CURRENT METER

Dr Rauschelbach Design.

Ozean I.

Made by Askania-Werke A. G., Bambergwerk, Berlin-Friedenau, Kaiserallee - 87-88.

The investigation of marine and tidal currents by means of current measurements is more than ever to-day one of the most useful processes in the realm of oceanography and hydrography. These studies are not only of great value from the purely scientific standpoint, but they furnish indications that are often extremely useful in practical navigation as well as in harbour and waterways construction, and in river and deep-sea fishery. Many of those engaged in certain branches of oceanography and other activities closely connected therewith experience the need of accurate current measurements for the satisfactory pursuit of their investigations or at least as a means of checking and amplifying the results obtained by the use of other processes.

The accurate measurement of the currents is however of more special importance for the determination of the periodic and aperiodic movements of the waters in tidal seas. The tidal current, being the horizontal component of the tidal phenomenon, is as yet easier to determine on the high seas than is the rise in the water-level due to tidal action, and therefore these measurements furnish indications that are essential alike to practical navigators and to scientific investigators, the latter in particular being thereby enabled to carry further and further forward their studies into the complex subject of tidal action. In order however, that these studies may be assisted by observation of the currents with the minimum expenditure of time and money, it is essential that the readings obtained should be as reliable as possible.

In smooth and shallow waters, as for instance in river estuaries, it is not difficult for a ship to be moored by four or six anchors with the assistance of a tug. At moderate depths the ship can with success be further secured in position by the use of an additional anchor at the bow and one dropped from the stern; where however the depth exceeds a couple of hundred fathoms, this process is not only very laborious and tedious, but is liable to involve the loss of the anchoring gear if a storm should spring up.

It follows from the foregoing that the ship should preferably be made fast to a single anchor, but that the current measuring apparatus and the method of observation should be so designed that errors due to yawing and swinging of the vessel can be eliminated from the final reading. This can be done mathematically by taking observations at short intervals extending over one or more periods of yawing and swinging, so that vectorial averages covering those periods can be found.

To determine the speed and direction of currents at various depths when working from an anchored vessel, numerous forms of current measuring and recording apparatus have been evolved during the past few decades. In nearly every design the rapidity of the current is determined by the number of revolutions of a helical screw or propeller.

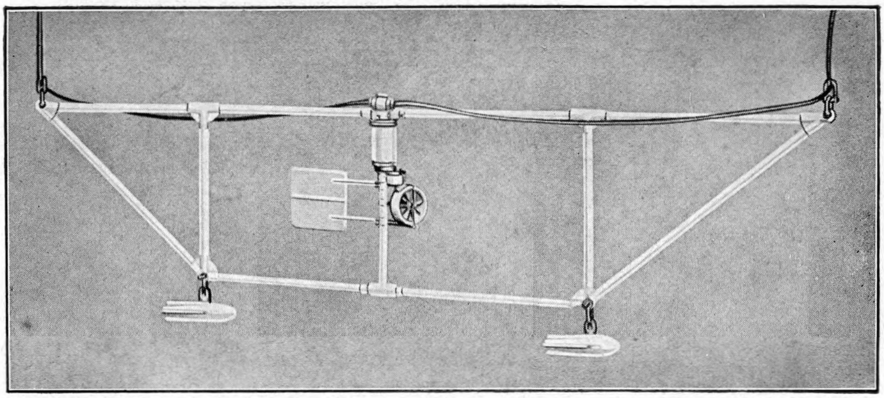
The direction of the current, however, is much more difficult to determine than its velocity. To establish the direction with accuracy, there has to be a standard direction on the current meter for every angle reading. The forms of apparatus that are known divide themselves into two distinct groups according to the manner in which they provide this standard direction. The first group comprises all those instruments in which a magnetic needle is the agent for indicating or recording the direction of the current. In every such instance the compass needle moves over a card which forms one with the vane that responds to the direction of the current, the card therefore adjusting itself automatically in relation to the needle according to the direction in which the current flows. In those forms of apparatus that belong to the second group, the standard direction is obtained by having the zero position of the current meter in a fixed and definite relation to the hull of the ship, *i. e.* to the ship's apparent course, this being achieved by a method of two-line suspension. In the current meters embodying a compass, the compass, needle will point to the magnetic North so long as it is subject only to the action of the earth's magnetic field. When, however, work is done with a meter of this type from an iron ship, a second magnetic field set up by the magnetism of the ship also acts on the compass needle, the so-called local attraction, which falsifies the readings of the compass. In shallow waters and on certain ships' courses the error due to local attraction may be as great as approx. 180° so that it becomes impossible to determine with any accuracy the direction of the current to be measured.

