ULTRA-SONIC SOUNDING MACHINE

LANGEVIN-CHILOWSKY, method

Fitted with the LANGEVIN-FLORISSON

OPTICAL ANALYSER

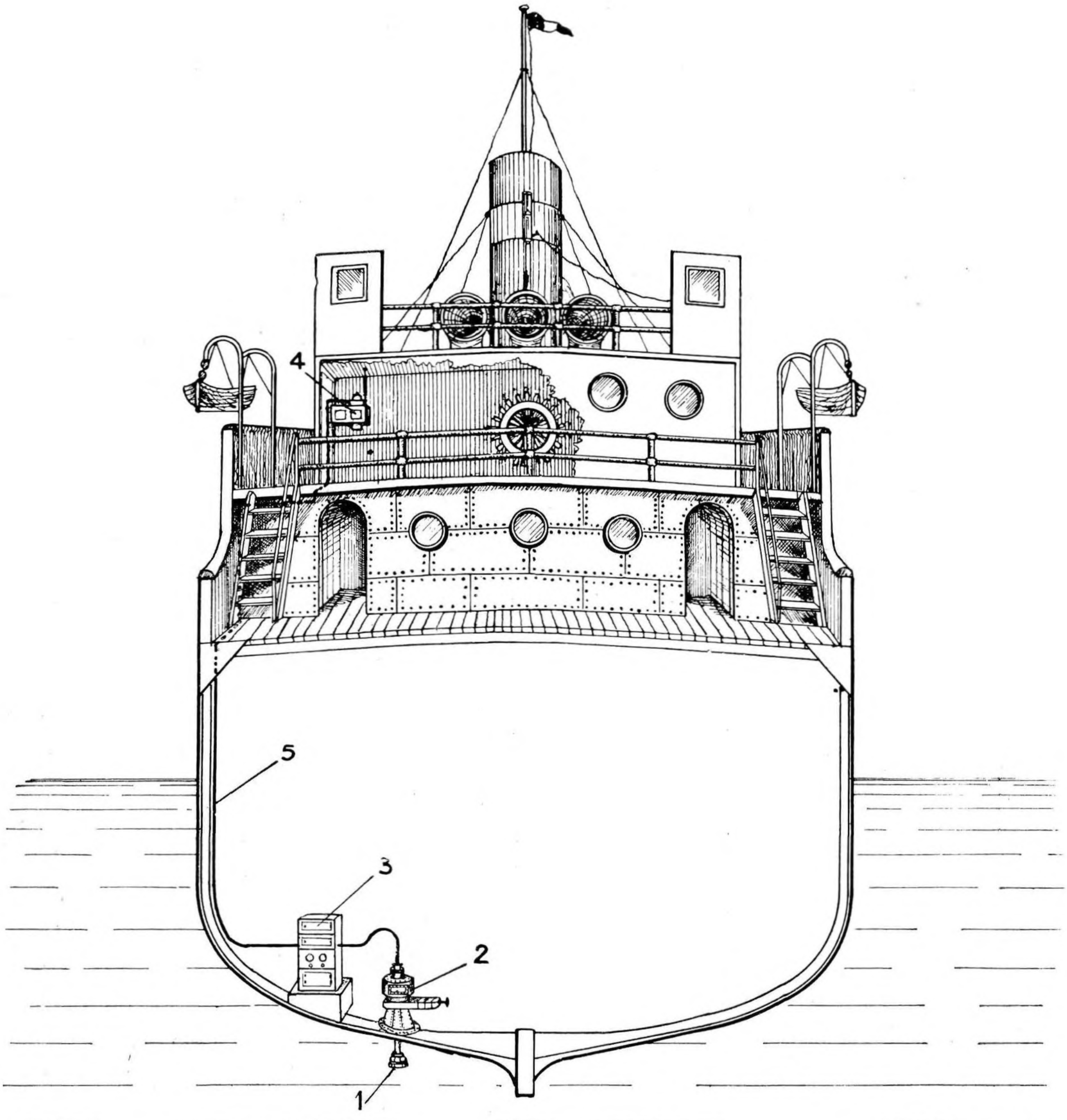


Fig. 1. — Installation of the *Langevin-Chilowsky* ultra-sonic SOUNDING MACHINE

1 — Ultra-sonic Projector for soundıng
2 — Hull Apparatus
3 — Transmitting receiving group
4 — Optical Analyser
5 — Electric Circuit

