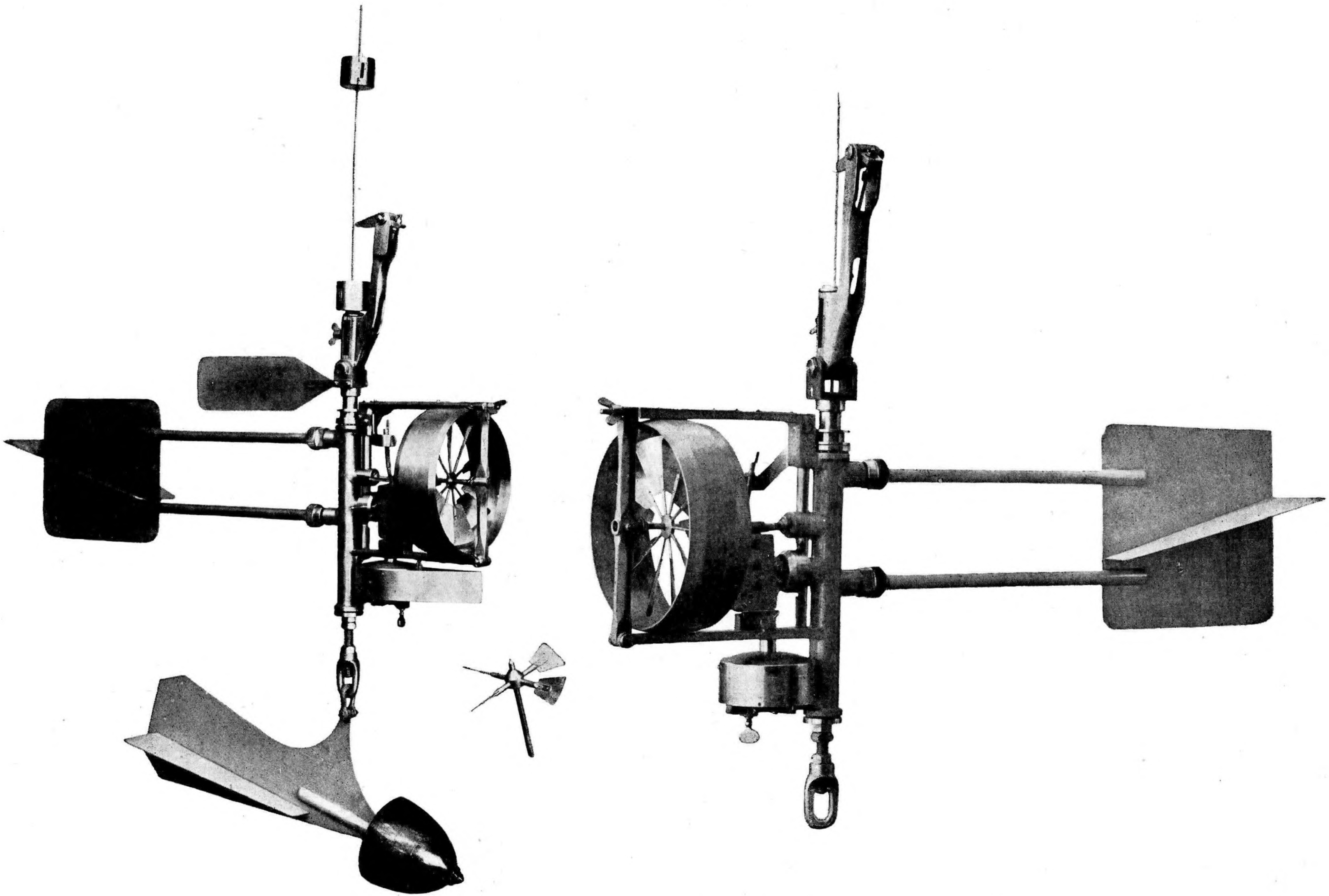

Merz Current-Meters — Mesureurs de Courant Merz

THE ALFRED MERZ APPARATUS FOR MEASURING THE FLOW OF STRONG AND WEAK CURRENTS

According to a pamphlet of ALFRED MERZ: *"Stark und Schwachstrommesser"*
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Since oceanographic observations were first undertaken, and especially since international maritime research has been inaugurated, a large number of devices have been constructed and placed in service for the measurement of current flow; but few of these devices have received universal recognition and none have been considered entirely reliable.

