ECHO SOUNDING - XIV.

(See *The Hydrographic Review*, Vol. XI, No. 2, Monaco, November 1934, pp. 25 and 62).

THE DORSEY FATHOMETER

by

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U.S. COAST AND GEODETIC SURVEY.

The regular type of fathometer (U.S. Patent No. 1,667,540) has been used by the United States Coast and Geodetic Survey since 1925 and it has proved very valuable in measuring all depths from 15 fathoms to 3,000 — the deepest encountered by this Bureau in regular surveying work. This work has all been done by what is called the red light method (see *The Hydrographic Review*, Vol. V, No. 1, May 1928, page 143), in which the depth is indicated by a flash in a rotating neon tube and recorded in the sounding book. A recording type depth indicator has not been considered necessary by this Bureau since it is felt that it is desirable to have the indications observed at all times so that any sudden change in depth can be noted.

While the regular type fathometer gives excellent results in depths greater than 15 fathoms, there was need for an instrument of high precision for depths less than 15 fathoms; consequently, in January, 1933, it was decided to develop an instrument primarily for shoal water, and not necessarily for depths greater than 20 fathoms. By measuring to 20 fathoms it was intended to overlap the depths indicated by the regular type instrument and it was felt that the least depths should be whatever could be obtained by the instrument. It was also thought desirable that a comparatively large number of indications per second should be obtained; the final decision, therefore, was to make the scale from 0 to 20 fathoms and have 20 indications per second, so that they would be so nearly continuous that an actual profile of the bottom could be observed. In order to get sufficient accuracy, it was decided to use a tuning fork driven by thermionic tubes and run a synchronous motor from this source. Figure 1 shows schematically the operation of the entire system.

INDICATOR.

The indicator consists of the rotor and the stators and a starting motor to bring the rotor up to synchronism, the desire being that the indicator shall run either at its correct speed or not at all. The motor is run by current taken from the fork circuit and amplified by a pair of power triodes. A tuning fork can easily be kept on its frequency with an error less than

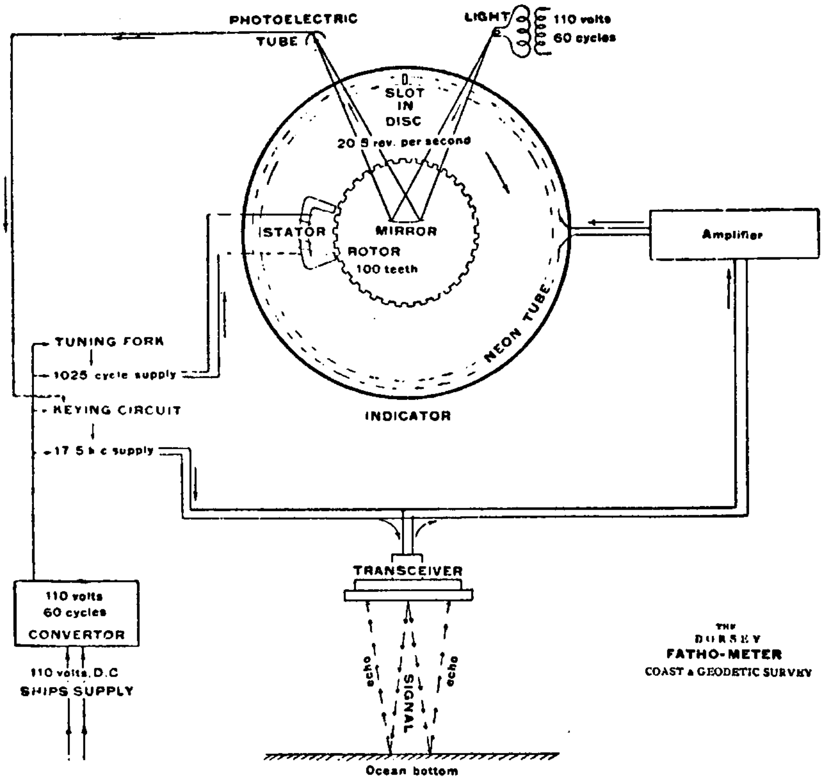


Fig. 1.

0.1 per cent, and if one uses temperature control of the fork any desired accuracy may be obtained. With a fork made of steel having a low temperature coefficient of modulus of elasticity, temperature control is unnecessary. By using a frequency of 1025 cycles per second and a stator without polarizing current, a synchronous motor having 100 teeth on the rotor will rotate at a speed of 20.5 revolutions per second. An annular space in the rotor is filled with mercury to act as a balance. In any method of controlling speed by a governor no correction to the speed can be made until the speed has changed, whereas with a tuning fork the regulation is almost continuous. With this fork frequency the velocity of calibration is 820 fathoms per second, or 1499.6 metres per second. On the same shaft with the rotor is a disk having a narrow slot and just back of this disk there is a neon tube bent in the form of a circle so that when the neon tube is illuminated it will be seen through the slot in the disk. In front of the disk is a glass scale calibrated to 20 fathoms, the fathoms being subdivided into feet. The diameter of the scale is about 8 inches so that the length of the scale is 25 inches, thus giving 0.2 of an inch for 1 foot of depth or 1.8 centimetres per metre depth if the scale is calibrated in the metric system. These divisions can easily be read to tenths so that it is possible to read to tenths of feet or to 10 centimeters on a metric scale. The dial is frosted slightly so that little light is reflected, making the flashes more readily perceptible. At one side near the teeth of the rotor there is placed a small neon tube, which is actuated from the 1025 cycle alternating current, giving 2050 flashes of light per second on the teeth making it appear to stand still when the rotor is in synchronism with the tuning fork.

