A RECORDING CURRENT METER FOR DEEP SEA WORK

by

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There is a general tendency of modern experimental research to replace the human observer by self-recording instruments. This is particularly the case in meteorological science, which is exceptionally well equipped with recording instruments for various purposes. The related science of oceanography is not yet so fortunately situated, the recording tide-gauge being almost the only apparatus of this kind which is commonly used.

For several years a large part of the work done by Swedish hydrographers has dealt with current observations. The currents round the coasts of Scandinavia are of considerable practical importance, not only for the navigation and the fisheries, but also for the local climate (1). The large amount of labour required for a prolonged series of current observations with the ordinary instruments has led Professor O. PETTERSSON to construct a recording current meter suitable for work in the open sea. The first of these instruments was made in 1906, and the type has since that time undergone considerable modifications. During the Swedish research cruises of last summer (1913) I had ample opportunity for work with this meter, and I then found it desirable to introduce some further improvements in its construction, resulting in a simplified manipulation of its different parts. The following is a brief description of the instrument in its present shape (1914).

In Fig. 1 I have drawn a schematic vertical section through the current meter showing the more important parts of its construction. (The ratio between the horizontal and the vertical dimensions of the meter is exaggerated in the proportion of two to one). C is a cylinder of thick brass tested to withstand pressures equal to 800 fathoms of water. The internal dimensions of the cylinder are: diameter = 10 cm., height = 60 cm. When in use the cylinder is kept hermetically closed by a lid which is pressed down by six strong screw-nuts. The meter is suspended from a bronze ring S attached to the lid by means of bronze ball-bearings. Owing to this arrangement the meter is free to swing round almost without friction, two large and slightly diverging rudders of brass-plate attached to the cylinder keeping parallel with the direction of the current.

Below the cylinder there is an anemometer wheel W, which is set revolving even by very faint currents (down to about 4 cm. per sec.). After a considerable reduction in speed by means of a gear the rotation is transferred to the recording apparatus inside the cylinder. This is not effected by means of an axis or any other material transmission which would involve risk of leakage, but instead two parallel magnets are used, one rotating outside the bottom of the cylinder and the other one following it on the inside, M_1 and M_2. After a further reduction in speed the rotation is transmitted from the inner magnet to a vertical axis, which carries attached to its upper end a horizontal glass disc D_1. The disc has an opaque border with transparent numbers from 1 to 48 round its circumference.

Once every 30th minute a flash of light is sent upwards through the edge of the disc from a small electric lamp L_1, which is fed with the current from two dry cells B_1

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(1) *About January 10, 1914, the Gullmarfjord on the west coast of Sweden, where our hydrographical station Bornö is situated, refused to freeze in spite of several days' severe cold* (—10° C.), *the fjord then being completely filled with salt and warm* (+3° C.) *Atlantic water. About a week later an inflow into the fjord of cold and nearly fresh water of Baltic origin had occurred, so that ice was readily formed after a single night at an air-temperature of* —3° C.