Among the best of these devices should be mentioned the EKMAN apparatus for the measurement of currents.

After a long series of exhaustive tests, begun in 1910, Alfred MERZ reached the conclusion that this instrument might be modified and developed into a serviceable current meter. Alfred MERZ thereupon undertook to perfect this device with the aid of Maximiliano MARX, Engineer of the Institute of Oceanography, taking into consideration the results obtained on tests and the experience acquired during these observations. The apparatus as modified has since been distributed throughout the world, but as yet it has not been fully described. Therefore, a description of the instrument and the improvements made will be given here.

The EKMAN apparatus for measuring currents is very delicately constructed and the last Hydrographic Conference in London in 1919 held, not without reason, that the instrument was suitable for fair weather observations only.

The double rudder bends very easily and may even break off entirely. According to the tests made in the Versuchsanstalt für Wasserbau und Schiffbau in Berlin, the propeller begins to turn at a velocity of current of 3 c/m per sec. but does not revolve at a uniform rate until a velocity of 4 cm./sec. has been attained. From this one is forced to conclude that the instrument is unsuitable for the measurement of weak currents. In addition, strong currents are also incapable of being measured by this device; *i.e.*, currents having a velocity of 250 to 300 cm./sec. At these high velocities, and even at the velocity of 200 cm/sec. which is frequently encountered, the instrument is forced out of the upright position by the pressure of the water to such an extent that the propeller starting and stopping device fails to function. As a result of this inclination of the instrument the number of revolutions of the propeller does not increase proportionally with the velocity, but at a slower rate, and falls off again after the critical velocity is exceeded. The relation between propeller revolution and current velocity is represented by a hyperbolic curve and not by a straight line throughout the range of velocities encountered in the measurement of ocean currents. This means that a definite r.p.m. always corresponds to two different velocities, so that in practice, no definite value of the velocity can be derived from the readings of the Ekman device — at least at the higher current velocities encountered in the ocean.

From the above report one must conclude that current velocities exceeding 200 cm./sec. have been measured by this instrument, but it is not apparent how this was accomplished nor how the value of the current velocity deduced from the instrument reading can be considered to correspond to the actual current velocity. According to the available tests reports, the instruments were tested by Dr. EKMAN in the former Central Laboratory of the International Oceanographic Institute of Christiania up to velocities of 20 cm./sec. only, and in the Versuchsanstalt für Wasserbau und Schiffbau in Berlin to velocities not exceeding 150 cm./sec. In both test laboratories the relation between propeller r.p.m. and current velocity has been given by the equation for a straight line. The Versuchsanstalt gives different correction constants both for the higher and lower velocities, indicating that the equations for a straight line are simply approximations to the actual curve. From this it is evident that the equations are only valid within the limits of the calibration and that extrapolation outside these limits must result in appreciable error.

For the rest it should be remarked that the tests in the Central Laboratory in Christiana were conducted in a canal of insufficient dimensions (40 cm. width). This explains the fact that the calibration corrections for the same instrument were found to be lower than those obtained from tests in the Versuchsanstalt; at least within the range of velocities between 10 and 15 cm./sec. In individual cases the difference between these and the Berlin test results amounted to as much as 4 to 5 cm./sec.

The unsatisfactory operation of the dropweight in strong currents is due primarily to the fact that the wire securing the instrument, on which the drop weight slides, does not take the same inclination as the instrument and consequently the wire and the axis of rotation of the device no longer form a very obtuse angle. Therefore the drop weight either fails to strike the releasing lever or else presses on it with insufficient force. A further disadvantage is the lightness of the first drop weight, which frequently fails to cause the releasing lever to function, even when the drift is slight, and at times sticks on the wire cable when the latter is not absolutely straight. Equally detrimental is the difference in the time of fall of the first and second weights and the lack of ease in manipulation.

