SELF-REGISTERING TIDE-GAUGES WITH ELECTRIC TRANSMISSION, USED FOR INVESTIGATIONS RELATING TO THE RECLAIMING OF THE ZUIDERZEE.

(Extract from the State Commission's Report, published in 1926)

A. — INSTRUMENTS OF THE GRADATION TYPE WHICH WERE USED.

The signalling apparatus at sea is placed as shown in *Fig. 1*, at the top of a vertical tube, within which a float goes up and down with the water level. The tape or wire *b* to which the float is attached causes a small roller *w* to turn round and make contacts; the apparatus is so arranged that a new contact is made for every 2 cm. water level variation.

Fig. 2 diagram shows the result obtained with the small contact roller *w*. It will be seen that the three contacts 1, 2, 3 of the transmission cable, alternately influenced through the return wires (in thicker lines) influence in turn three magnets I, II, III, placed inside the registering apparatus situated ashore, which causes anchor *a* to turn round. The rising of the water level causes the contact roller *w* to turn round in the direction indicated by the arrow and consequently causes the anchor to pivot in the direction indicated, so that the toothed bar bearing the registering pen *S* goes up.

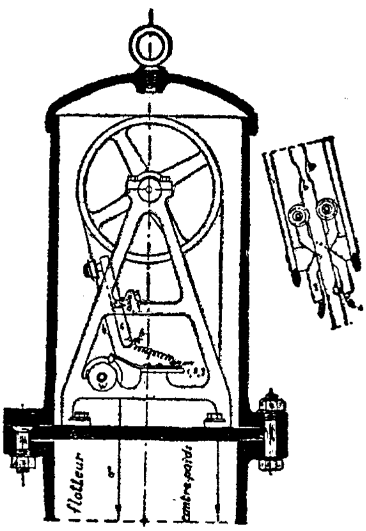

FIG. 1
Recording apparatus of the graduation type.

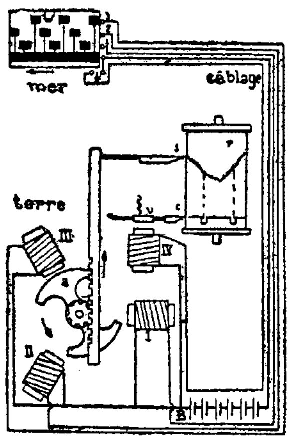

FIG. 2
Diagram of the gradation type.

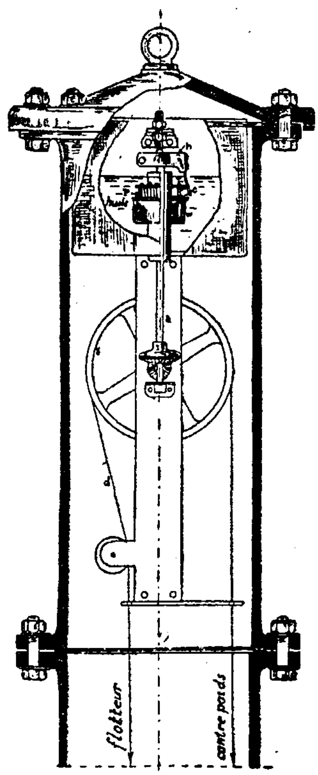

FIG. 3
Registering apparatus of the resistance type.

It is easy to see that on the reverse motion of the small contact roller *w* the registering pen moves downward on the paper stretched over the registering roller.

The current is supplied by a battery of accumulators *B* mounted on the registering apparatus and giving about 12 volts. The current power is over one ampere, so that the battery must consist of large cells and be frequently recharged.

So long as the water level varies regularly, the registering takes place without any disturbance. But with strong waves, it may happen that a contact is of such duration that the small anchor may not have time to take up its new position. This may put the registering apparatus out of order.

