THE « DE VRIES » RECORDING TIDE GAUGE

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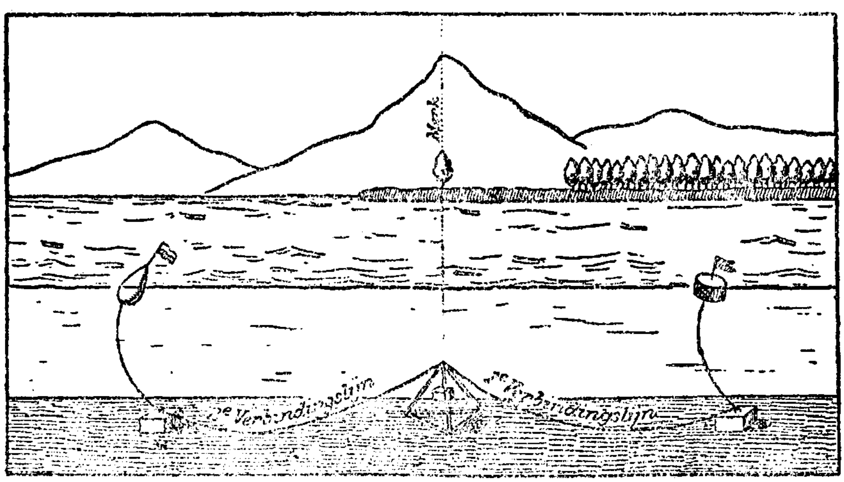
(Translated from the Dutch.)

The Hydrographic Service of the Netherlands possesses a certain number of recording tide gauges of the *de Vries* and *Smitt* types. These instruments may be submerged to a depth of 15 metres. The enclosed clockwork mechanism has a maximum running time of 35 days, so that observations may be continued over a period of 29 days. However, the operation of the instruments is not absolutely reliable, and for this reason due care should be taken in handling them — but even then contingent risks of derangement are not excluded. Even their inventor recommends using two instruments with the idea of increasing the chances of obtaining a complete series. In the tropics, up to the present time the instruments have given nothing but dissatisfaction. The cause for this has not yet been determined. In their present state they are only serviceable in furnishing an indication of the vertical movement of the water outside the channels. The dry-point (perforating) tide gauge described hereinafter is the best suited for the determination of reduction of soundings in daily field operations.

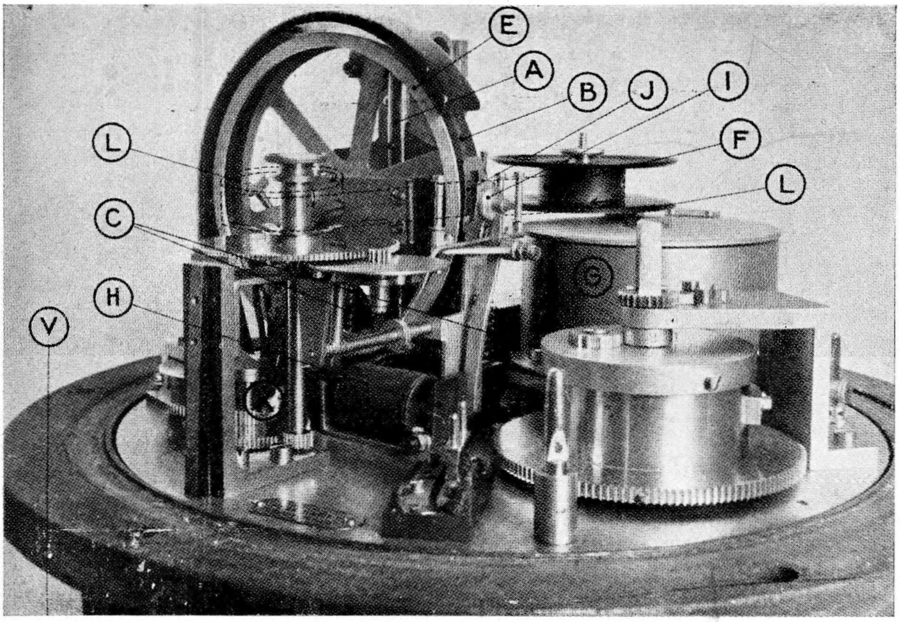
The tide gauges under consideration consist of a closed box in the interior of which the movement of an hydraulic clapper subjected to the pressure of the water and acting against an antagonistic spring, is transmitted, magnified, to a roll of paper (tide gauge with drypoint) or on to a film (photographic tidegauge) by some suitable transmission system.