In order to send the signal, contacts were found unreliable, due to chattering, so a small concave mirror is rotated on the shaft to reflect light from an incandescent lamp to a photo-electric tube. The tube and lamp are placed on top of the indicator under small hoods. A slot under the photoelectric tube is adjustable so as to correct the position of the flash at zero made when the signal is produced so that the readings may indicate surface depth instead of depth under the ship. Figures 2 and 3 show the front and side of the indicator.

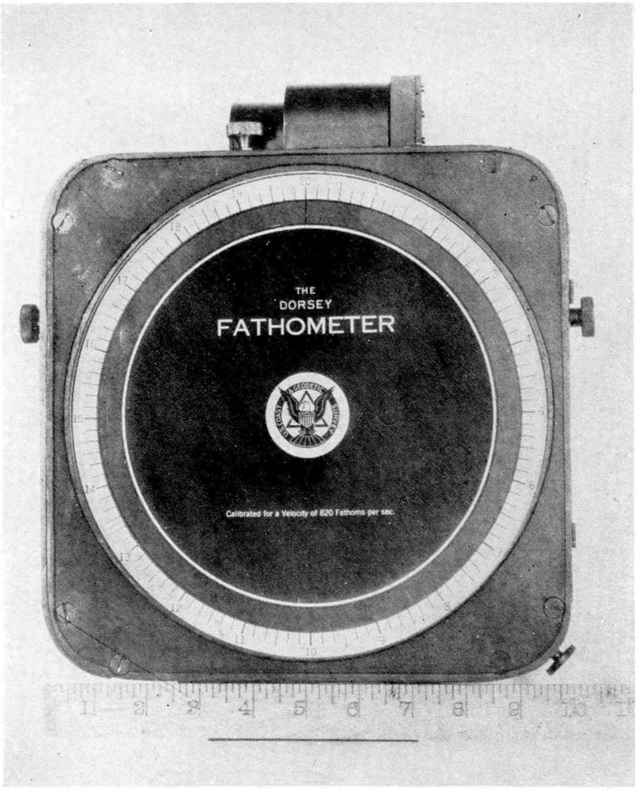
POWER SUPPLY.

The electromotive force generated by the flash of light on the photoelectric tube is amplified by a single triode and then changes the grid bias of a thyratron, a hot cathode gaseous triode, causing a condenser, with renewable charge, to discharge through the anode-cathode circuit of the thyratron. This discharge current passes through the primary of a transformer, the secondary of which is in the screen grid circuit of a pair of power pentodes in a self-exciting push-pull circuit tuned to a frequency of 17.5 kilocycles. The signal is then amplified by a pair of power triodes in the push-pull circuit and passes to the transceiver. The method of changing the screen grid voltage from about 200 volts negative to 300 or 400 volts positive gives an extremely short and regular signal. No current is taken by the anode circuit of the tubes until the screen grids become positive, thus economizing the high tension current. This method of sending the signal has proved very simple and absolutely reliable. With no moving contacts in the indicator, construction and performance are simplified and less energy is necessary to drive the moving parts.

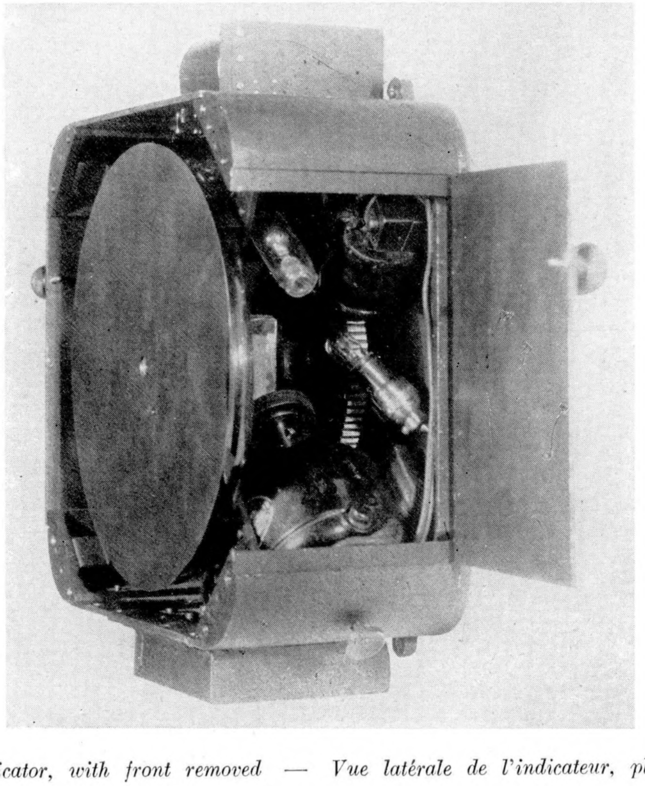
While it is easier to send on one instrument and receive on another, it was decided to use only one transceiver so that the scale of the indicator would be uniform throughout; consequently, no matter how shallow a depth was measured, there would be no correction due to the longer path required for the sound waves when two separate instruments are used for sending and receiving. Although the difficulties were great at the beginning, the increased effort to use the single transceiver made it worth while to spend the extra time in the development. Figure 4 shows the power supply.

AMPLIFIER.