The ingenious device for obtaining the direction of the current by balls thrown out in the compass bowl, also develops some faults in operation. Of these the greatest is due to the fact that the number of balls dropped — three per hundred revolutions — is very small in weak currents. Under such conditions the true direction of the current may only be obtained after observations of long duration, which is especially disadvantageous since very weak currents usually show frequent marked changes of direction. In strong currents the point of the compass needle tends to catch in the compartments in the bowl due to the inclination of the pointer or the distortion of the arms and the balls fall into the compartment in the position in which the compass has accidentally jammed. Therefore the current direction indications were inadequate or unserviceable both in strong and weak currents. The Ekman current meter gives satisfactory results only with average current velocities between 4 and 150 cm./sec.

Filling the shot container each time, especially in cold weather and rough seas, is difficult. The unavoidable blocking of the counter or the shot discharging device often necessitates the instrument being taken below decks and dismantled. The construction of the after propeller bearing is unhandy and makes quick examination or overhaul very difficult.

Further, the excessive vibration of the instrument in strong currents is detrimental since this causes great dispersion of the shot even when the direction of current flow is constant — as a result the indications are sometimes useless.

Therefore, the Ekman current meter has been gradually remodeled until it has reached the form of construction shown in the illustration of the "Alfred MERZ current-meter" which will be described.

In order that the instrument might withstand the severe conditions encountered in a heavy sea, the design was improved as early as 1911; giving the device increased strength. The protective ring *A*, the rudder *H* and the rotating shaft *C*, were strengthened to withstand greater strains. With such improved instruments it was possible to work in weather with wind force between 6 and 7.

To reduce the inclination of the instrument in strong currents, the horizontal rudder *J* was fitted. Tests conducted in the Versuchsanstalt in Berlin showed that the inclination of the rotating axis was so greatly reduced by this attachment that the relation between r.p.m. and current velocity might be represented by a straight line for all practical purposes up to velocities of 300 cm./sec. Thus the figures given by the instrument for all currents encountered in the various oceans correspond to a definite current velocity and the results are no longer ambiguous.

It should be noted that the corrections to the observed values taken from the calibration curves are only reliable when the kind and amount of the loads in calibration tests and in actual practice are identical. Sufficient attention has not been paid to this fact up to now, since the test records give no data pertaining to the method of applying the load nor its amount. The new instruments will have such data supplied with them.

In order that the starting and stopping of the propeller might be accomplished in a reliable manner, even in the strongest currents, the whole mechanism has been altered. The head "*B*" of the rotation shaft "*C*" has been made movable in order that it may adjust itself constantly to the inclination of the suspension wire. Directly attached to the head is the forked lever "*K*", which thus maintains its position relative to the wire under all conditions. The first drop weight presses the forked lever "*K*" downwards and strikes the lower part of the axle head. When this lever is pressed down a chain is stretched taut to the lever "*D*". This results in releasing the propeller. The