NOTE. — The dimensions of the ultra-sonic apparatus have been enlarged with reference to he whol

ULTRA-SONIC(*) SOUNDING MACHINE
(LANGEVIN-FLORISSON System)

The Ultra-Sonic Sounding Machine (**), LANGEVIN-FLORRISON System, makes automatic soundings practicable in a ship under way.

It consists of the following principle elements which are shown in Fig. 1 :

I. An ULTRA-SONIC SOUNDING PROJECTOR supported by a special *Hull Device.*

II. An ELECTRICAL TRANSMITTING AND RECEIVING GROUP consisting. of the grouping of :

A) A special *Transmitter,* called a single wave train transmitter and

B) A *Receiving Amplifier,* specially fitted for Ultra Sonic Soundings.

III. An OPTICAL ANALYSER, an automatic device which governs the whole sounding machine, and which measures the "echo interval", *i. e.* indicates directly and continuously the depth under the ship.

(*) Also "Super Sonic".

(**) The principles of the use of Ultra-sonic Waves for Echo Sounding are not reproduced, but they are given in detail in Special Publication N° 3, (October, 1924) of the International Hydrographic Bureau (pages 11 and following), which should be referred to.

I. — ULTRA-SONIC SOUNDING PROJECTOR and HULL DEVICE.

This ULTRA-SONIC PROJECTOR (Figs. 2 & 3) appears as an iron box 6, the central part of the bottom of this being the outer vibrating armature of the piezo-electrical condenser. It is this surface which transmits the ultra-sonic vibrations to the water. The box contains a piezo-electrical plate of quartz 7 placed between the outer steel plate 8 and the inner counterpoise plate 9 ; these two plates form the armature of the condenser. A highly insulated wire 10 crosses the neck of the Projector and connects the inner plate to the electrical transmitter with an earth return.

The Projector is extremely strong and requires no electrical maintenance. It is delivered ready for use, and must not be taken apart.

The HULL DEVICE on which the Projector (Fig. 1) is mounted, is shown on a larger scale in fig. 4.

The tube 11 carries at its lower end the Projector 12. It slides vertically in the stuffing-box 13 and through the truncated conical ring 14.

The supporting stays, which must resist the strains due to the relative motion of ship and water are carried by a ground-work comprising :

a) A casing 15, strongly riveted to the strakes and timbers.

b) A bronze sluice valve 16 of 350 millimetres (13.8 in.) opening.

c) An air-lock chamber 17, for inspection and stripping purposes. It is suitably strengthened and joined to the frames of the ship in order to withstand the strains of a ship under way.

A hand or electrical device which raises or lowers the tube, is fitted on the frame of the chamber (not shown in the figure), as well as a brake 18 which retains the tube in the chosen position.

This device as described allows the Projector to protrude several decimeters outside the hull, but in most cases the normal working of the Sounding Machine is assured only by opening the sluice valve, as the Projector is completely lifted up into the chamber.

