cone of the old MAGNAGHI card, a double ferrule has been adopted consisting of two truncated cones joined together at their small ends. The lower truncated cone forms a passage for the pivot-pin and the small upper ferrule holds in its seat a small truncated bronze cone *Q* to which is attached a hard-stone cap.

The card is thus constructed in two parts :-

a) The peripheral part *P*, called the *float* and *b*) the central part *Q* called the ballast. In fact the peripheral part *P*, immersed in the liquid, has an excess buoyancy of *s* grammes which is obtained by adapting the weight of the card to its volume (In a liquid composed of a 15 % solution of alcohol at a temperature of 15° Centigrade (59° F.), $s = 26$ grammes (401 grs.) exactly. On the other hand the central part Q has, under the same conditions, a deficiency of buoyancy of q grammes ($q = 32$ grammes (494 grs.)). Thus, as a result of the difference between the excess buoyancy of the float and the excess of weight of the central part, the two parts P and Q, which constitute the card, remain together and bear jointly on the pivot with a weight of $q - s$ grammes. The glass which covers the upper part of the bowl is pierced at the centre, the hole being fitted with a metal liner in which a screw plug is fitted. With a pair of pliers the central part Q of the card may be drawn through this hole and, by means of a special-shaped spanner, the pivot-pin, which is screwed into the bottom of the bowl may be unscrewed and extracted.

Hence the examination and, if necessary, the substitution of a new pivot or cap become very simple operations. It should be noted that by making use of additional small weights the weight q of the central part Q may be varied and may be adjusted at will according to the density of the liquid (this density varies with the percentage of alcohol in the mixture and with temperature). By changing the total weight of the system on the pivot, the passive resistance which opposes the perfect orientation of the card may be made very slight.

4. *TELESCOPIC AZIMUTH CIRCLE.*

In this type of compass bearings are taken by means of a telescopic azimuth circle invented and made by MAGNAGHI for his original compass (*see* fig. 4).

A reflecting prism is set in front of the object-lens of the telescope and serves to direct rays coming from objects above the horizon (*e. g.*, stars) along the axis of the telescope. Another prism, which is quite small, is fixed in the interior of the tube in front of the ocular lens and brings an image of the card graduation, which is immediately under it, into the field of vision. Thus the observer who is taking a bearing of an external object sees the image of this object superimposed on the image of the graduation of the card which makes accurate and rapid reading of the bearing possible.

Fig. 5 gives a general view of the compass with its azimuth circle. The compass is supported on a tripod which is used on shore for obtaining rapid observations of variation (1).

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(1) This note is intended to provide a modest contribution to the subject of a proposal made by the Norwegian Hydrographic Office and published in the International Hydrographic Bulletin for June, 1931, page 155, under the title of *Exchange of Data on Magnetism*.

It should be recalled that the greater number of the observations for variation at sea during the period 1905 to 1908 by the *Galilee*, of the Carnegie Institution of Washington, were taken with a liquid compass and azimuth circle of the well-known RITCHIE make, which is the standard in the United States Navy (diameter of the compass card 7 5/8 inches). In this connection see Publication N° 175, (Vol. III) of the Carnegie Institution and a report entitled: *The Magnetic Work of the Galilee*, 1905-1908, page 17. With regard to the method of observation and of correcting these measurements, the reader is referred to the same report, pages 61 and 134. On the question of the accuracy obtained, it is stated (page 19) :-

> « Studies of the declination results with the instruments which were used in the *Galilee* work showed that on land the magnetic declination could be obtained with the Standard RITCHIE 7 5/8 inch liquid compass, using either the cylindrical mirror or the dark plane mirror, within 0°,2 and with special care within 0°,1. However, these devices did not afford such precision when used at sea; it was found, for example, that the results from eight different sets of 10 pointings each differed at times as much as 0°.5. »

It is known also that, in the *Carnegie* from 1909 on, the observations for declination were made with an improved instrument called the *Marine Collimating Compass* (which was invented and perfected by J.-W. PETERS and J.-A. FLEMING) in which the card, though derived from the RITCHIE Card, differs from it in that the float, in place of the graduated circle, has four systems of optical collimators arranged at 90° from each other, around the circumference. For a complete description of this instrument readers are referred to the Publication (N° 175) mentioned above and particularly to page 177 of the report: *The Magnetic Work of the Carnegie* - 1909-1916. With this instrument very precise measurements may be made at sea as well as on shore, as is proved by the results obtained by the observers on board the *Carnegie*.

We take the liberty of adding that the application of the system of suspension which is described in paragraph 3 of this note to the *Marine Collimating Compass* would probably result in a further and not inappreciable improvement in this instrument.