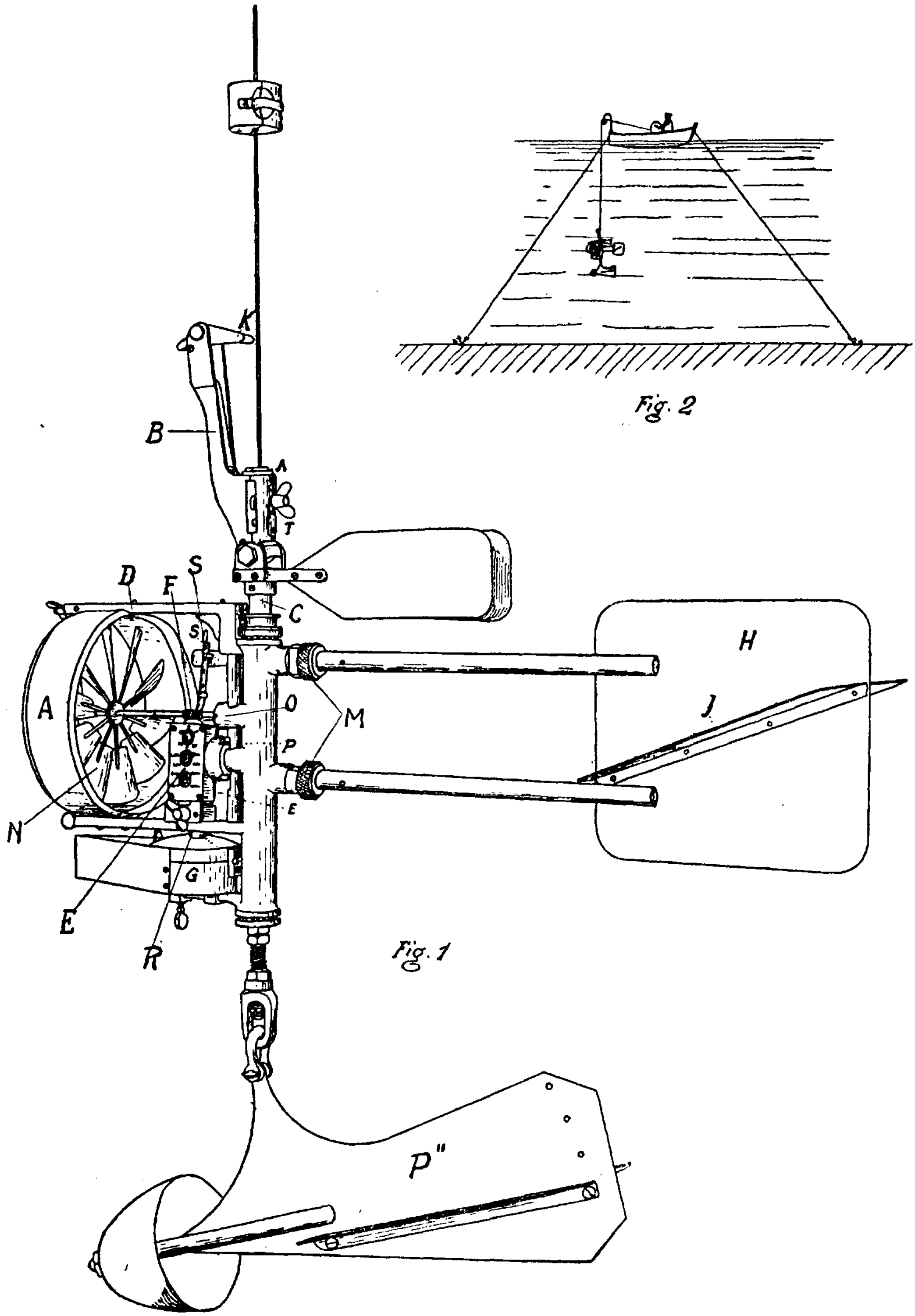

Fig. 1

Fig. 2

Merz Current-Meters

dropping of the second weight causes the propeller to be locked; the whole process being repeated. It is evident that with this construction the operation of the drop weights is entirely independent of the inclination of the wire with respect to the axis of rotation. Under numerous tests at velocities up to 300 cm./sec, the instrument functioned perfectly without a single failure in this respect. The weights are easily handled and are all of the same size and shape. Since 1914 drop weights have been used which have the same rate of fall in water.

As a result of the more upright position of the instrument following the fitting of the horizontal rudder, the magnet needle does not become caught in the bowl except at the very highest velocities. With the idea of entirely eliminating the danger of the magnet needle jamming, the future instruments will be designed with a gimbal suspension for the compass bowl.

