NOTE ON MICROMETER-DRUM HYDROGRAPHIC CIRCLES

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For over one hundred and fifty years, the double-reflection hydrographic circle has been one of the basic instruments for surveying at sea.

Since its inception (Borda's double-reflection circle), successive improvements of its individual features have resulted in a sturdy instrument that handles easily and may be readily adjusted. Yet two defects persist which, although minor, cause inconvenience, and an effort has been made to correct them :

(1) Operation of the index arm : When following the variations of an angle, the observer finally reaches the limit of the micrometer screw range, and is thus compelled to interrupt his observation.

(2) Reading of the vernier : A precise reading is occasionally difficult to obtain when the craft is rolling and visibility is poor.

Hydrographic circles equipped with racks remedy both these defects.

Description of circle

The principle of the double-reflection instrument remains unchanged : a sturdy, rigid circle of 16-cm diameter, equipped with a flat limb, a large mirror and a small one that are both easy to replace, and a squat index arm swinging on a large, well-encased, carefully centred pivot.

The graduations of the limb are engraved in degrees from 0 to 160 on either side of a middle position corresponding, in principle, to the parallelism of the mirrors.

A rack is engraved on the outer edge of the circle. The space between each tooth corresponds to a 1-degree angle at the circle's centre, and consequently to two divisions of the graduation.

A conical tangent scew is mounted on the outer edge of the index arm. This screw and the rack are so cut as to engage perfectly, leaving a very slight amount of play amounting to about one-thousandth of a millimetre, corresponding in principle to an angle of 10 seconds at the centre.

The tangent screw axis is capable of rotating around one of its extremities while remaining in a plane parallel to the limb plane — this fixed point is integral with the index arm. The other extremity of the screw axis is held in by a spring which normally keeps the screw engaged with the teeth. A release enables the screw to be disengaged for rapid rotations of the index arm.

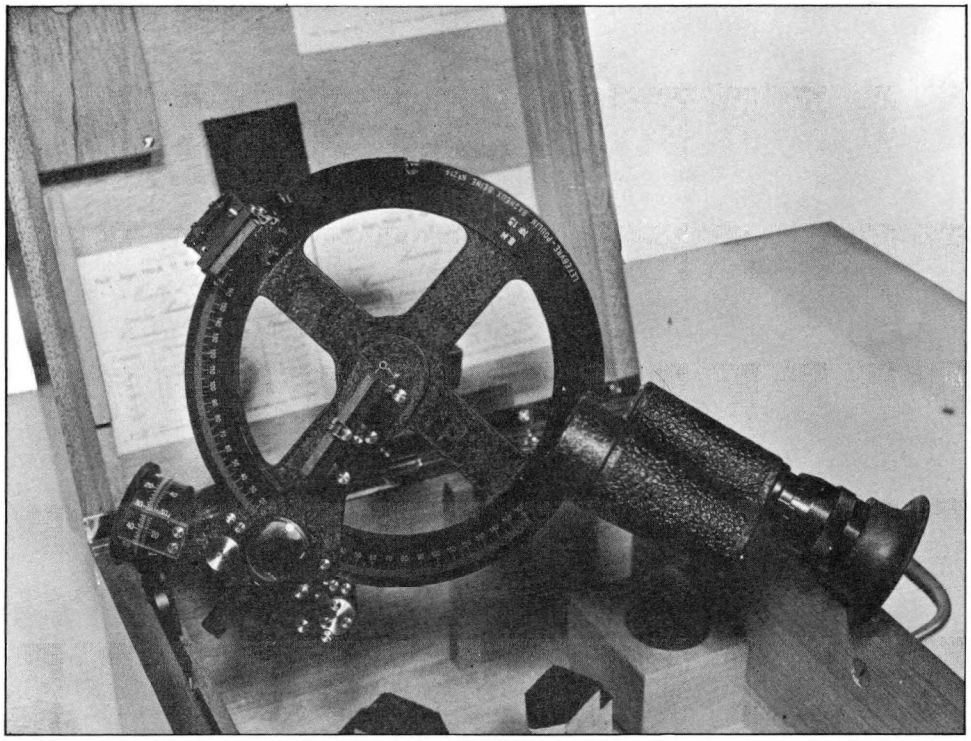

Fig. 1. — Standard Micrometer-Drum Hydrographic Circle. Full-face.