The amplifier consists of a pair of push-pull triple grid tubes as a preamplifier, after which a superheterodyne circuit is used to amplify on an intermediate frequency of 175 kilocycles, after which the signal is rectified and actuates a pair of thyratrons in series through the anode-cathode circuit, of which a condenser is discharged, as was described in the keying circuit. The discharge of this condenser through a transformer generates a voltage of about

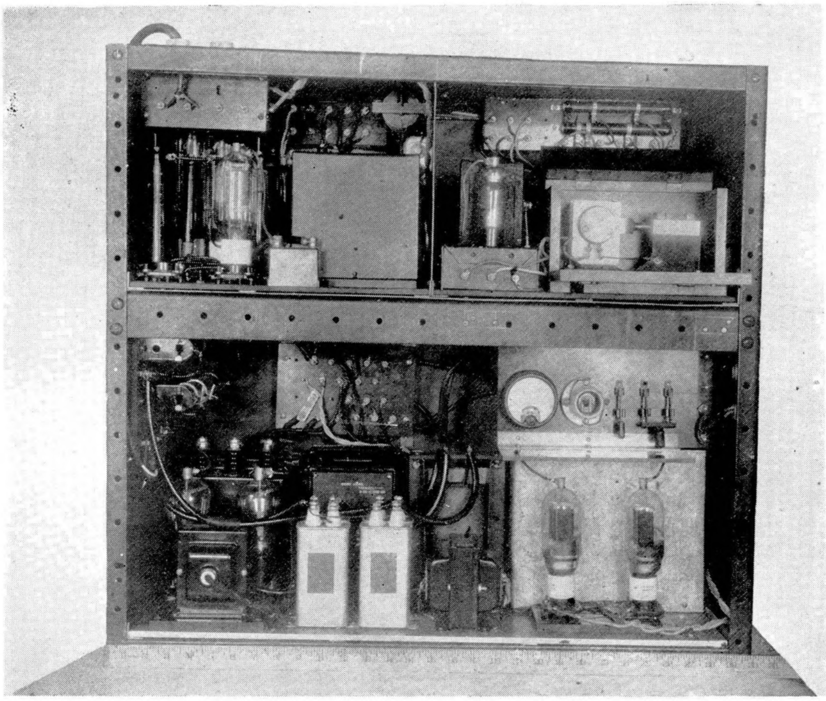


Front view of Indicator — Vue de face de l'indicateur

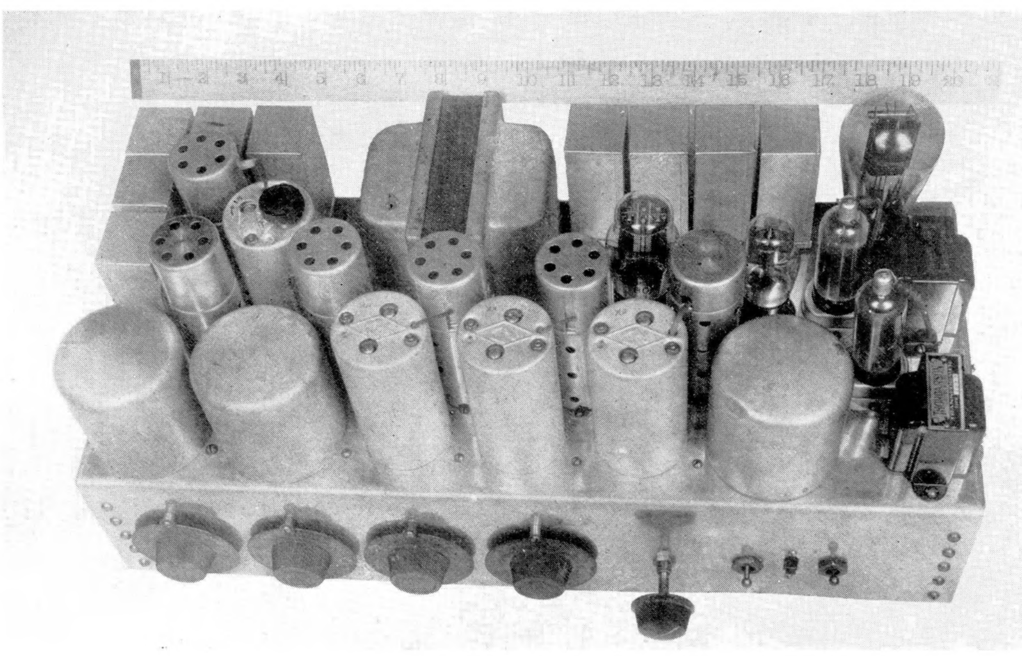


Side view of Indicator, with front removed — Vue latérale de l'indicateur, plaque avant retirée

THE DORSEY FATHOMETER — LE FATHOMÈTRE DORSEY



Power Supply — Alimentation



Amplifier, top view — Amplificateur, vue en plan

THE DORSEY FATHOMETER — LE FATHOMÈTRE DORSEY

700, which produces a flash in the circular neon tube back of the rotating disk. The duration of this flash is probably not over 2 or 3 millionths of a second, resulting in a brilliant red flash so brief that the slot appears stationary and for a constant depth the indication is so steady that it can be viewed through a magnifying glass and the variation on the scale is less than 1/32 inch. The whole apparatus is so sensitive to changes in depth that the indicator registers the differences in depth as a small surveying ship rises and falls on a light swell. Figure 5 shows top view of the amplifier.

The instrument has been used during the last field season for two months on the surveying ship *Lydonia* and about a month on the *Hydrographer*. The ranges of depth measured were from 5 feet to 120 feet. On the *Lydonia* comparisons were made every day for several weeks between the fathometer indications and the lead line to determine if there were any variations between the two methods. It appears that the fathometer indications are more reliable than the lead line, even when the latter is handled by the most skilful leadsmen of many years experience. With the ship stopped, the lead line and fathometer indications agree to within a few inches, or as close as can be read, but with the ship under way, there is always a slight difference, the lead line indicating the greater depth by an amount of about one foot. On the *Hydrographer*, the cross sounding lines of the survey show agreement of depth to a few inches with the fathometer, while with hand lead soundings an agreement to within a foot is generally considered satisfactory work.

During the coming season it is expected to use the fathometers on these two ships again and in addition make an installation on the Tender *Gilbert* and one on a 75-foot launch to determine its operation on small craft.