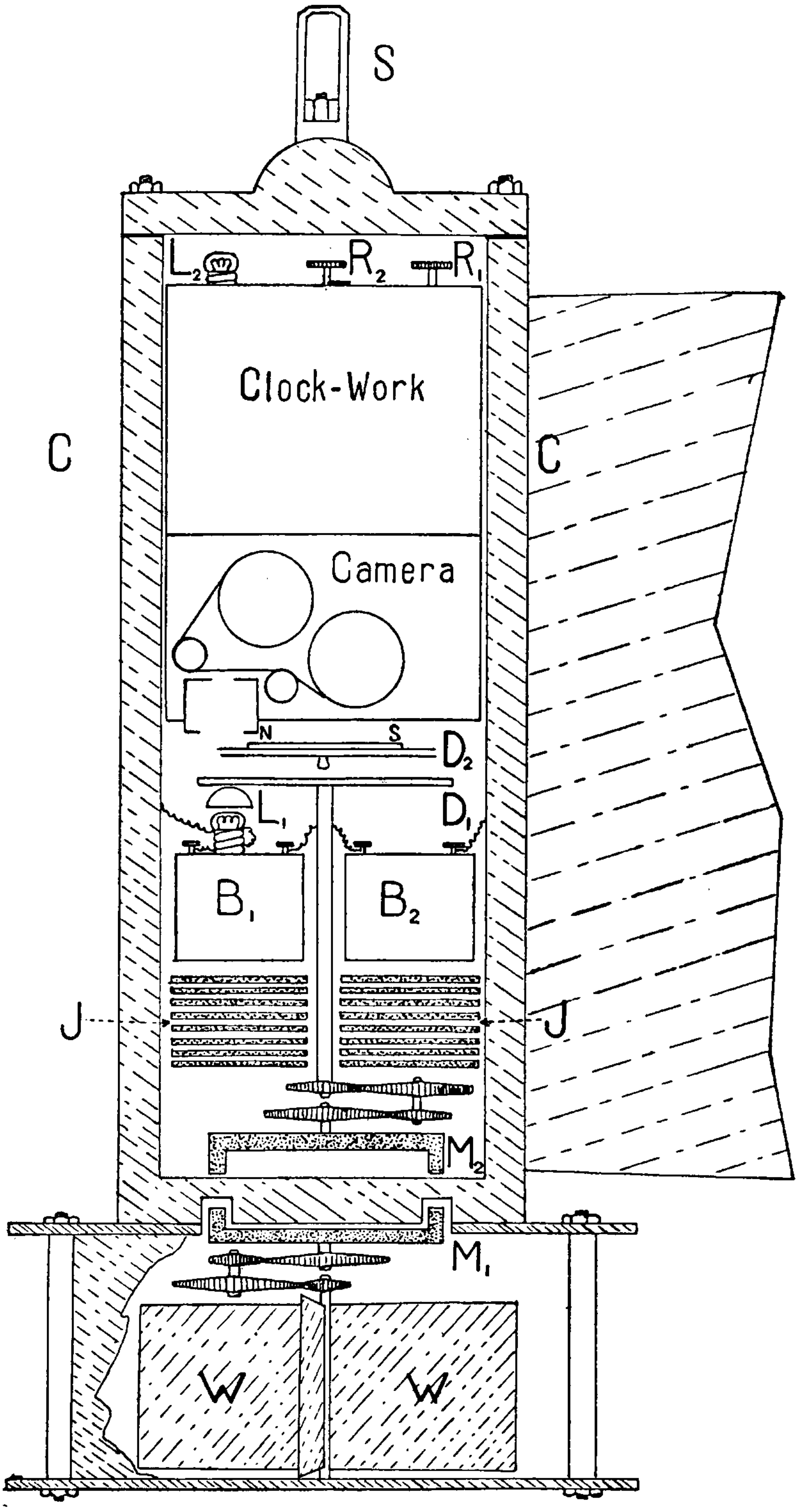

Fig. 1

Section montrant les différentes parties de l'enregistreur de courant.
Section showing the principal parts of the Current Meter.

and B_2. The light then enters a tiny camera, where an image of the number of the disc which happens to be before the camera is photographed on a long film. The clockwork which moves the film also makes the contact which sends the electric current through the lamp at the moment of the exposure. By subtracting the number visible on one photograph from that on the next we find by how much the current has turned round the glass disc during the corresponding interval of 30 minutes. By means of an empirical Table or a curve (which is practically rectilinear) the average velocity of the current referred to the same interval is then found in cm. per sec. With the present instruments a velocity of nearly 100 cm. per sec. is required in order to carry the velocity-disc round by a complete turn between two exposures, so that the same number is visible on two succeeding photographs.

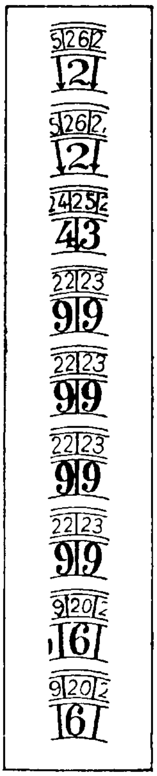

FIG. 2
Type of Record.