The Projector is only lowered outside the hull in case of heavy

Fig. 2

ULTRA-SONIC QUARTZ
PROJECTOR

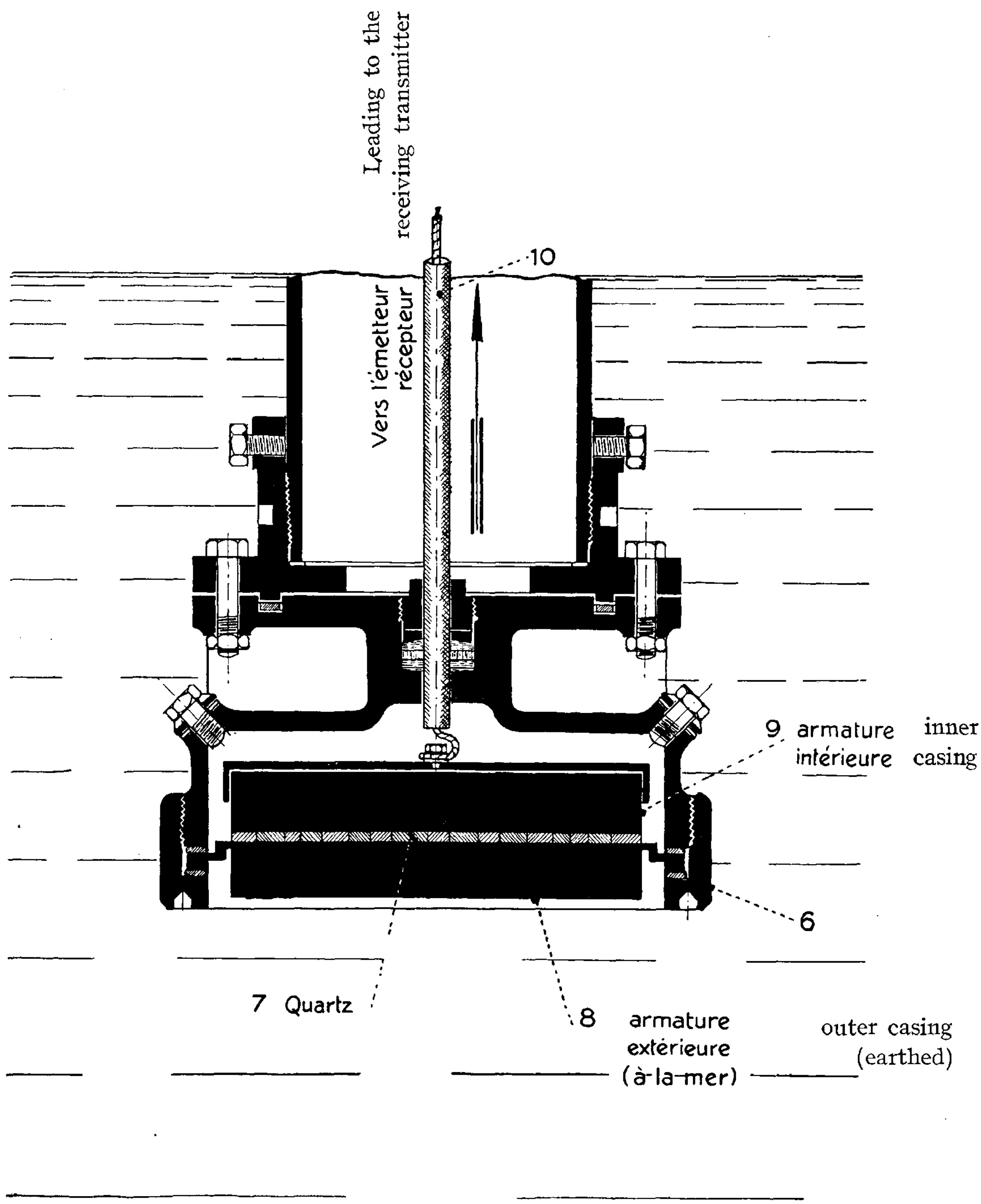


Fig. 3