HYDROGRAPHIC PRECISION SOUNDINGS WITH THE MARTI HAMMER-BLOW SOUNDER

(Extract from a note kindly communicated to the International Hydrographic Bureau by the Chief Engineer of the "Ponts et Chaussées" in charge of the Maritime Service of the Gironde, Director of the Autonomous Port of Bordeaux).

The principle and certain details of the MARTI hammer-blow sounders have already been described in the various publications of the International Hydrographic Bureau ;(1) we shall therefore confine ourselves here to giving the new details thanks to which the accuracy of the results furnished by the instrument has recently been increased.

(1) See : ***The Hydrographic Review***, Vol. III, N° 2, July 1926, p. 89.
Vol. V, N° 2, Nov. 1928, p. 121.
Vol. XI, N° 2, Nov. 1934, p. 43.
and ***International Hydrographic Bulletin***, 1934, N° III, p. 63.

The Autonomous Port of Bordeaux undertakes sounding work of considerable extent every year, not only in the river, from Bordeaux to the sea, but also at its mouth, the main object being to collect all the information necessary for a methodical study of the changes of depths, and afterwards, by the help of the data thus obtained, to prepare a general programme of improvements. These annual soundings cover 80,000 hectares (309 sq. miles), with a density of two soundings per hectare (about a sounding per acre), *and are shortly to be extended further offshore,* where an investigation into the changes in the submarine banks may provide valuable information on the steps which should be taken to defend the coast against the sea.

So as to carry out such a programme without incurring excessive expenditure, the Autonomous Port of Bordeaux requested Ingénieur Hydrographe Principal MARTI, inventor of the continuous sonic sounding recorder, to develop a similar apparatus specially for taking soundings of sufficient accuracy in shoal depths.

The requirements peculiar to this problem were the following: to take soundings, with a degree of accuracy equal to that furnished by the ordinary sounding lead, in depths which might be as little as 2.5 metres (8.2 ft.) below the keel of the boat.

If it be desired to obtain a degree of accuracy comparable with that obtained with the sounding lead, say about 0.25 metre (10 in.) in shoal

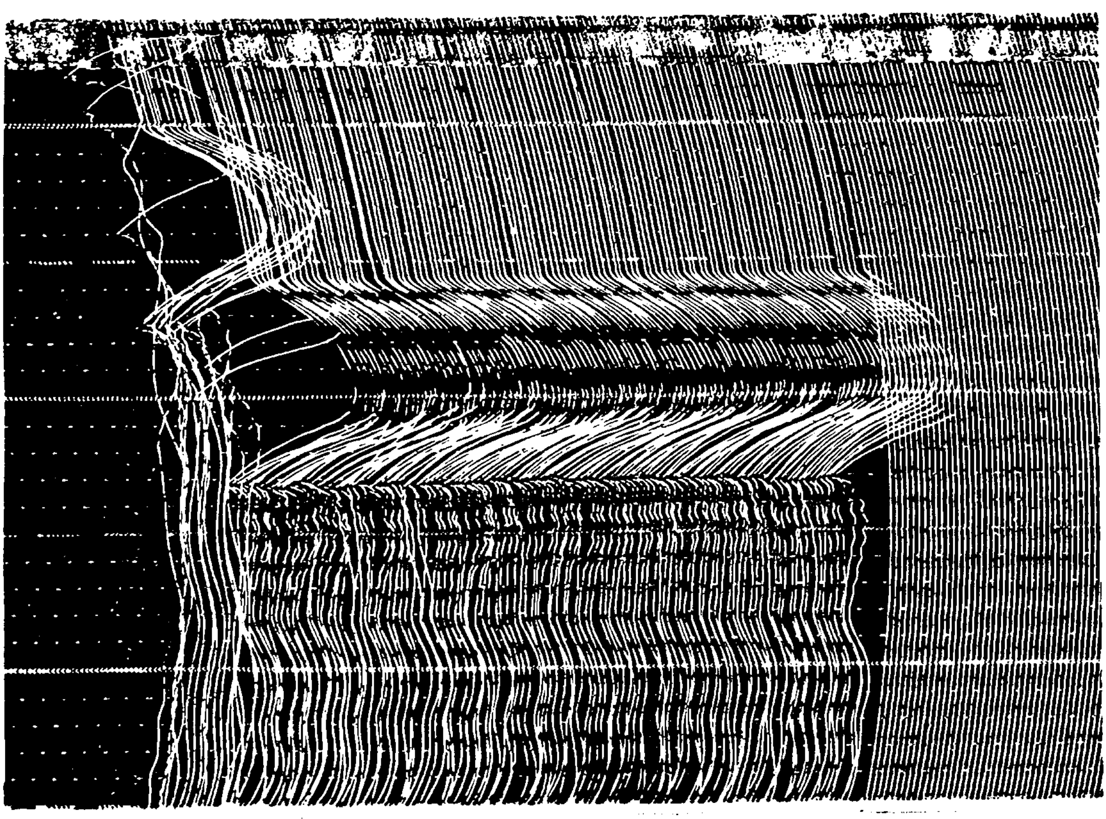


FIG. 1

depths, it must be possible to appreciate an interval of the order of 1/3000 of a second on the record. This condition imposes serious mechanical difficulties which Mr. MARTI has been able to overcome.

With soundings in very shoal depths, the time interval between the emission of the sound and the reception of the echo, being only a few thousandths of a second, is too short for the oscillograph to have returned to its position of rest when the echo is received. Under these conditions, the curves obtained, which are shown in the left-hand part of the photograph (Fig. 1), do not enable the echoes to be sharply distinguished. To obviate this grave disadvantage, arrangements are made for three emissions only out of fifty-two to be recorded, merely so as to verify that nothing has gone out of adjustment and that the emission curve remains well in coincidence with the zero line.