Immediately above the velocity-disc there is a similar disc D_2, of a slightly smaller diameter, which carries two compass needles, and has numbers round its edge for every 10th degree of arc. On each photograph there is therefore also a number from the second disc, giving the direction from which the current was flowing at the moment of the exposure.

The clockwork will run for a fortnight, giving an uninterrupted record of nearly 700 observations of the velocity and the direction of the current.

Among the details of construction the following may be mentioned:

Across the orifice through which the light passes before entering the camera a fibre is stretched, an image of which is visible on each photograph dividing the field of vision in two.

Thanks to that arrangement it is possible to determine from the photographs the exact position of each disc at the moment of the exposure to within 0.1 of the distance between two of its numbers. This gives an accuracy of about 0.2 cm. per second to the recorded values of the velocity, and of 1° to the direction.

L_2 in the figure is an index-lamp attached to the top of the case which holds the clockwork and the camera. It is set in series with the other lamp so that when it is seen to burn, one may be certain that the lamp L_1 is also in working order.

R_1 is a handle by which the clockwork is released or arrested. By turning round a second handle R_2, the moment for the occurrence of the next exposure may be advanced or retarded.

Between the glass discs and the magnetic transmission are interposed a number of soft-iron discs, J in Figure 1, which protect the compass disc from the magnetic field generated by the transmission.

The current meter may be suspended either from a ship or from G. EKMAN's submarine hydrographic station. A brief description of the latter arrangement will be given here, as it allows the meter to be used to its best advantage.

Gustaf Ekman's Submarine Hydrographic Station (1).

A large buoy, B in Fig. 3, is kept well below the surface by two diverging wire ropes attached to anchors on the sea-bottom. The wire rope attached to one of the anchors is kept down by a heavy extra weight (of iron rails shod with wood) which is oblong in shape so that it can be towed along the bottom by a buoy-rope attached to the second anchor. This is done in order to depress the buoy B to a suitable depth, say 10 metres, below the surface, the current meter having first been suspended from it by a wire rope, equal in length to the desired depth of observations *minus* 10 metres. The place of each anchor is denoted by a buoy floating on the surface, and carrying a flag visible from a distance of several miles.

The commander of the Swedish research steamer, Lieutenant G. RIDDERSTAD, who has taken a prominent part in the development of the submarine station, has brought down the time required for mounting the station to less than one hour and a half, whereas it can be taken on board in less than an hour.

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(1) Svenska H. B. Kommissionens Skrifter V., 1914. — *The principle of this arrangement was suggested by me to the Kommission in 1910.*

The current meter may be left hanging in this manner at any depth exceeding that of the buoy *B*, and takes the current observations while the research vessel is otherwise engaged. After a fortnight, the whole system is raised to the surface, the meter is taken on board and the film developed, giving a record of a completeness which it would be practically impossible to realise with any other current meter. The advantages of this new method will be understood by anyone who has experienced the strain felt by the human observer in the course of a prolonged series of observations with ordinary current meters.

