been provided with a number of technical improvements by J. GRAAFEN and could be used satisfactorily this year on the *Meteor* cruise, when opportunity offered, under the most severe conditions of service; i.e. in the open sea at great depths. The device proved fully serviceable.

The results obtained from the gauges set out were satisfactory.

In order that an immediate insight might be obtained into tidal conditions prevailing at that locality, and in order to check the functioning of the apparatus, the writer made a preliminary analysis of the results aboard ship, obtaining a series of points at hourly intervals (the apparatus gave readings every five minutes).

The results have been plotted in Fig. 1 and 2. Fig. 1 shows the heights of water on the Southern Echo Bank, which may be subject to slight changes in the ordinates after final calculations have been effected. The diurnal inequality is clearly marked. In Fig. 2, the curves have been drawn for the two apparatus set out on the Cape Verde Bank, plotted independently and superposed on the same coordinates. There is close agreement between the two curves. Here we see clearly the semi-monthly inequality while the diurnal inequality is much less pronounced.

A SOLUTION TO THE PROBLEM OF ADJUSTING THE COUNTERBALANCE OF A SHIPBOARD THEODOLITE

by

A.R. STICKLEY (WEATHER BUREAU, WASHINGTON, MAY 1938.)

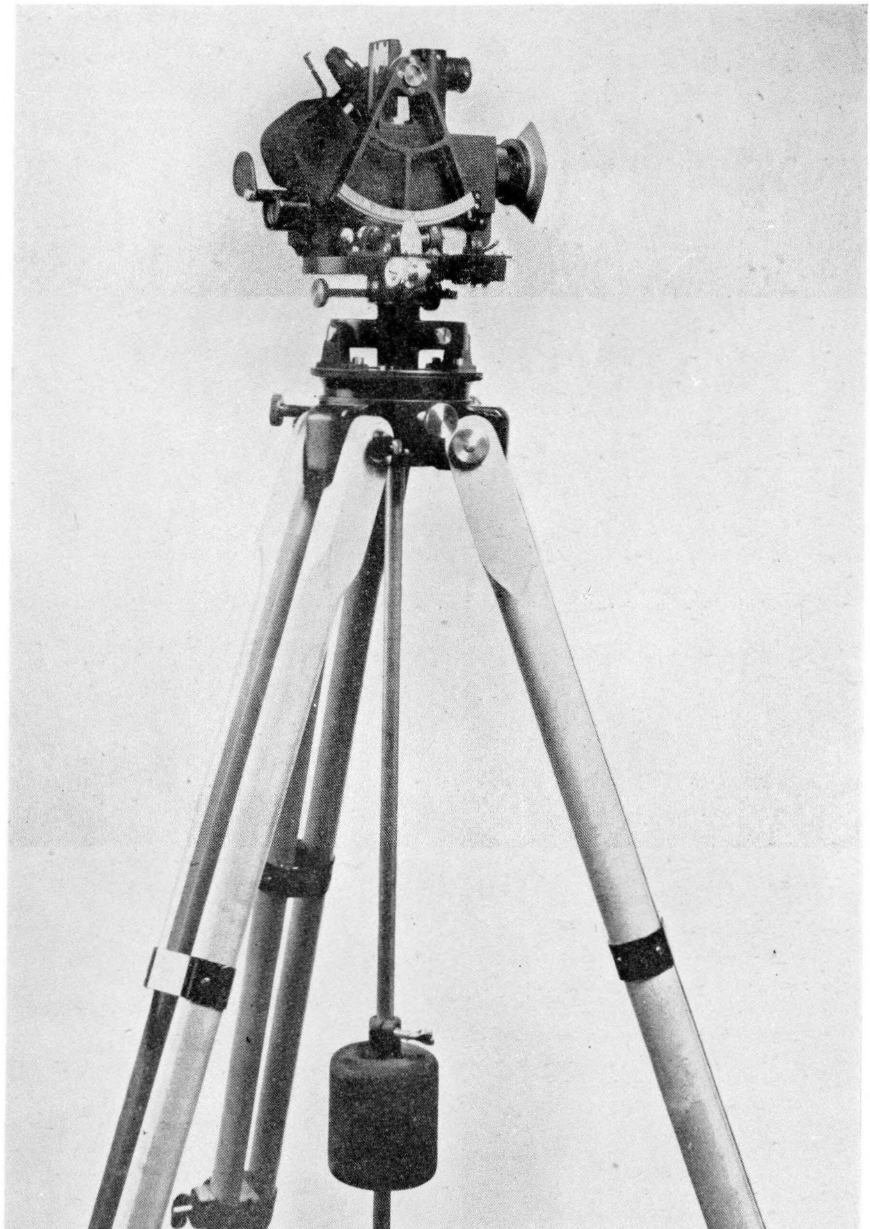
(Extract from *Monthly Weather Review* — Washington — Dec. 1938, p. 401)