The photograph herewith shows, in succession from right to left, the parallel curves recorded when no sound is produced, the depth curves showing the echoes but not the emissions, and finally the check curves showing the emissions.

In the sounding vessel *Cordouan*, the apparatus is as shown in Figure 2.

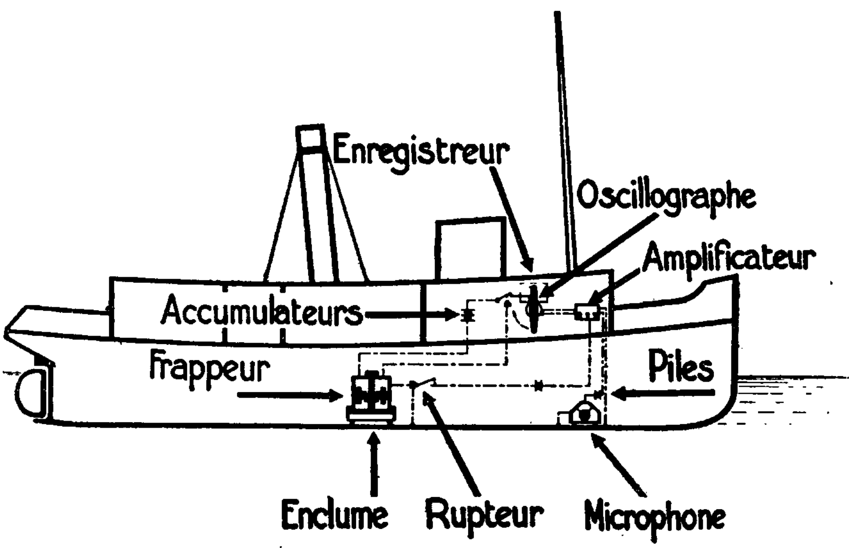


FIG. 2

Frappeur : hammer
Enclume : anvil
Rupteur : switch
Piles : dry cells

The *striking apparatus* (Fig. 3) comprises an anvil and a hammer.

The anvil *E*, a big disc of special steel, rests on a cast-iron ring *F*, fitted with a rubber joint underneath and solidly attached to a plate in the bottom of the sounding craft. The cavity thus formed between the anvil and the hull is filled with water, giving ample continuity in the medium between the anvil and the bottom without making it necessary to pierce the hull. The hammer *M* is forced vigorously downwards by a strong cylindrical spring *R*, but can be raised by a powerful electromagnet *A*. Thus, when the current is

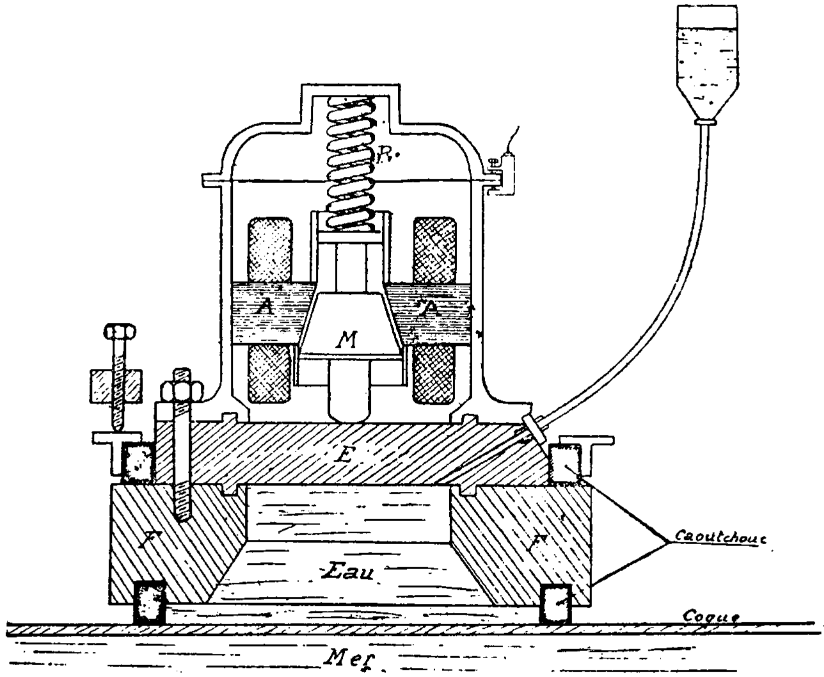


FIG. 3

broken, the hammer is violently projected on to the anvil, the energy absorbed by the shock being 0.3 kilogrammetre (2.2 ft. lb.). To avoid ill effects due to self-induction, the electric current is considerably reduced before rupture by interposing a resistance, the hammer however being still held up. The rotating arm of the recording apparatus which controls the working of the striker is provided with two switches for this purpose, one of which establishes the normal current, the other the reduced current.

To prevent the emissions (except for the check emissions) being recorded, the oscillograph circuit passes through a circuit breaker attached to the anvil. This circuit-breaker is very simple, being composed of a weight actuated by a small cylindrical spring, which automatically breaks the circuit at each hammer stroke.

The *receiving apparatus* consists of a listening tank filled with water, inside which is a microphone. The receiving circuit includes a T.M. 32 microphone with filter, especially designed for precision soundings. A potentiometer enables the sensitivity of reception to be adjusted ; the adjustment must be such that the noises of moderate intensity (parasitic noises) be not recorded, the amplifier nevertheless remaining sensitive to the violent noises, the echo of the hammer-blow being one of these latter. It is however necessary to avoid over-polarising the valve, as this might cause a slight lag in the recording of the echo.

The *recording apparatus* constitutes the chief difficulty in precision sounding by sound. In fact, as has been shown at the beginning of the present note, it must be possible to record times of the order of 1/3000 of a second sufficiently sharply. It is consequently necessary that the rotating arm which carries the stylus pen should travel sufficiently fast and yet that the inscription should be accurate.