The high cost of exploratory voyages with big ships on the high seas, coupled with the fact that the measurements of currents thereby obtained are not altogether reliable, would seem to make the use of current meters of this design no longer justifiable. Since 1924 we have been engaged in collaboration with Oberregierungsrat Dr. RAUSCHELBACH of the German Marine Observatory at Hamburg, in perfecting step by step a two-line suspension current meter containing no compass in the instrument itself, whereby reliable readings can be obtained. This current meter and its accessories are hereafter described.

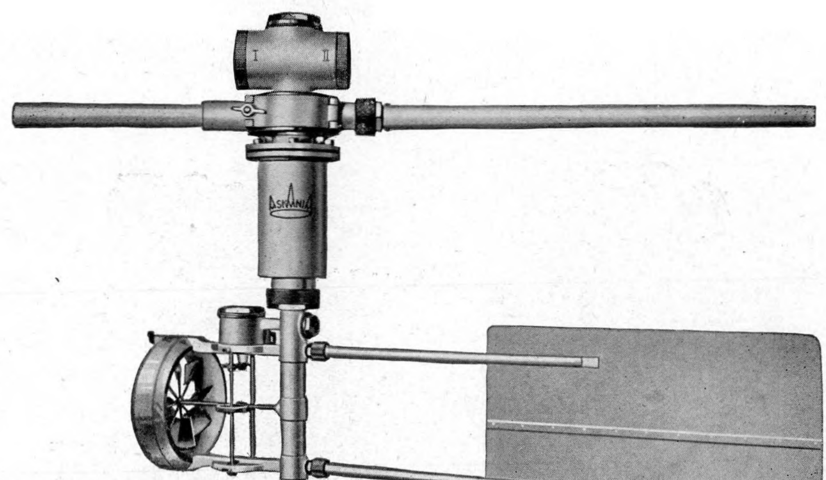
DESCRIPTION OF CURRENT MEASURING GEAR.

The essential parts which go to make up the complete equipment of the new current-measuring gear are :

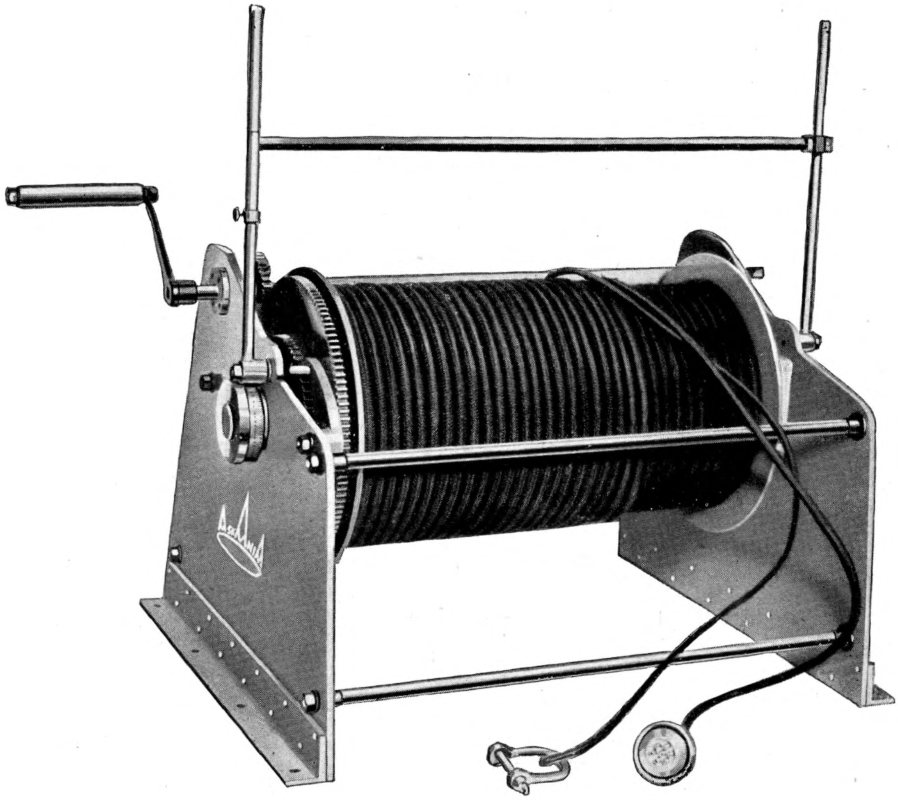
1. The actual current meter with switchgear, spindle, current vane, propeller, contact box and bottom contact.
2. The current-meter frame.
3. Loading weights.
4. Cables.
5. Guide pulleys for cable.
6. Winches for cable.
7. The recording apparatus.
8. The accumulators.