The usual shipboard theodolite is essentially a sextant mounted on gimbals and equipped with a horizontal circle. In order to keep the sextant upright in the gimbal mounting, a shaft with a heavy weight or counterbalance on it is rigidly attached to the outer spindle of the horizontal circle assembly. On some types of instruments, such as that shown in figure 1, this weight or counterbalance may be adjusted vertically. In the use of such an instrument, then, the problem naturally arises as to what is the optimum counterbalance adjustment for a given set of conditions aboard ship.

As far as can be learned, the only reference to any attempt to solve this problem is that contained in an article written by F. Eredia on the "Exploration of the Atmosphere by Means of Pilot Balloons on Board Merchant Vessels", which was published in volume IV the "Annali dell'Ufficio Presagi" appearing in 1932. A translation (1) of his remarks regarding the problem of offsetting the effects of the motion of the ship is as follows :

"This problem has been solved by supplying a Cardan suspension (gimbal mounting) with a pendulum rigidly attached to it (the theodolite) — giving the pendulum sufficient mass since the center of gravity should be rather low. The length of the pendulum may be varied continuously in such a manner as to modify the period of oscillation so that it avoids resonance with the period of oscillation of the ship. Moreover, three springs notably reduce the oscillation of the pendulum itself,

(1) Furnished by Carl Russo of the Aerological Division



"Experience has shown that, having once regulated the period of the pendulum by means of trial in the best possible manner, pilot balloon soundings can be taken with the same ease as on land."

Since conditions, as far as the motion of a given ship is concerned, vary greatly from time to time — depending upon the type of sea encountered and the ship's heading into it among other things — it is believed that it will be of considerable advantage to be able to compute the optimum position of the counterbalance for a given set of conditions aboard ship. To this end, the following investigations have been pursued :

To begin with, the problem as to the proper counterbalance adjustment for a free suspension (i.e., without springs) of the theodolite was considered and an attempt was made to apply the classical equation for forced vibrations with viscous damping to it. To do this the following assumptions and limitations were imposed initially :

1. — The motion of the theodolite was considered to be confined to a single plane — this plane being that perpendicular to the axis of the most pronounced angular motion of the ship — its roll.

2. — It was assumed that the theodolite had been so oriented that the axis about which the instrument oscillates within the gimbal ring was parallel to the ship's axis of roll.

3. — It was assumed that it would be possible, finally, to so adjust the counterbalance that its amplitude of oscillation with respect to the vertical would be less than 8°.

4. — Damping proportional to the first power of the angular speed with respect to the vertical (viscous damping) was assumed. The torques due to other types of damping were assumed to be negligible.

5. — In accordance with the theory of the seismograph, the inertia effect on the part of the instrument on gimbals was assumed to be concentrated at its center of gravity.

6. — The error introduced by considering the direction of the acceleration of the point of suspension due to the roll of the ship to be at all times normal to the counterbalance shaft was assumed to be negligible.

7. — The effect of any torques which might arise when the theodolite moves through the air with the rolling of the ship or which might arise due to the blowing of the wind is assumed to be negligible.

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