At the free extremity of the axis is a drum 35 mm in diameter, engraved with two sets of graduations in opposite directions, each graduated twice from 0 to 60. A complete turn of the drum corresponds to a turn of the screw, hence to a 1-degree shift of the index arm, and therefore causes the reference mark on the arm to move two divisions along the limb.

Projecting from the drum is a knurled knob which enables the tangent screw to be actuated without rubbing against the drum graduations.

A reference mark engraved on a small plexiglass window screwed to the index arm indicates the reading mark for the minutes. A lens fixed to a support enables the divisions of the arc to be read off easily opposite the reference mark on the index arm. The width of the window on the arm is such as to require numbers for every 10 graduations only, without causing hindrance to the observer.

The result of this new arrangement is improved reading of the measured angle (the degrees by means of the lens, and the minutes on the tangent-screw drum). Moreover, the course of the index arm during the minute setting is no longer limited by the length of the screw.

Accuracy

Concerning the cutting of the rack, a simple calculation shows that if the error is to be kept under half a minute, the cutting accuracy must be of about one hundreth of a millimetre.

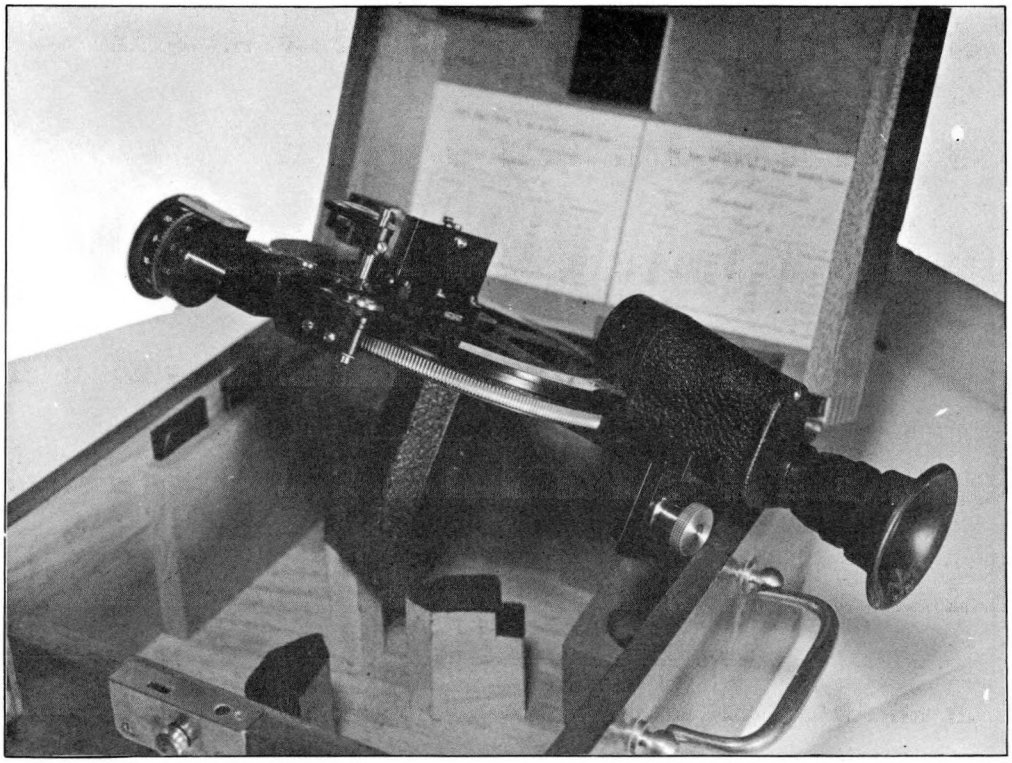

Fig. 2. — Standard Micrometer-Drum Hydrographic Circle. Side view.