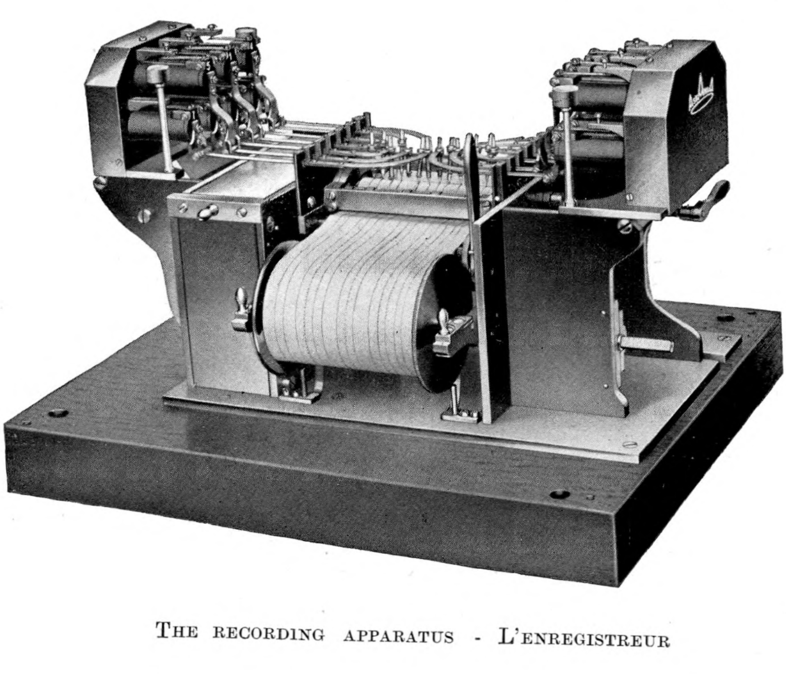
THE CURRENT-METER FRAME - LE CHASSIS DU MOULINET



THE CURRENT-METER - LE MOULINET



WINCH - TREUIL



THE RECORDING APPARATUS - L'ENREGISTREUR

The current meter is secured within its frame in such manner that it is free to rotate on a vertical spindle. This spindle carries two welded projections by means of which it supports on one side a protecting ring within which a multibladed propeller is free to revolve, and on the opposite side the vane, the function of which is to keep the propeller turned so that it faces the current.

The current will, according to its strength, cause the propeller to revolve more or less rapidly. The velocity of the current can be deduced from the number of revolutions performed by the propeller within a given unit of time, the constants applicable to each propeller having been determined once for all by means of towing experiments.

The propellers are calibrated at the Experimental Institute for Waterways and Shipbuilding in Berlin. Each current meter is accompanied by a propeller test certificate.

When the apparatus is in action the revolutions of the propeller are transferred by means of worm gear to a contact disc situated in the small contact box in front of the spindle of the instrument, which is connected by cable to the recording instrument kept on board.

The direction of the current in relation to the frame of the instrument, or to the head of the instrument which is secured so as to prevent it from revolving, is measured by means of the switchgear in the interior of the current meter casing. Twelve contact levers, insulated from each other but permanently connected to the head of the meter, brush against 12 cam-discs connected with each other by conducting material and rotating in unison with the spindle of the current meter. These 12 cam-discs fall into three groups. The angle formed by the longitudinal position of the frame and the direction of the current or of the vane must be somewhere between 0° and 360°. When the scale is tried, to find the angle, contact between one of the four cam-discs in the first group and the contact lever opposite to it will first tell us within which quadrant the required angle is situated. At the same time, contact between one of the levers and one of the three cam-discs in the second group will show within which third of that quadrant the angle is to be found. Finally, contact levers touching one or two of the five cam-discs in the third group will show in which tenth of that third the required angle is located. Every time the angle between the direction of the frame and that of the current alters to the extent of 3°, the contacts between levers and cam-discs will be different and will be distinctly recognisable.