The pen is 225 mm. (7.87 in.) from the axis, and the arm makes a revolution in 0.46 second, or about 2 revolutions per second. The linear velocity of the pen thus works out at 3.08 metres (10.105 ft.) per second. Under these conditions a depth of one metre, which corresponds to a return journey of two metres or, say, to a time of 1/750 of a second, appears on the smoked paper with a width of 4 millimetres (0.16 in.). It is thus perfectly possible to read a difference of depth of 0.25 metres (10 in.), which corresponds to a millimetre (0.04 in.) on the graph. For this difference to show the variation of the bottom, it is essential that the speed of the rotating arm should be constant to within about 1 %. The centrifugal governor used for this purpose (Fig. 4) is driven directly by the motor; it consists of a straight spring *R*, at the end of which is a small bob *M*. This spring lies along its own axis of rotation and makes an electric contact with a small-diameter stud *P*.

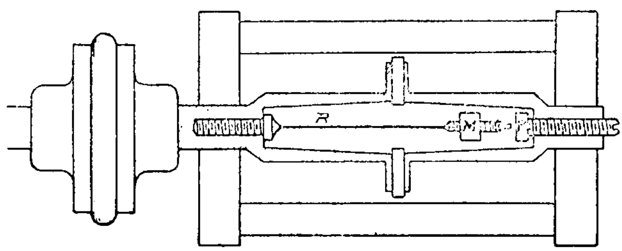


Fig. 4

As soon as the speed of rotation exceeds a determined value which is a characteristic of the spring and of the position of the bob, the spring bends abruptly, thus cutting the feed circuit of the motor. The control thus obtained is excellent.

The driving motor used is of the series type, of 1/5 h.p., and turns at 6,390 r.p.m. It drives the turning arm which carries the oscillograph through an endless-thread gear. The arm in turn drives the rolling mechanism for the paper strip through suitable gearing.

The whole of the recording apparatus forms a cubical coffer (Fig. 5) with sides of 33 centimetres (1 ft. 1 in.), weighing about 100 kilogrammes (2 cwt.).

Analysis of the graphs (Fig. 6). The curve *AB*, recorded in the course of a sounding, consists first of a sector of a circle *AC*, followed by the elbow *C* which indicates the echo, and then a damped sine-curve. The whole series of points *C* in a set of curves gives a nearly rigorous representation of the bottom. The curve cuts the zero line at a point *M*, and the length along the curve *MC* is a measure of the time taken by the sound to go from the anvil to the microphone after reflection at the bottom, and so of the depth of water under the keel. To obtain a true sounding, the height of the tide at the moment of sounding must be taken into account, also the draft of the sounding vessel and the obliquity of the path followed by the sound.

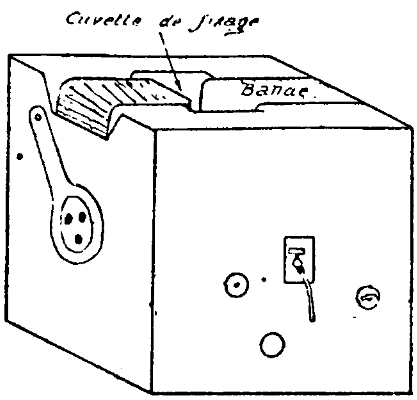


FIG. 5

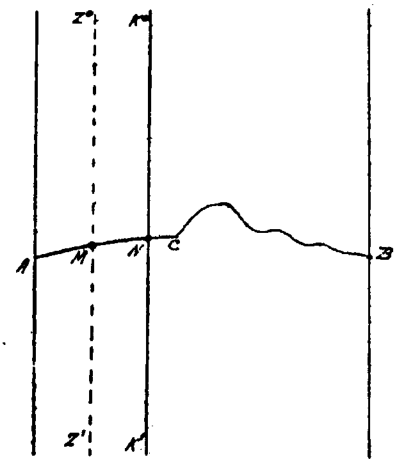


FIG. 6

The first correction is made by drawing, on the graph, after the sounding work is done, the straight line K^0K^1 at a distance from the zero line corresponding to the height of the tide. The other two corrections are automatically applied with the aid of diagrams drawn up under the following conditions (Fig. 7). If the striker F and the microphone M are separated by a distance $MF = 2a$, the sound follows the track $FAM = 2x$, which, for a draft e of the boat, corresponds to a depth of water y, equal to

$$y = e + \sqrt{x^2 - a^2}.$$

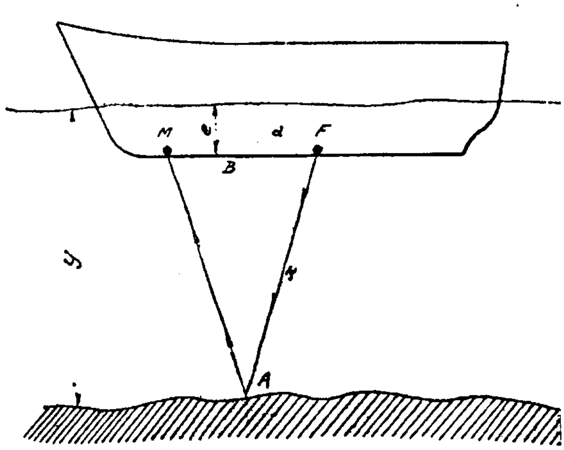


FIG. 7

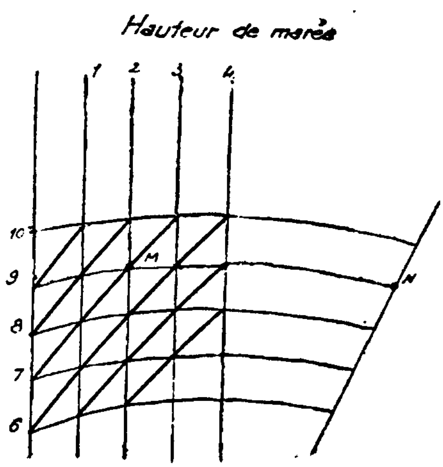


FIG. 8

For a determined value of e, let us draw on tracing paper, on the scale of the graph for the abscissae and on any scale for the ordinates, the usable part of the hyperbola thus determined (Fig. 8).