In order that they might record the exact distance between the gauge and surface of the water, these instruments must be subjected to frequent checks, which may be accomplished in the workshop by means of a manometer or, aboard ship, by immersing the instrument with the ship stopped.

In the latter case, account must be taken of possible rising of the instrument due to the prevailing current. The "scale of readings" obtained for the dry-point instrument, or the table of corrections for the photographic, is utilized subsequently for making the abstract of the records. Since the apparatus is enclosed, the temperature of the sea water and the variations in the atmospheric pressure which act respectively on the interior and the exterior of the

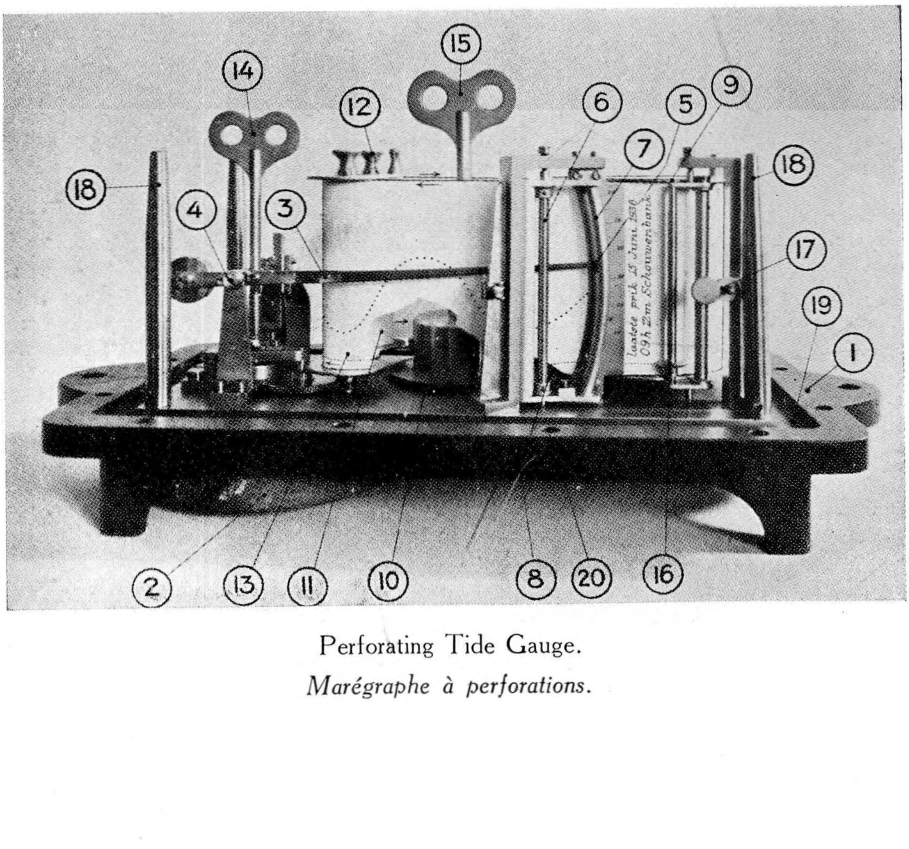


instrument, also have their effect upon the record. It has been found empirically that with a rise of 1 degree C. in the temperature the apparatus indicates a depth 4 cm. less than the actual depth of water. The temperature correction is therefore:— 4 cm. for each degree C. rise in temperature. The correction for a rise of 1 mm. of mercury of the barometer is —1.3 cm.



De Vries Photographic Recording Tide Gauge.