This is the same accuracy of cut as in the micrometer-sextant rack, whose radius is equivalent to the diameter of the circle. The same machine is used for both instruments.

This tolerance of one-hundredth millimetre is actually respected. But it is obvious that the eccentric error is an everpresent threat owing to the circle's short radius, and that it constitutes the source of the most serious errors.

It should however be realized that the angles measured with the circle are used graphically, and that if necessary they can be corrected according to the values given for each circle by an eccentricity table determined by the Optical Institute Laboratory. In any event, experience indicates that results obtained with the micrometer-drum circle are wholly consistent with those supplied by ordinary circles. The improvements carried out and the sturdiness of the new instrument largely compensate for the slight decrease, occurring in theory rather than in practice, in angular measurement accuracy, inasmuch as the circle can be very easily adjusted.

Optics

The design of this new circle has also enabled an improvement to be worked out in the telescope. Ordinary circles have so far been equipped with a small Galilean telescope of slight magnification and restricted visual

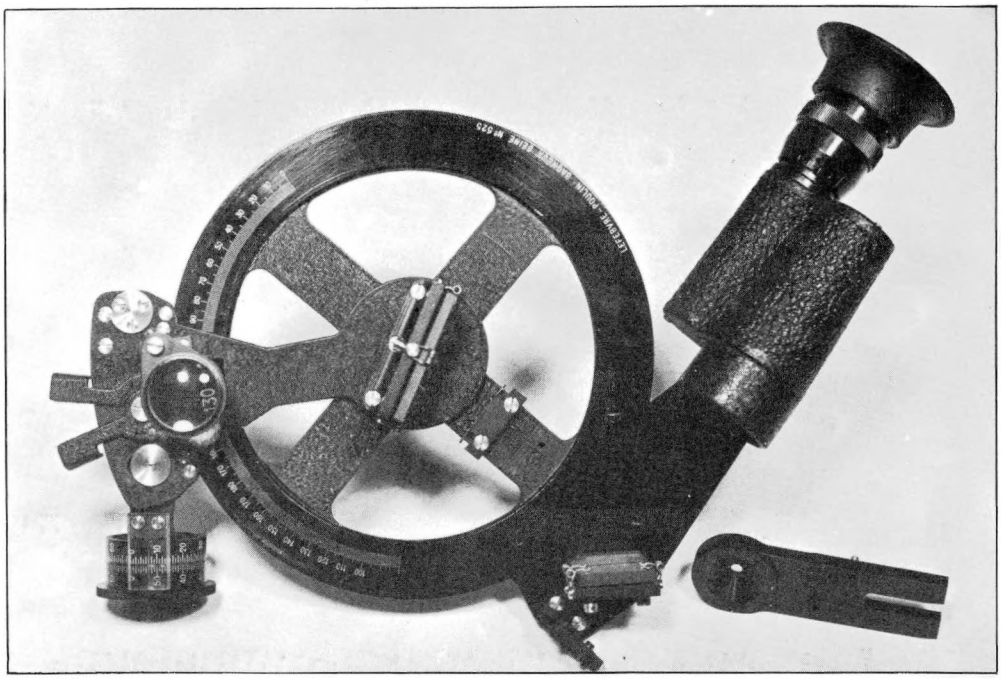

Fig. 3. — 180° Micrometer-Drum Hydrographic Circle. Full-face.