ULTRA SONIC PROJECTOR

Fitted for sounding

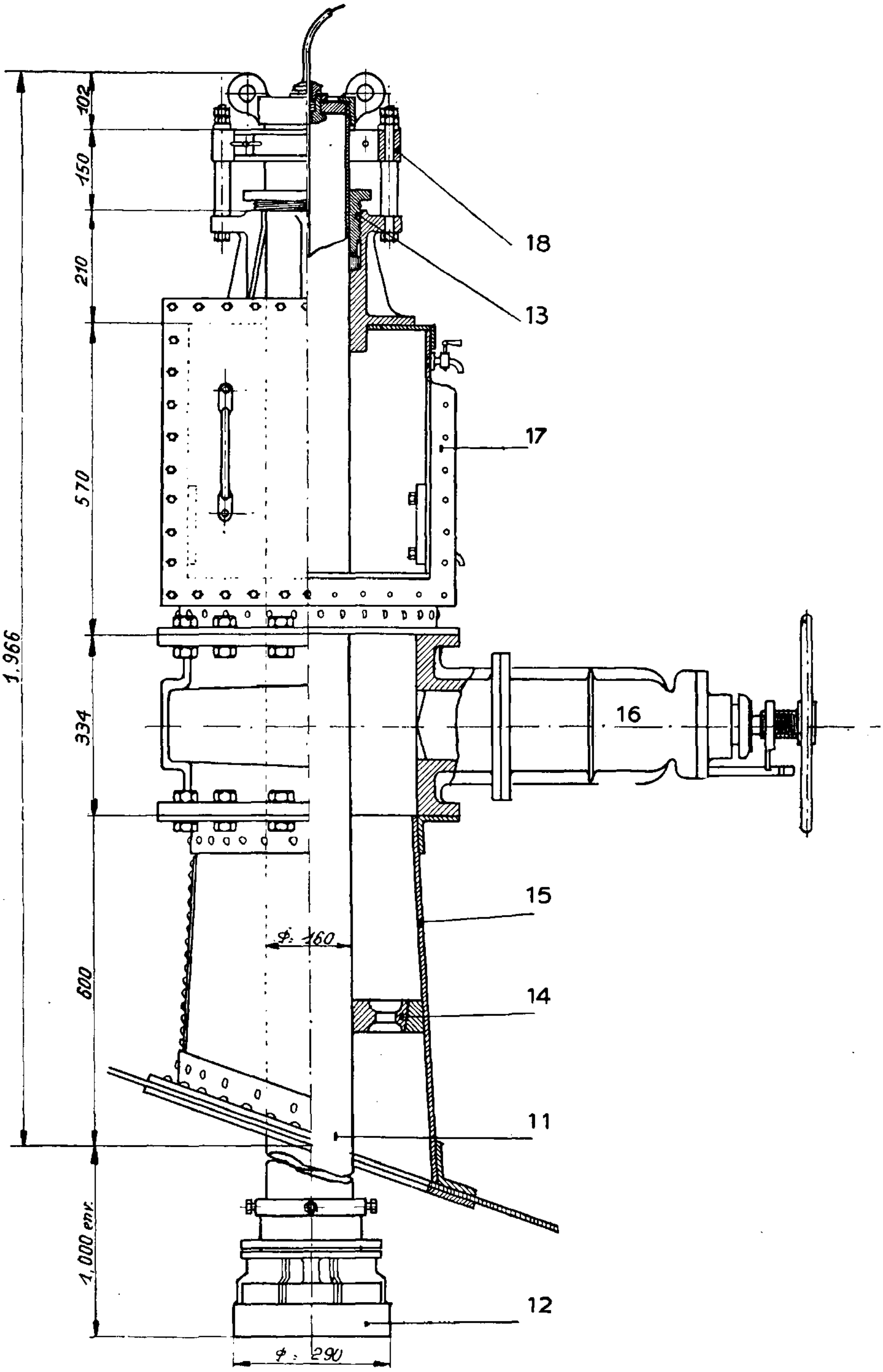


Fig. 4. — *Elevation*

HULL APPARATUS

ULTRA-SONIC SOUNDING MACHINE

LANGEVIN-CHILOWSKY Method