Marégraphe de Vries à enregistrement photographique.



Perforating Tide Gauge.

Marégraphe à perforations.

Before lowering the tide gauge to the ocean bed, it must be suspended from an iron tripod. The instrument is thereupon placed in position in the following manner:—

An effort is made to install the instrument in the water along a range which can easily be marked; this has the advantage that in case the buoy is lost there is some indication as to the line to be dragged to recover the apparatus. When about 70 metres above the line of bearing the anchor for the first buoy is let go, the buoy dropped in the water and line paid out dropping down with the tide or backing if necessary to the end of the first buoy connection line. The tide gauge is then put overside, and when a sufficient length of line has been paid out, the anchor of the second buoy is dropped. The two buoy ropes are then spread out on each side of the line of bearing so that a dragging anchor would certainly hook them, the more so as the location of the instrument is adequately marked by the buoys. It does happen at times, however, that an instrument is lost by becoming buried in the sand or simply due to the impossibility of recovering it: which gives rise to disappointments and loss of time and money. The position of the instrument and the buoys is determined by the Snellius method.

The recovery of the instrument takes place as follows:—

When there is a current the boat should take position above the buoys, drop anchor and then, continually paying out chain, pick up successively the upper buoy, the instrument and the downstream buoy. Under these conditions no attempt should be made to pick up the instrument without first anchoring. That can only be done in the absence of any current.

The Photographic Tide Gauge (See fig.): This instrument consists of a circular base and a cover which is fastened on by means of bolts. Through the base plate there passes a vertical axis (A) which turns on four small steel balls so that it can be displaced vertically with a minimum of friction. This axis carries a round disk on which is stretched a rubber sheave which is exposed to the pressure of the water. The pressure of the water is counterbalanced by two spiral springs (C) which are connected by a bridle to the axis. On this axis there is also a pot hook which engages without play in a pinion fastened on a small horizontal axis, which carries in addition the aluminum wheel (E).

On the celluloid rim (B) of this wheel, the scale is marked.

In order to modify the maximum height of water indicated by the instrument, it is necessary to change the hydraulic clapper which is subject to the water pressure. This operation can only be performed at the factory.

The wheel (E) turns entirely freely, so that all detrimental friction caused by a tracing point is avoided. Although the diameter of the wheel is only 13 cm., the length of the scale is 40 cm. In comparison with the dimensions of the instrument this length is rather great, so that one graduation of the wheel equals a difference of pressure of

$$\frac{\text{O to 550 cm. water}}{\text{O to 1500 cm. water}} \text{ or about } \frac{1/14}{1/50} \text{ of the amount of the water in question.}$$

The position of the wheel and consequently of the water level is reproduced on the film (F) (indicated by dotted line on the photograph) which unwinds parallel to the axis of the wheel.

At the time the photograph of the graduations on the wheel is taken, the image of the small controlling index indicates the reading. The photograph is taken every half-hour; its occurrence is determined by a clock-movement (G) which, through the intermediary of a catch operated by the drum, acts upon a small spring contact which establishes the electrical connection. As a result of this contact the anchor (H) is attracted by the electro-magnet and the hammer (I) then presses the film against the control index and the graduation of the celluloid scale; at the same time a small electric lamp, located on the inner side of the graduations, is illuminated.

After the lighting, which lasts about one second, the contact is interrupted and the anchor of the electro-magnet, falling back into place releases the mechanism (K) which causes the bobbin containing the film to turn sufficiently for a fresh exposure.

The rolls (L) of the film may be inserted in the instrument and taken out in full daylight. As a precautionary measure, however, it is best to take out the film only in a dark room.

The instrument is capable of supplying continuous registration over a period of five weeks. Practically speaking, the clock-work mechanism has no work to perform. The instructions of the manufacturers, which state that a very uniform operation should be obtainable, have not been confirmed in practice, although in this connection the photographic tide gauge is superior to the perforation type.

In order to facilitate the reading when the series exceeds 12 hours, the mechanism produces shortly after each 24th record (12 hours) a displacement of the film without lighting. In this manner the film is divided into 24 sections for observations, each of one half-hour, separated from each other by a small light band.