From the individually insulated contact levers and also from the contact box to which the revolutions of the propeller are transmitted, connecting wires lead to the head of the meter, which carries two cable connections. At these points two seven-core cables are fixed by watertight connections. About 3 metres from the lower extremities of the cables two supporting ropes are firmly secured to the cable covering, and by these ropes the instrument frame is suspended.

The two cables pass over two light guide pulleys on the end of two boom carried on board the observation vessel and reach the winches placed on board, each of which is designed to carry 30 fathoms of cable. By means of these winches the current meter in its frame can be lowered to any desired depth.

Each cable is connected to the winch in such manner that the electric current passing through each core of the cable can be picked up separately by means of sliding contacts and transmitted, for instance by means of seven-core rubber-insulated leads, to the recording instrument. This should preferably be kept in a room or cabin protected from wind and weather.

The recorder uses chart paper 110 m/m in width, which moves forward by clockwork at the rate of 30 m/m per minute. It is provided with 14 pens, with 14 corresponding electromagnets which actuate them each time the respective circuits are closed. The first of these magnets receives each minute a sharp surge of current, through a relay to the primary circuit of which a ship's chronometer making contact once a minute is connected. The first of the 14 pens accordingly traces an accurate time record on the chart. The second magnet actuates the second pen, which records the number of revolutions of the propeller. The remaining 12 pens serve to record the direction of the current. These also are actuated by electro-magnets connected by leads to the contact levers of the cam-discs in the switchgear. Every 10 secs. or every 5 seconds a current is sent through the instrument, this being so arranged that the current actuates different electro-magnets according to the position of the current vane at the moment and the corresponding pens draw points on the chart. These pens are charged with different coloured inks — red and blue — according to their groups so that a glance at the chart will tell the observer at once which of the contact levers in the several groups are making contact for the time being with the cam-discs in the body of the current meter, and by that he can measure the angle between the frame of the current meter and the actual current.

Assuming that the suspension points of the two cable pulleys are in a line exactly parallel to the ship's axis, the direction of the current will be evident from the angle indicated by the recording instrument, taken in conjunction with the ship's course as shown on the ship's compass. The angle can be determined with an error of not more than 1.5° at each individual reading.

To prevent undue lateral displacement of the current meter in its frame when the current is exceptionally strong, it is loaded with two special weights, shaped like floats.

The electric current required for the working of the entire apparatus is furnished by a special type of battery with 5 or 6 cells, which has been tested in practice and found capable of giving continuous service for more than 4 weeks at the rate of 13 to 14 hours per diem without becoming exhausted.

Several instruments of this design were used in the summer of 1928 on more than 100 days on the lower Elbe and in the outer Ems, and gave perfectly satisfactory readings. It is clear, therefore, that the two-line suspension electric recording current meter can be used wherever an exact knowledge of the velocity and direction of currents is required. In the course of exploratory voyages on the high seas, the current meter is suitable for giving particulars of currents at any depth down to 30 or 40 fathoms; in tidal waters or shallow seas generally, not exceeding that depth, indications of the currents at any