When, for instance, in the position given on the drawing, water rises suddenly by 6 cm., contacts 3, 1, 2, 3 close rapidly one after the other. If the right pole of the anchor has not come quickly enough opposite magnet I, the polarization of magnet II, which follows immediately after, does not attract the left pole but the right pole of *a*, so that when contact 3 is made, the anchor (and consequently the registering pen) comes back to its original position instead of travelling over an arc of 180°. There has therefore been an error of 6 cm. (3 divisions) and when subsequently records are made the apparatus registers 6 cm. too low.

There could be no question of adequately damping the motion of waves so that in stormy weather such motions could not take place [1].

Particular care should be taken that on the record obtained, the water height corresponding to any ordinate showing the check mark is really the check height. If such is not the case, the apparatus has had a "miss" which occured when the check marks were being recorded, it is advisable to regulate the apparatus so that contact 4 closes at a water height reaching often, for instance the N.A.P. datum. Neither is there any objection to making two notches in tape *b*, which allows checking by means of two water heights. One, for example, may be taken at 150 or 200 cm + N.A.P. and be used in stormy weather.

It is obvious that the float tape must be kept in the right direction both before and after passing between the small wheels of fork 5; the details of the device do not appear in *Fig. 1*.

The fact that these tides-gauges have not always worked satisfactorily, is accounted for by the "misses" which in stormy weather, were so numerous, that it had not been possible to reproduce with certainty, on the diagram, the water height during the time interval between two check marks.

B. — EARLY INSTRUMENTS OF THE RESISTANCE TYPE.

In the same way as was done for the apparatuses which have just been described, an effort has been made to render the installation at sea as simple as possible and also to minimize as far as possible the possibilities of disturbance due to the introduction of sea water into the parts. For this purpose, contacts were placed in an oil bath (*Fig. 3*).

The vertical motion of the float is converted through the wheel *s* and a level gearing into a rotation of the small axis *a*. On the latter is fastened an arm *h* bearing a contact spring *c* rubbing against a large number of small contact studs arranged in a circle (see: *Fig. 4*). These small studs divide electric resistance *w* into equal parts.

Part w_1 of the resistance situated between the first stud next to *A* and the spring *c* set in motion by the float constitutes one sector of the current, the remaining part w-w_1 another sector.

To each of the sectors corresponds in the receiving apparatus, following resistance *W*,

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(1) During the winter 1918-19, tests were made with a tube bored with small holes and placed under the sea-front promenade at Scheveningen, with a view to ascertaining to what extent it is possible to damp the impact of waves without affecting other movements of the water surface. That is why a height checking contact was introduced by making a notch *v* (*Fig. 1*) in the float tube which, when passing between two small wheels fastened to a fork *S*, allows the closing of contact 4, thus polarizing magnet IV, which brings down the checking pen *C*. Each time the notch in the float tape *b* passes under the small wheels of *S*, the line traced by *C*, bears a peak.

a galvanometer coil. The current strength in small coils I and II is evidently that of the resistances of the corresponding circuits $(w_1 + W) : (w - w_1 + W)$; the result is that the strongest current passes through the small coil which is part of the circuit with the least resistance (in this case that with w_1).

These small coils are part of a Bruger's ohmmeter (1). They are made to pivot round the poles of a permanent magnet and work in an opposite direction in their action against the lines of force. It seems that the position of the coils and consequently that of the registering pen is governed solely by the ratio of the currents, that is by value $(w_1 + W) : (w - w_1 + W)$. W and w being invariable, this value is determined by the quantity of w_1, which means that it is derived from the position of contact c and consequently from the water height.

When the mobile contact c is near A, the height registering pen is raised to its highest point. With the water going down, c goes round the circle of contact studs, the indicator goes down and when c is on contact E, the registering takes place right at the bottom of the diagram. When the water goes further down, c comes back to contact A and the indicator resumes its highest position, after which, going down continues.

With commonly used instruments, the arm bearing the contact moves round once at each change of water height of 150 cm. There are 75 small studs p; so that the space between each corresponds to 2 cm. Resistance w is 1.800°, resistances W are each at least 5.000°. The battery here has also a 12 volts-tension, the current strengths are therefore very low (a few milliamperes).