In order to avoid the barometric and thermometric corrections, the space in the interior of the tide gauge may be kept in communication with the outer air by means of a tube which, in the case of shallow water, is suspended from a tripod. On account of the great danger of water penetrating into the instrument case under these conditions, and due to the fact that we have a simple and automatic method of applying the above-mentioned corrections in making an abstract of the data, the Netherlands does not make use of this tube. In the tropics where the differences in the temperature of the water are slight and there exist no great changes in the barometric pressure, the above-mentioned corrections may be neglected. The instrument can provide a photographic exposure at any desired instant through the medium of an electric cable which is secured at (V). In this manner it is possible to control and check the operations of the instrument before using it, by letting it down to various depths; the photographic records thus obtained at these depths then permit the observer to follow the position of the scale corresponding to the depth to which the instrument is immersed beneath the surface.

This is one of its advantages over the perforation tide gauge which can only be lowered to another depth for checking after waiting one half-hour.

Instructions for Use — Preparation and Immersion in Water.

1.— Wind up clock mechanism and the paper-reel mechanism (K).

2.— Check the storage batteries (E.M.F. 4 volts, current 4 1/2 amp.).

3.— Check up the connections as stated in the instruction sheet on the cover; see if the lamp burns as it should; and that no light escapes to one side.

4.— Allow the instrument to run during one day for trial before mounting the film. Stop from time to time for check.

5.— In a dark room insert the film in front of the little plate index. Do not wind the spring too tight. Keep the sensitive side turned in. See if the film shifts properly when the automatic device functions, and for this purpose give the roll several turns before starting the automatic functioning. Check the number of turns of the handle necessary to bring the sensitive portion of the film in front of the window. Read the position of the drum — if possible in the dark room with the aid of a red light and a magnifying glass.

6.— Close the black cover.

7.— By means of the handle turn the film the requisite number of predetermined turns to bring the sensitive portion of the film in front of the window. Listen, to determine when the first recording takes place; this will be noticed by an audible "tick"; and read the time on the chronometer of the first photographic exposure. In order to make certain of the operation the ticks for several succeeding exposures are also timed.

8.— As short a time as possible before putting the instrument in the water, it should be hermetically sealed.

9.— Suspend the instrument from an iron tripod.

10.— Place the device in the water at a place, even in the open sea, where the depth is less than 15 metres. Note the time the instrument is immersed in the water, as well as the sounded depth. These two indications serve as a check on the time of the first photographic exposure *under* water. Consequently care should be taken to put the device in the water between two "ticks" to avoid the possibility of an exposure during the descent.

11.— During the taking of the series, note the temperature of the water at the depth of immersion of the instrument and also the barometric pressure. In the Netherlands the trials were conducted at the lightship in the vicinity.

Recovery of the Instrument.

1.— Sound, and note the time when the instrument is brought to the surface. It is not possible to arrange to bring the instrument up at a moment between "ticks" because the running of the clock mechanism under water cannot be exactly determined.

2.— Remove the cover.

3.— Read one or more "ticks" and time them on the chronometer. We then know the instant of the first exposure after raising the instrument.

4.— Unwind the film the requisite amount with the handle.

5.— Take off the black cover; note the position of the drum (this can be done in the draughtsman's room or, better, in the dark room).

6.— After removing the film, check the automatic functioning and see if the lamp still burns.

7.— Develop the film.

8.— After development, and taking into account the time recorded for the last photograph before placing the instrument in the water and for the first after raising it, calculate the times of the photographs taken meanwhile.

9.— By means of a table of correction, determine the exact depth and plot this graphically.

PERFORATION TIDE GAUGE.