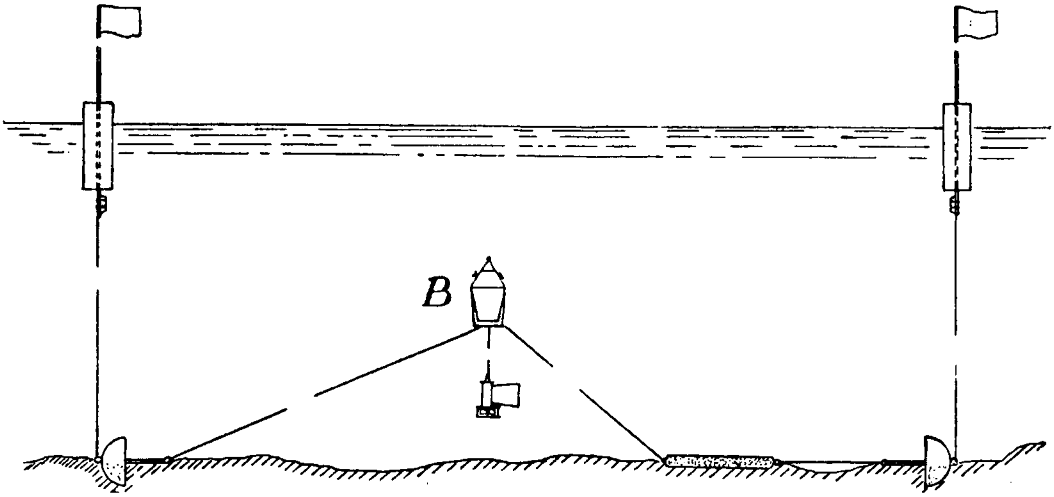

FIG. 3.

Ekman's Submarine Hydrographic Station.

The most considerable errors adhering to current observations in the open sea by the older methods, are those due to the swaying, the rolling, and the pitching motion of an anchored ship under the influence of the surface current, the wind and the waves. Numerous attempts, more or less futile, have been made to overcome this difficulty. With G. EKMAN's submarine station all errors of this kind are excluded, as the position of the submerged buoy remains practically uninfluenced by the movements of the surface water. Hitherto this station has not been used in depths much exceeding 100 metres, but nothing prevents the same arrangement from being used at much greater depths.

By means of one or two dozen of such submarine stations scattered around the coasts of the North Sea, each provided with, say, two recording current meters hanging at different depths, a very complete survey of its currents might be attained which would undoubtedly be of considerable practical importance, both for navigation and fisheries, and might also give valuable information to meteorologists of the surrounding countries.

With a few similar buoys anchored in the Florida Strait, giving records of the intensity of the Gulf Stream, it will be possible to feel the pulse of this great artery of the North Atlantic, which is known to vary considerably from year to year. The study of this important meteorological factor will undoubtedly give a valuable clue for early forecasts of the European climate.

In studying the amount of water carried by a river the recording current meter will do excellent service if suspended either from a bridge or from the submarine station, which may then be used without any surface buoys.

I propose to use the submarine station also to support recording densimeters of a new construction, which will be used for a study of the boundary waves in the open sea round the coasts of Sweden. It might perhaps also be utilised for measurements of the amplitude and the period of the wind-waves and the height of the tidal wave far from the shore.