Putting the point C on this hyperbola, the Y-axis of which must coincide with the zero line of the graph, we can immediately read the true depth when the height of the tide is zero. To take the height of the tide into account, the diagram must be completed in such a way as to obtain the deduction for height of tide graphically. This result is very simply attained by drawing the curves of equal depth. If, for example, the point N on a depth curve corresponds to a depth of water of 9 metres and the height of tide is 2 metres, the point M will be found on the equal-depth curve of 7 metres and the reading will be taken off immediately.

These very simple arrangements enable a rapid and precise analysis to be made of the curves recorded. It is thus sufficient for a sounding boat to have three or four diagrams corresponding to different drafts of the ship, for her to carry out all the work in a minimum of time.

Here are a few examples of noteworthy records.

FIG. 9. — It will be seen that, while the echoes are perfectly recorded both on the right and the left-hand sides of the photograph, they are not in the least so in the centre part, where the sounder was crossing the wake of a ship. In this case the sonic waves are absorbed by the air bubbles churned up in the water by the propellers.

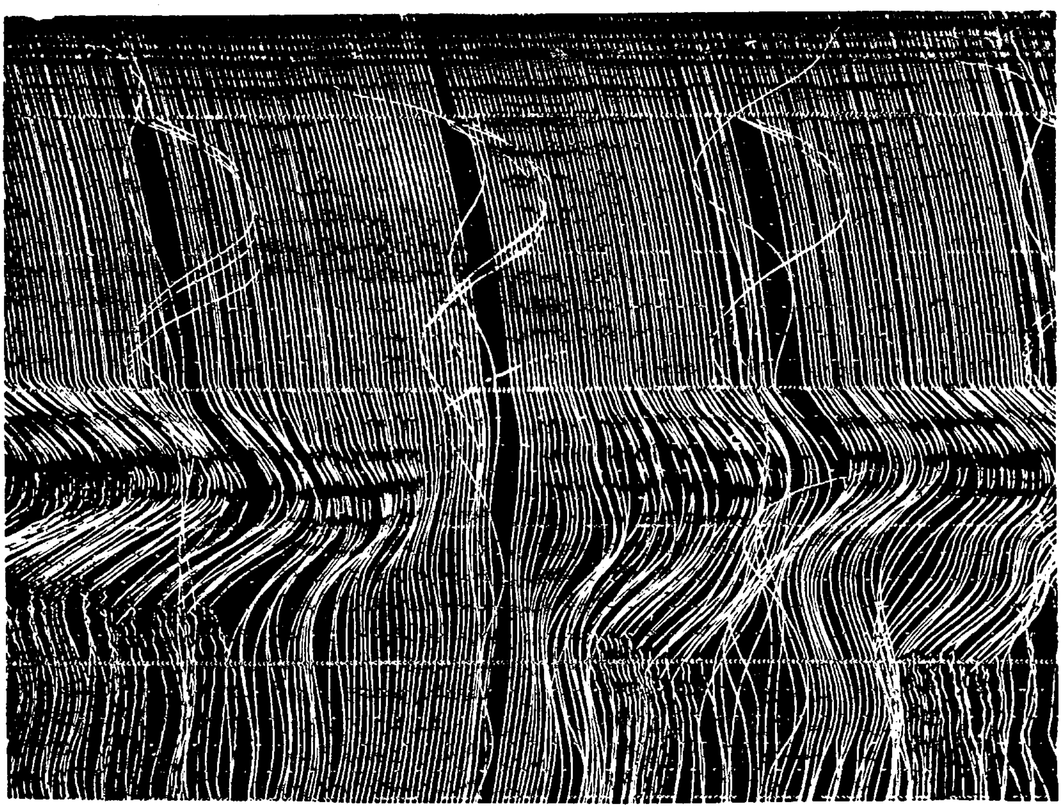


FIG. 9

FIG. 10. — Check soundings at the entrance to St. Nazaire have shown a shoal on the western verge of the Passe des Charpentiers. This shoal had hitherto been missed by the soundings made by the local authorities.