The perforation tide gauge consists of a cover and a base (1) on which the recording mechanism is mounted. In the cylinder (2), pierced with orifices for the free passage of the water, situated on the base-plate, is a hydraulic clapper which, as a result of the prevailing pressure, presses against an antagonistic spring. This movement is transmitted, amplified, to the recording lever (3) which is movable at (4). The point of the recorder (5) thus describes a small circle having its centre at (4). About the axis (6) there moves the D-shaped hammer (7) which carries at its lower end a tension plate, against which the teeth of wheel (8) press at each turn. If the tension plate happens to be just opposite the space between two teeth, the hammer is free with respect to the recording lever. In engaging one of the teeth the hammer, acting against a flat spring, is forced towards the exterior, while on engaging the space between teeth, and due to the slackening of the tension on the flat spring, it is projected with such force towards the interior that a distinct "tick" is produced, and the needle point pricks a hole in the paper. Immediately thereafter the lever is again freed in its movement. As the rate of rotation of the wheel (8) is one tooth every half-hour, there will be 48 perforations in 24 hours.

The cog wheel (8) at the same time produces a rotation of the drum of the clock-mechanism (9) about the vertical axis, and takes its own motion from the wheel (10) fixed on a case of the clock spring and driven by a clock spring wound up with key (15).

The drum of the clock mechanism (9) contains the clock mechanism proper and is provided on its upper cover with several openings for the regulation of the rate.

The fresh paper is rolled up on the cylinder (11). The button (12) should be screwed down until one notices a slight resistance on unwinding. After having disengaged the cog wheel (16) from the drum by means of the adjusting screw (17) the band of paper is then passed behind the recording point, around the drum, and then rolled on to cylinder (13). A clock spring which is wound by means of key (14) tends to keep the cylinder (13) turning regularly so that the paper is kept well taut and no slack can occur. Afterwards the regulating screw (17) is backed off.

The small cog wheel (16) freely movable about a vertical axis, is pressed firmly against the drum, actuated by clock mechanism by means of a spring which is not visible in the photograph.

Since, at the height of the wheel, there is on the drum a crown on which are vertical slots, the small cog wheel (16) perforates a horizontal line of holes in the paper while it is unwinding. It is with respect to this punctured line that the depths are ultimately read by means of a "scale of readings".

The cover is then fitted on the base. There are four pegs (18) to aid in centring the cover. Water-tightness is provided by means of the rubber gasket in the groove (19). The bolts passing through the holes (20) hold the cover securely in place.

As in the photographic tide gauge, there is inside the cover of this instrument a nozzle for the attachment of a rubber hose to communicate with the exterior air. The perforating tide gauge does not offer the advantage of an easy counting of the record provided by the unexposed strip on the film after each 24th exposure. This disadvantage becomes all the more pronounced as the perforating tide gauge is more irregular in operation than the other, since the skipping of a single point will occasion an irreparable error of half-an-hour. It is therefore advisable to make the count very carefully with the aid of a magnifiying glass, especially on those days when there is a considerable swell, owing to which the points do not form a regular curve but a series of points which shift from one side to the other of the regular line. It might happen that as a result of the jerky movement of the recording lever, there may be failure to record one of the points, an omission which in the case of a smooth curve might be readily revealed but which, with large gains and losses, may not be clearly discernable.

On the other hand, the perforating tide gauges are provided with a more reliable mechanism than the photographic tide gauges, and offer the further advantage that the record may be utilized immediately on raising the instrument, a fact which makes the evaluation of the data more rapid, especially where the daily reduction of soundings is concerned.

The smaller scale of the record (about 1/50 as opposed to the photographic scale of 1/14) has never been found to be a source of inconvenience in practice ; the curves obtained with the *de Vries* recording tide gauge immersed in 12 metres of water do not differ practically from the curves obtained from a tide pole located in the immediate vicinity and read every half-hour.

The price of the perforating tide gauge is about 400 florins, while that of the photographic type is about 1000 florins. With regard to the use made of them in the Netherlands, the great difference in price is out of all proportion to the slight advantage obtained from the latter instrument.

1.— Lift the iron cover and place the instrument on a table with the side containing the recording system towards the operator.

2.— Roll the paper on the cylinder (11) and screw down on button (12) until a slight resistance to turning is noted.

3.— Wind up the driving mechanism by means of the key (15).