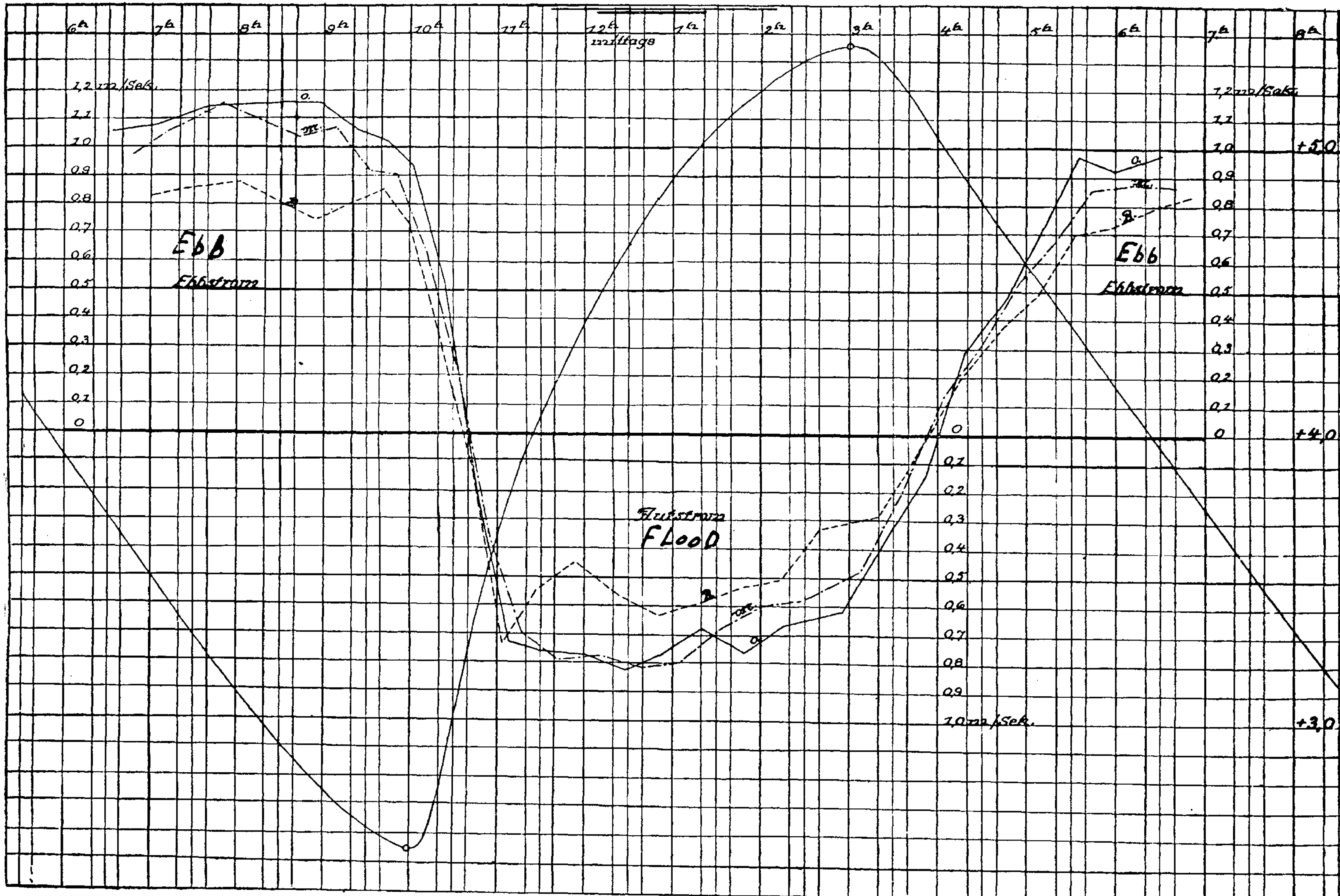


Fig. 1. — Tidal curve and Velocities of Current constructed from Observations made at Pagensand, 25th June 1926.

depth from the surface right down to the bottom can be obtained. In the vicinity of land, for investigating the coastal current, or in river reaches, estuaries and ports where it is required to analyse the action of tidal currents, the current meter can be most advantageously used on board observation vessels. It is likewise of great service to waterways, conservancy or port authorities, as the continuous record which it furnishes enables the nature of the current in all details to be determined, *e. g.* whether it flows uniformly, or whether it is turbulent, whether it retains or alters its direction between the surface and the bottom, whether it turns and if so in what manner, etc...

With all this the current meter, as regards the accuracy of its directional readings, is far and away superior to all others. Current directions can be recorded 6 or 13 times within a minute — according to choice — with an accuracy of about 1.5° for each individual reading, whilst the accuracy of the velocity readings lies within a few m/m per second.

In order to demonstrate how complete are the determinations obtained in a short period with the aid of the RAUSCHELBACH current meter, an extract from a table of observations made at the tide-station of Pagensand (53°42'37", 5 N., 9°30'10",0 E.) is given below.

On June 25th, 1926, the depth of the water at Pagensand was 7.5 metres (low-tide) and 10.2 metres (high-tide); current observations were started at a depth of 0.8 metre from the surface and were continued metre by metre to the bottom, At each depth observation lasted a full 2 minutes.