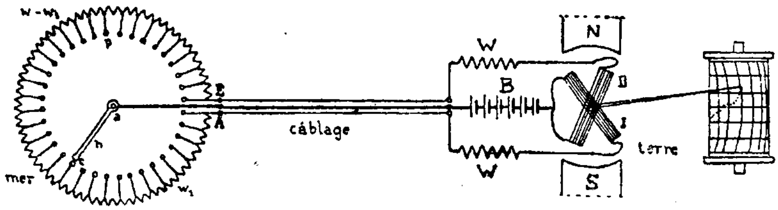

FIG. 4
Diagram of the resistance type with ohmmeter.

These apparatuses cannot get out of order, to each float position corresponds a definite position of the registering pen. Should the latter change its position owing to some disturbance (as for instance a contact with the hand, jumping off a contact, etc...) it will resume the position corresponding to the water height as soon as the cause of disturbance is removed.

The part played by the check contact in the gradation type is filled here by the interval which occurs when passing from contact E to contact A and vice-versa.

The registering is quite independent of the battery voltage; when this varies from 6 to 15 volts, for example, the registering pen remains motionless.

Slight registering errors are caused by changes of temperature. They are due to the fact that records corresponding to contacts A and E are no longer exactly at the extreme lines of the diagram but slightly away from them and can be corrected through a small variation of pre-connection resistances W. It is usually sufficient to make this adjustment twice a year notably in the spring and approach of winter.

The main cause of disturbance lies in the fact that the power driving the registering pen is very low. That is why a special registering method is also resorted to, it consists in keeping generally the pen entirely free and in applying it at regular intervals by means of a sort of frame on an inked canvas placed directly on the registering paper.

There is also a registering apparatus (2) which is even entirely insensitive to changes

(1) Sold to the trade by Hartmann and Braun, Francfort-on-Main.
(2) Manufactured by the Cambridge Instrument C°, London and Cambridge.

of battery tension and which allows more available power to drive the registering pen. It consists in making a Wheastone bridge with resistances w and $w - w_1$ of the registering apparatus. It is not used with the apparatuses which we have just described but with Schoute's mercury tube of which we shall speak later. The mode of adaptation is given in *Fig. 6.* In this apparatus, the registering pen s is fixed on to a mobile contact c which can slide along resistance W.

When position of c is such as :—

$$W_1 : (W - W_1) = w_1 : (w - w_1) \qquad (190)$$

no current passes through part C_c of the bridge and the galvanometer g placed there as a relay remains at zero. If (190) is not satisfied, the relay is set to work. If c is too low, it moves a spring (not shown in the figure) which raises the small carriage to which c is secured. If c is too high, g will be shifted in the other direction and will act on a second spring which will bring C down.

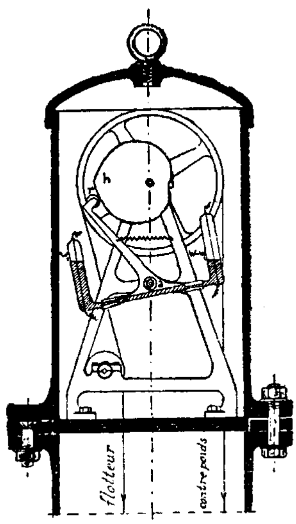

FIG. 5

Registering apparatus with mercury tube.

C. — DR. SCHOUTE'S MERCURY TUBE.

As in the case of the early registering resistance apparatuses which we have just described, the installation at sea requires two resistances the sum of which is constant. These resistances consist of a platinum filament welded in a U shaped tube. This tube which is partly filled with mercury (*Fig. 5*) turns round a horizontal axis by means of an eccentric secured on the float wheel. In this way the platinum filament penetrates more or less into the mercury, so that the distance travelled by the current and, consequently, the resistance, are variable.