4.— Move the small cog wheel (16) away from the drum by setting up on the adjusting screw.

5.— Pass the paper roll, after having refolded the ends obliquely, between the two guide vanes, around the drum and then on the cylinder (13). Turn the drum by hand for several turns to make certain that the paper will roll freely about the drum when the clock mechanism is functioning and that it is not pinched in the guides.

6.— Slack up the adjusting screw (17) so that the cog wheel (16) comes to rest against the lower edge of the paper band. Make sure that the small teeth engage the slots in the crown of the drum. The paper is now obliged to turn with the drum. It is with respect to the horizontal line of dots that one reads later the holes perforated by the recording mechanism.

7.— Wind up the recording mechanism by means of key (14). The slack of the paper will be taken up by the cylinder (13).

8.— Wait until a perforation has been made in the paper relative to the half-hour and note the time on the paper. Mark the first prick clearly with a sharp pencil.

9.— Immediately after the paper has been perforated, make sure that the point has been fully withdrawn. If this is not the case the point will tear the paper and the perforations will not be clear. In such case regulate the adjustment of the hammer slightly ; it is necessary that the latter should have sufficient elasticity to insure a clear perforation. Close the cover tightly. The precautions to be observed in placing in the water and raising the apparatus are the same as those for the photographic instrument.

After having raised and opened the instrument, wait for the next perforation to occur, and mark the time on the paper (see photograph) after having clearly marked this prick with a sharp pencil line.

Near cylinder (11), pinch the paper. Then holding the cylinder (13) securely with the left hand, the wheel (16) is disengaged from the paper, then slightly releasing the pressure of the fingers, the cylinder (13) is freed so that it may continue to turn slowly on its vertical axis until the mechanism has run down.

If the cylinder (13) is not held after disengaging the cog wheel (16), the spring will suddenly unwind, with possible damage to the spring.

As long as the instrument is not ready for service, do not pass the paper around the drum, because every half hour there will be a perforation which will result in an unnecessary waste of the paper.

By counting the holes from the instant the first hole is produced until the last, one determines the times of the intermediate punctures. By means of a small reading scale one then determines the depths and plots them graphically.

Subsequent Study of the Data.

a) With the aid of a tide pole installed for comparative readings :—

We assume that the mean height of sea level during the twenty-four hours is the same for the two instruments.

When, for instance, in the *Thomas Smit Gat* observations are made for several days with a recording tide gauge and with an auxiliary tide pole, we determine (*without* application of the relative corrections for the daily mean of barometric heights and the temperatures of the series) the mean level during twenty-four hours by taking the mean of the 48 observations from half-hour to half-hour throughout the entire 24 hours.

The same thing is done with the observations obtained from the tide pole installed for comparative readings in the case under consideration, i.e. West Terschelling. By plotting grapically the two mean levels we obtain the following diagram, which shows us that between the 8th and the 12th May 1938 the mean level of the sea at *Thomas Smit Gat* fell below that of Terschelling, indicating that the temperature of the water increased during that time or that the barometer fell.

Assuming that the daily mean sea levels for the two tide gauges coincide, we may deduce the following from the diagram:—

Date	Indication of daily mean sea level on the tide pole (auxiliary) of the *Thomas Smit Gat.*	Indication of daily mean sea level on the tide pole installed for comparative readings in West Terschelling.	Indication of the NAP on the auxiliary tide pole of the *Thomas Smit Gat.*
1938			
8th May	828	9 - NAP	837
9th May	826	10 - NAP	836
10th May	825 1/2	10 1/2 - NAP	836
....	....	....	....
19th May	838	2 - NAP	840

Thus we obtain first a correction for any possible sinking (subsidence) of the instrument. It might happen that at the site of the instrument the dirt is carried by the current, burying the instrument deeper and deeper and thus causing the graph of the daily mean to rise more and more above the sea level obtained from the tide pole used for comparison.

Further, the final corrections for the daily variation in the barometric heights and the temperature of the sea water are found to have been effected automatically in this manner.