In the preceding figure N° 1 those velocities only of the current are entered which correspond to the surface (O) to the middle depth (M) and finally to the bottom (B). They are given in m/sec. The directions of the currents observed at the depths mentioned are shown in figs *2a*, *2b*, and *2c*.

Directions of currents are referred to true North.

A good illustration of the accuracy and clearness of the records made by the RAUSCHELBACH Current meter is given by the following figures :—

Time	*Depth*	*Directions*	*Velocity*
6 h. 38	0.8	346.0°	1.090 m.
39		346.0	0.994
—			
48	4.5	345.7	0.970
49		345.3	1.055
—			
59	8.2	344.0	0.823
7 h. 0		343.3	0.869
—			
3	0.8	346.9	1.073
4		345.2	1.089
5		345.5	1.090
—			
15	4.4	346.7	1.057
16		346.3	1.080
—			
25	8.0	346.3	0.851
26		344.3	0.748

and so on.

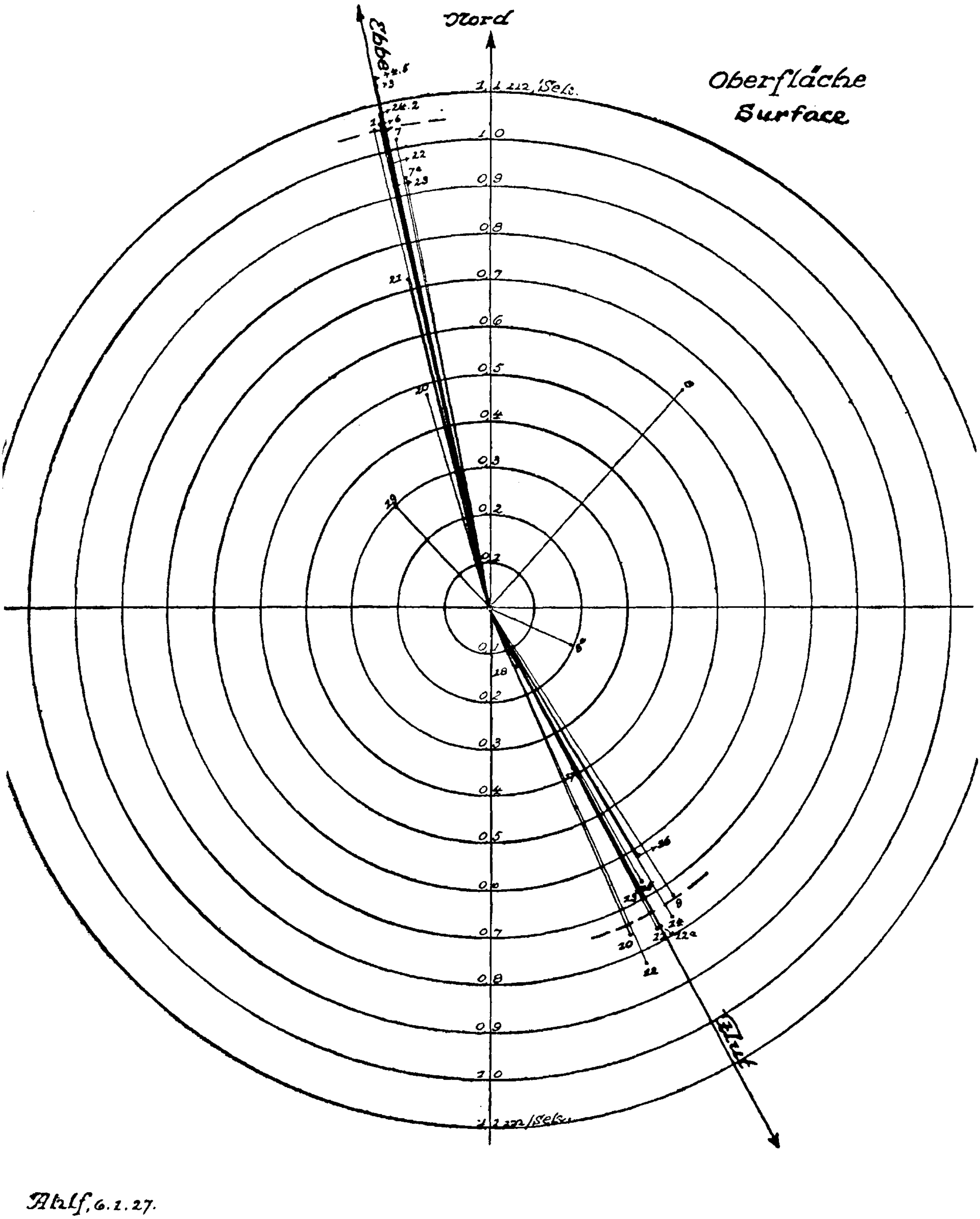


Fig. 2a. — Observations for Velocity and Direction of Current Pagensand, 25th June 1926.