The heavy strains to which propeller and bearings are subjected when measuring strong currents necessitated the employment of the heavy four-bladed propeller (instead of the ten-bladed used for weak currents), and the use of hard metal bearings, both being designed to permit easy replacement. This precaution however has proven superfluous as several instruments have been in operation for years without the necessity of renewing these parts. The hard metal bearings were so slightly attacked by the sea-water that tests made after months of steady operation showed no change in the constants. The four-bladed propellers for strong currents begin to turn at velocities of from 6 to 7 cm./sec, and show a uniform velocity of rotation at velocities greater than 8 cm./sec.

The apparatus provided with a four-bladed propeller has been used in 1917 for measuring the violent Bosphorus currents; it could be kept in operation at velocities ranging from 8 to 300 cm/sec, and it has been called apparatus for measuring strong currents (the report of proceedings actually states that it is a strong-current meter).

For the measurement of weaker currents the so-called weak-current meters are employed. — These are fitted with 8 bladed propellers (or 10 — bladed propellers) having a very slight moment of inertia. The instrument is fitted with the same type of bearings as the strong-current meter. These propellers rotate at a uniform rate at velocities less than 2 cm./sec. and are suitable for use in currents up to 150 cm./sec. Therefore this type of instrument is suitable for some oceans or parts of oceans for all purposes, as well as for the measurement of very weak deep currents. In spite of their lightness of construction these instruments, manufactured since 1912, have been found to be sufficiently rugged for practical purposes and may be kept in operation for months without repairs or alteration in their constants. They have recently been improved by a new counting mechanism which delivers 6 balls to the compass bowl for every 100 revolutions, thus increasing the reliability of the current direction indications (previously 3 balls for every 100 revolutions).

The inconvenient shot filling device has been improved since 1912 by the introduction of the shot magazine. This holds 25 balls, is fitted into the shot tube and releases its contents to the counting mechanism automatically. When emptied the magazine is easily replaced by a filled magazine. It automatically releases the shot it contains freely, when a sufficient depression is exerted with the hand to bring the elastic jointing into action. Further, the counting mechanism has been made more accessible, so that derangements may be readily repaired without dismantling the instrument; it being simply necessary to remove a small door at the rear side of the mechanism housing.

The compass and housing has also been entirely redesigned. The compass is better secured. the water drainage provided for by small openings in the bottom of each compartment and the easily jammed bayonet joint replaced by a lock hinge. The magnet has been strengthened and the pivot on which it is supported was made adjustable in the vertical axis. The pivot may therefore be raised by screwing up to the original level after it has become worn down in use or by repeated sharpening. Further, as mentioned before, the housing is mounted in a gimbal suspension, thus reducing the influence of vibration and inclination on the magnet needle.

The magnetic needle is strengthened to increase its stability at all depths. It is composed of two arms forming an obtuse angle at the intersection of which is the cap which holds it on the pivot. The upper part of the cap is shaped like a cup from which is removed a small segment corresponding in size to the north arm of the magnet needle. On the upper part of the north arm is a groove of circular section through which the small lead balls roll after leaving the magazine *S* and reaching the counting mechanism *E*. Thence they pass into the collar *R* of the magnet bowl *G* and then fall on the cup-shaped part of the needle. Rolling along the groove of the north arm of the needle they fall into one of the 36 compartments of the compass bowl.

In order to reduce the vibration as much as possible a number of alterations in design have been made. The protecting ring has been given a greater diameter and the counting mechanism is reduced in size, as well as being moved back from the propeller. Small holes for water circulation have been drilled in the double wings along the axis of rotation. Since 1917, the simple rudder *H* has been fitted, far removed from the rotating axis in order to stabilize the instrument. The rudder is attached by the removable lock nuts *M* and the whole instrument may therefore be packed in a box measuring 54 to 44×24 cms.

In 10 experimental trial runs at velocities up to 200 cm/ sec. over a distance of 150 metres, these new instruments showed a maximum dispersion of 30° with a constant direction of current. Of the 26 balls dropped, 21 lay in the compartment corresponding to the current direction, 4 in the compartment to the right and one in the compartment to the left. The mean deviation from the true current direction was 1°.