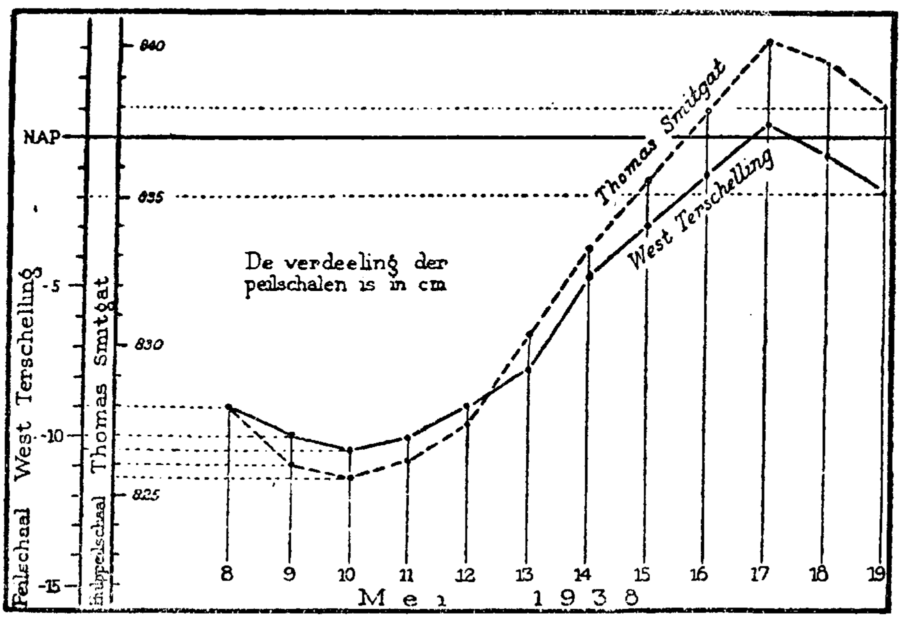


DIAGRAM.

It may be objected to this method of procedure that, though it is acceptable with respect to the temperature correction, this is not true for the barometric corrections which, in the case of European waters, might become quite considerable in a short space of time ; and it might be stated that on the days when the barometric heights differ by more than 15 mm., the correction for the mean barometric height, which would be mid-way between two extremes, the maximum error can only be 7 1/2 × 1,3 cm, or 9.8 cm. In view of the fact also that, on days where such variations in barometric height exist, the state of the sea is such that more often than not the recorded heights of mean sea level can only be considered as approximate, so that an error of about a decimetre is of no particular importance.

In the Waddenzee similar methods were followed, but with the difference that for each twenty-four hours it was assumed not that the mean levels but that the *levels of low water* shown by the auxiliary tide pole and the tide pole for comparative readings, were equal. In this case also the corrections for sinking of the instrument, for barometric heights and temperatures of sea water were effected automatically.

b) Without the aid of a tide pole for comparative readings:—

In this case the correction for temperature and height of barometer is necessary. There should also be a correction for the possible sinking of the instrument. Further, it will be necessary to determine, in addition to the daily mean levels (corrected in this case for barometric height and temperature), the mean of the entire series.

If the graph of the daily means appears to drop below that of the general mean level at the commencement of the series, and to be above it at the end, this must be attributed to a sinking of the instrument. By turning the graph a sufficient amount so that the daily means will coincide more closely with the general mean, we can determine approximately the amount of the sinking and therefore the daily correction.

A still better means of determining the possible sinking of the instrument is with aid of an auxiliary tide pole located in the vicinity, which is read during a period covering at least one high water and one succeeding low water at the beginning and end of the series, and if possible between times also. From the data thus obtained and by the method of mean levels (corrected finally for the barometric pressure and temperature), it is possible to calculate the corrections for the sinking of the instrument.

Without regular observations made on another tide pole for purposes of comparison, it is impossible to correct exactly for the possible sinking of the instrument, because in general this sinking will not take place at a constant rate. The rates for the sinking will determine the degree of accuracy of the results. Usually the amount of the sinking will be slight, but on banks it may attain a rather considerable value.