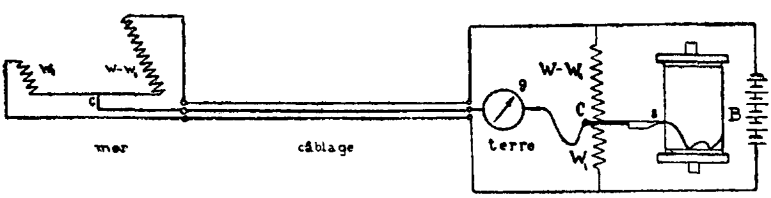

FIG. 6

Diagram with Wheatstone bridge.

When the h part where the eccentric radius is longest, touches the small wheel r the mercury tube is in its most inclined position to the left, resistance w_1 becomes as small and

$w - w_1$ as great as possible. The registering pen is then in its lowest position (*Fig. 6*); as *h* rotates, when, for instance, the water is rising, the mercury tube leans regularly to the right until the other end is reached, the notch corresponding then to the small radius *r*; the pen *s* is then in the upper part of the diagram.

When water continues to rise, the mercury tube and consequently *s* move back, there are therefore points of return on the diagram which may be used as check marks. Beyond these points of return the diagram is as folded up.

The registering is disturbed when the buoy bearing the apparatus at sea tilts down, which happened several times to tide-gauges in the North Sea.

The diagram on the registering sheet moves then upwards or downward; the extent of the error may be inferred from the position of points of return.

The mercury tube is used at Callantsoog with a recording Ammeter for registering apparatuses (on shore). Care must be taken to render ineffective the variations of the battery tension.

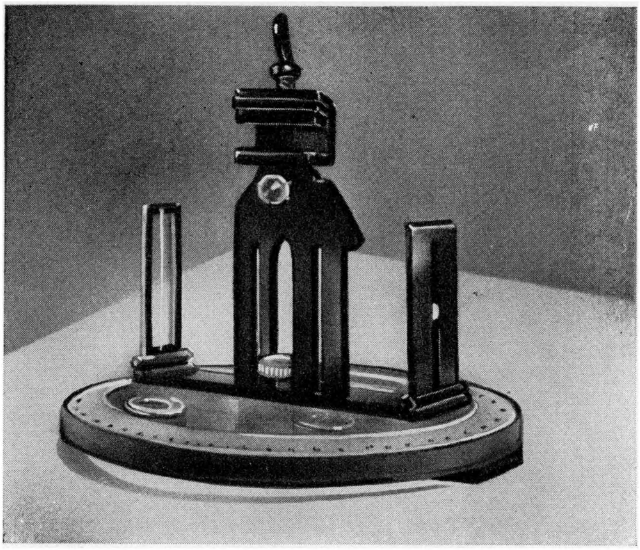

FIG. 1
Radio-active day and night alidade for dioptric and telescopic use

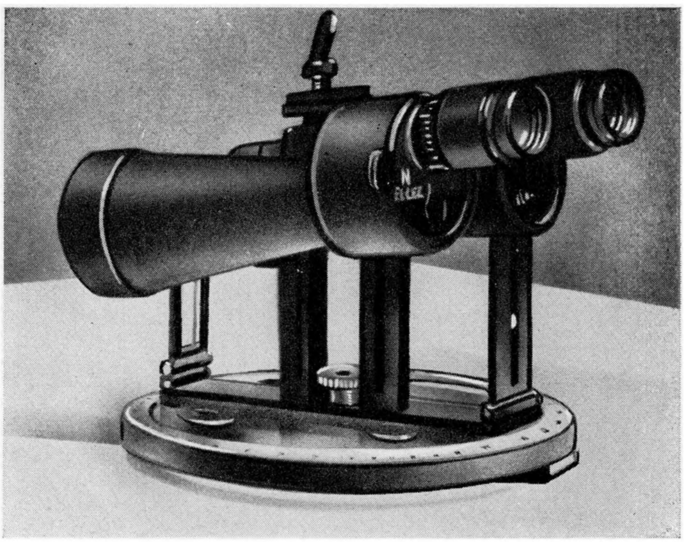

FIG. 4
Night and day Radio active alidade with D.F. 7 × 50 binoculars fixed on.