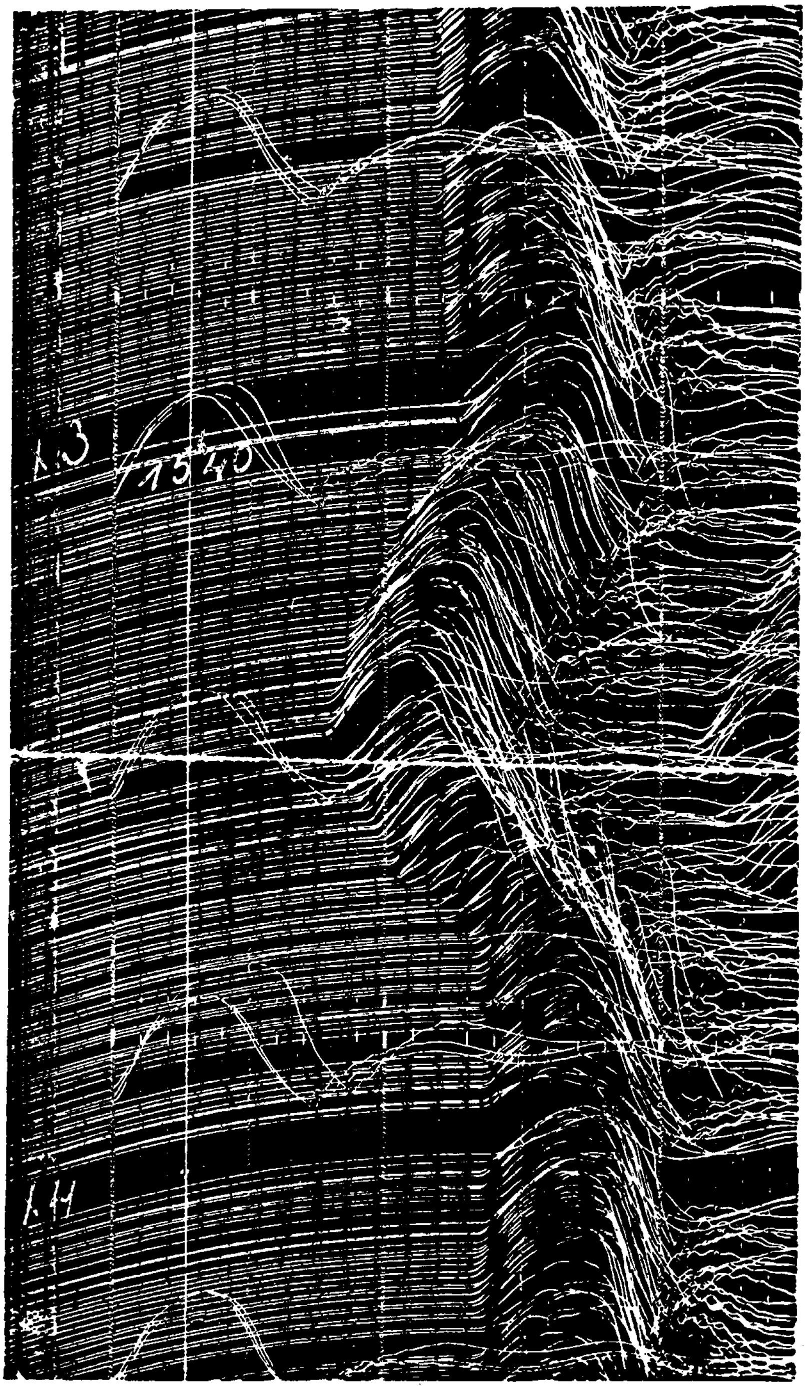


FIG. 10

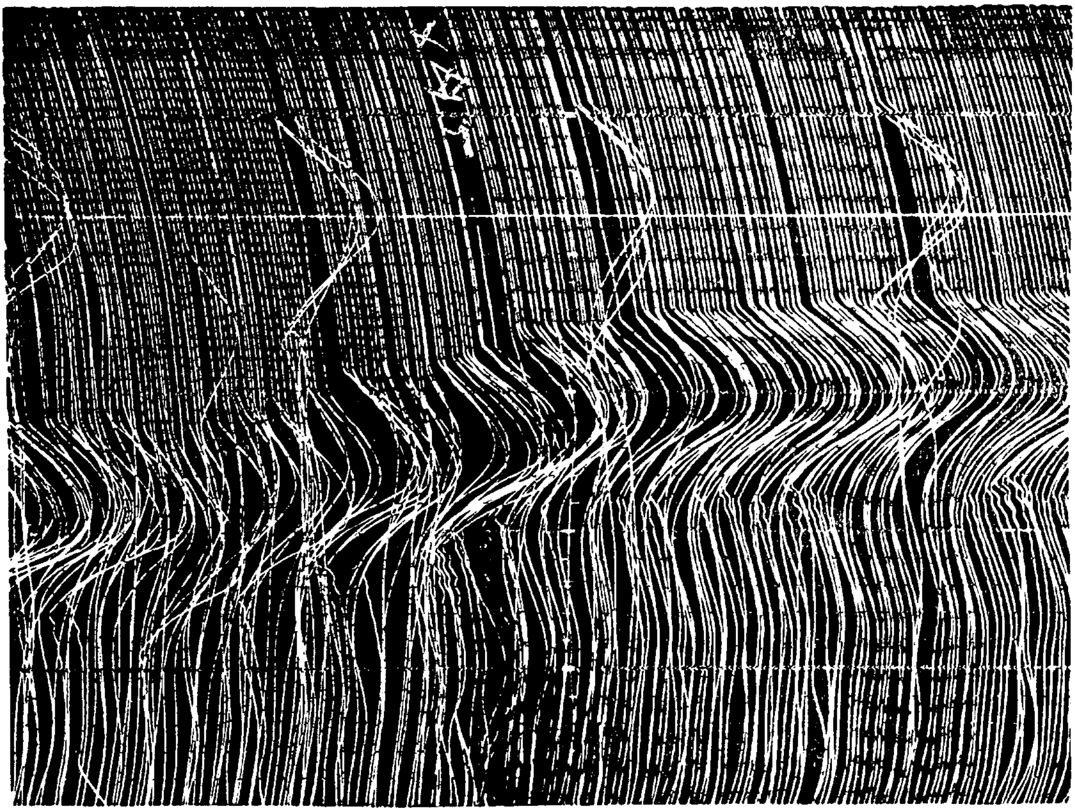


FIG. 11

FIG. 11. — Influence of the nature of the bottom. Sonic sounding enables one to detect the nature of the bottom with fair accuracy. The right-hand part of the graph shows well parallel curves with a very sharp echo elbow. Here we have a hard bottom. In the left-hand part, on the contrary, the echo elbows are more open. Many emissions, too, have not produced echoes, the sound being completely deadened. This is a case of a soft bottom. By systematically studying the opening of the echo elbows and the proportion of "duds" it is possible to obtain a good idea of the nature of the bottom.