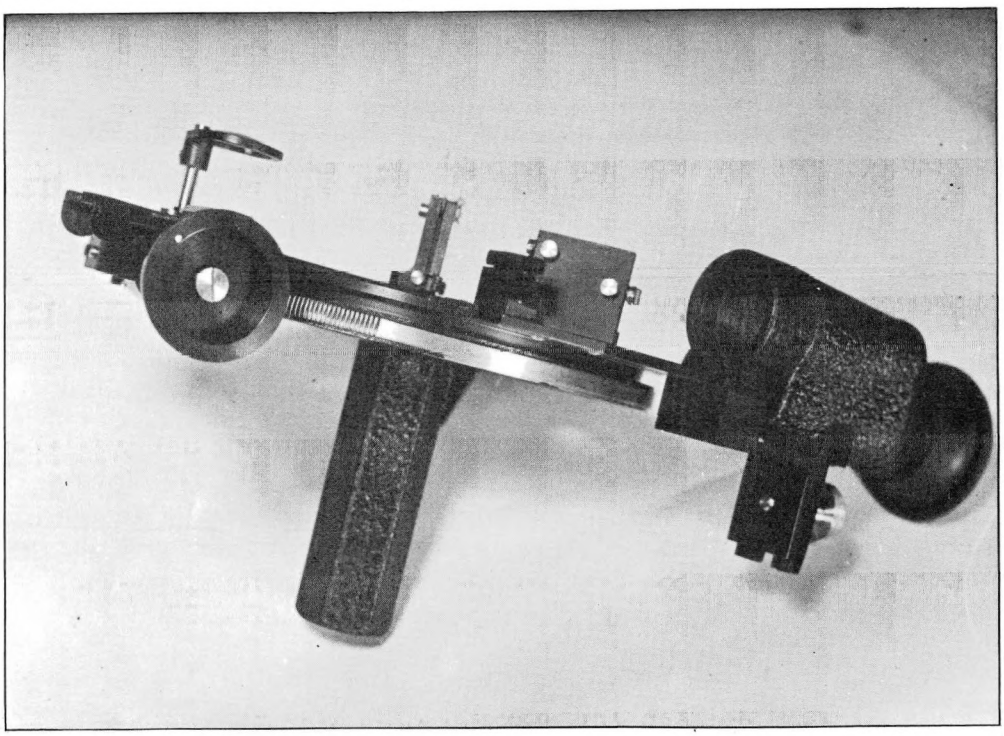

Fig. 4. — 180° Micrometer-Drum Hydrographic Circle. Side view.

field. Use of this telescope is so inconvenient that the general practice during launch soundings is its replacement by a sight vane with a large aperture and consequent extensive field of view.

The new circle has therefore been equipped with a monocular prismatic telescope : the lens diameter is 30 mm, magnification 4 and field 7.5 degrees. The eyepiece is provided with a strong rubber shade against accidents.

The new instrument, which weighs 310 grams, is heavier than the older one, but this drawback is a minor one as the weight of both circles when fully equipped is about the same (1 350 grams for the new and 1 390 for the old). In addition, the weight due to the telescope is fairly near the handle of the instrument, which makes it easier to obtain satisfactory balance.

180° micrometer-drum circle

The same principles have been followed in the design of a new 180° hydrographic circle. An effort has moreover been made to increase appreciably the distance between the large and small mirrors in such a way that an observer using his right eye (which is the general case) can easily see the point located behind him without interference from the right side of his head.

To this end the small mirror and telescope (the same as on the ordinary micrometer-drum circle) have been transferred to the outer side of the limb. The distance between the two mirrors is thus 9.5 cm, and thus enables the ready observation of angles from 150 to 210 degrees.

In this observational position, the knob operating the endless screw of the index arm is located immediately behind the small mirror, which facilitates operation (the handle is held in the right hand, and the index arm moved with the fingers of the left hand).

The index arm can of course be pivoted to the zero of the arc and the collimation can thus be satisfactorily checked.

Conclusion

Both circles are adequately protected against corrosion : they are coated with baked enamel paint; the rack and tangent screw are made of bronze, and the mirrors are held in place by stainless-steel clips.

Prices are relatively low, and such as to warrant the manufacture of two separate instruments as compared with the smooth-limbed hydrographic circle, which is still costly to produce.

The circles have been tried out on surveying expeditions and have been very favorably received. As a result, the French Hydrographic Office has decided that they should be gradually substituted for the previous models now used by survey missions.