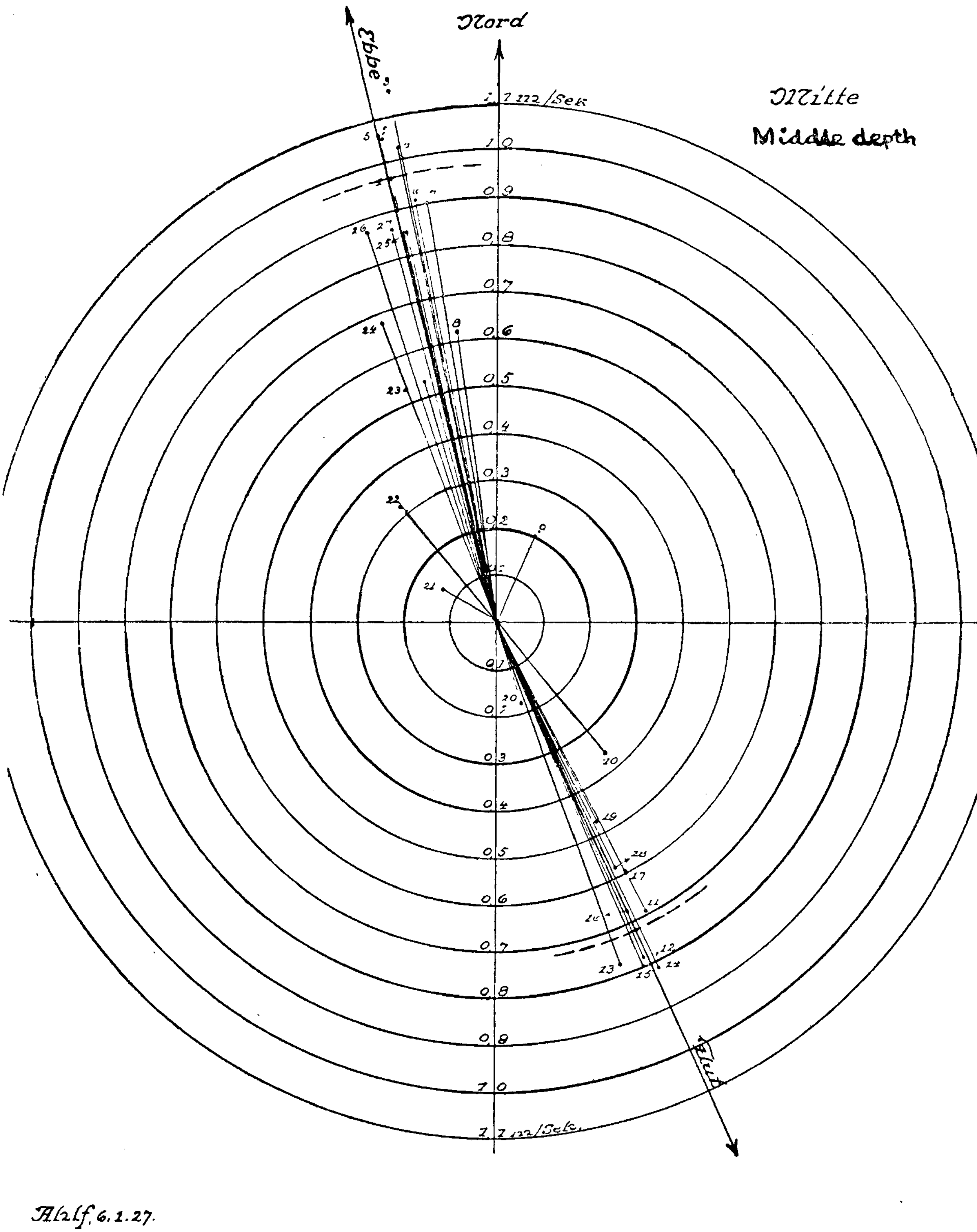

Nord
Ebbe
Mitte
Middle depth
1.1 m/Sek
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Flut
Half. 6.1.27.