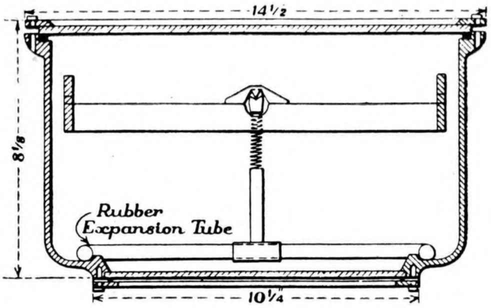

Fig. 1

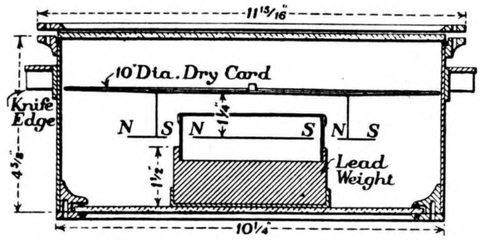

Fig. 2

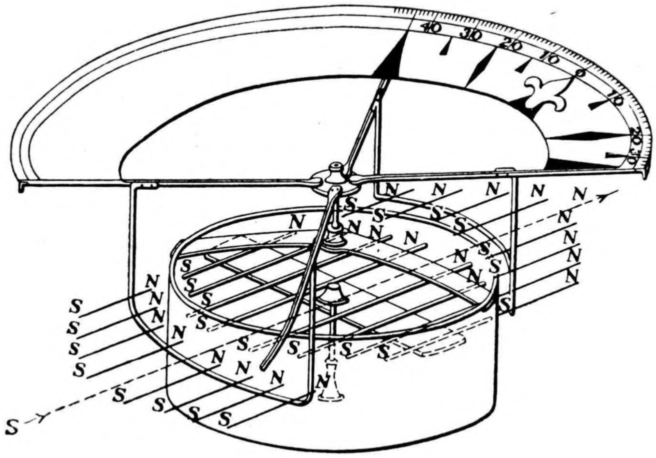

Fig. 3

The Stella Dual Magnetic Compass.

Le compas magnétique Stella à double système d'aiguilles.

Many meteorological problems of the highest importance can apparently only be solved by a more systematical co-operation between meteorologists and oceanographers. The proposed investigation of the North Atlantic (1) seems to offer an exceptionally favourable opportunity for taking steps in this direction.

THE STELLA DUAL MAGNETIC COMPASS.

Since the unsteadiness of the ordinary form of dry-card compass renders it unsuitable for accurate steering, the liquid compass is generally employed for that work, although the liquid type of compass lacks the delicacy, sensitivity and lightness of the dry-card instrument. Recently, however, a new type of compass has been designed by Mr. N.-C. BAIRD and this instrument, it is claimed, while retaining all the advantages of the large-diameter dry-card compass, is not less steady than the liquid type. This compass, known as the STELLA DUAL MAGNETIC COMPASS, is made by Messrs. Stella Engineering Company, 38 Bath Street, Glasgow.

The appliance includes an outer and an inner vessel. Figure 1 is a section of the outer vessel in which the inner vessel is suspended on gimbals formed by two pairs of knife-edges at right angles, so that the inner vessel always remains horizontal if the outer vessel is tilted. The latter is completely filled with a non-freezing liquid which serves to damp out any oscillations of the inner vessel, and the weight of the inner vessel is adjusted, by means of a lead weight, to give critical buoyancy. A section of the inner vessel is reproduced in Figure 2, while Figure 3 is a perspective drawing which serves to make the principle of the instrument clear.

In the inner vessel an annular dry card is suspended by four radial arms from a pivot mounted on a central cylindrical box, and four sets of 4 short magnetic needles are mounted on stirrups carried by the radial arms as shown in Figure 3. The magnets are also shown in Figure 2.

Neglecting for the moment the contents of the cylindrical box above referred to, it will be seen that the annular card (and its attached magnetic system) moves entirely in air and that it will set itself in the magnetic meridian, but it will also be obvious that unless means are taken to prevent it, the card will continue to oscillate about a mean position for a long period. The method of preventing this oscillation is particularly interesting and ingenious. Referring to Figure 3, it will be seen that the cylindrical box contains another magnetic system consisting of eight comparatively long needles mounted on a bar supported by a pivot from the bottom of the box so that they lie in the same plane as those of the dry card. The central box is filled with non-freezing liquid, so that the movement of the magnetic system is highly damped. If now the compass is turned away from the magnetic meridian, the central magnetic system will turn back to the meridian comparatively slowly, but with almost dead-beat motion. The annular card will oscillate slightly about its mean position, but the oscillations are kept of small magnitude and are rapidly damped out by the interaction between the magnets suspended from the dry card and those enclosed in the central box. Experience has shown that when the compass is turned through an angle of 180° from its equilibrium position and then neglected, the card will come completely to rest in the right direction in a little less than 50 seconds after having made only four oscillations.

The total weight of the dry card and its system is only 60 grains as compared with about 200 grains, which is the weight of the moving system in ordinary dry-card compasses. (The weight of the card for 7 in. compass is about 25 grains).

Another advantage claimed for this new system is that disturbance from outside magnetic influences is reduced.

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(1) O. PETTERSSON & C. F. DRESCHEL. — Mémoire sur des recherches dans l'Atlantique avec programme. *Copenhagen. Imprimerie J. Jorgensen & Co.*, 1913.