Fig. 2b

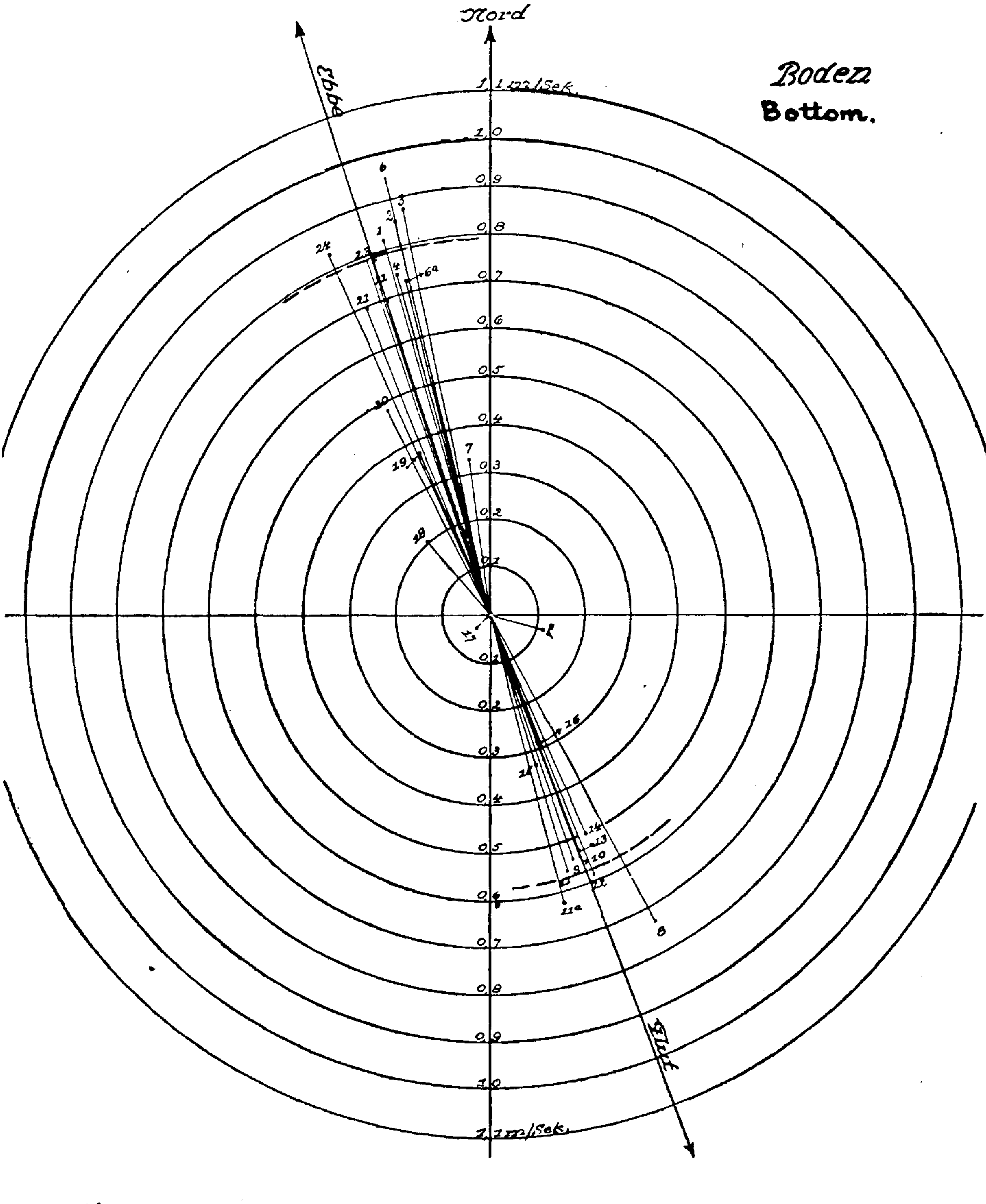

Nord
Bodem
Bottom.
Ebbe
Flut
1,1 m/Sek.
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
1,1 m/Sek.
Half, 6. 1. 27.

Fig. 20