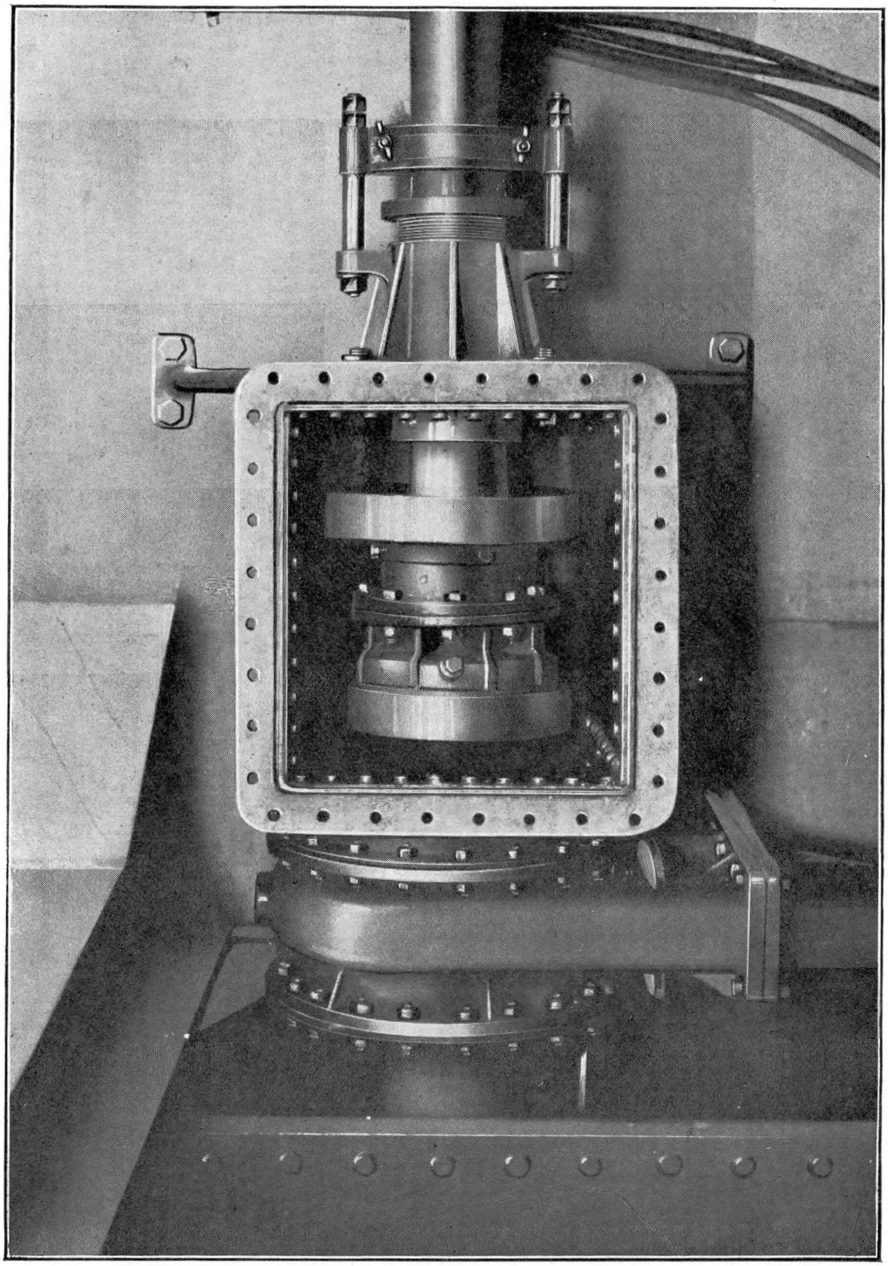


Fig. 5

HULL APPARATUS

Installation as fitted in the
"AMMIRAGLIO MAGNAGHI"
Hydrographic Vessel of 2500 tons Royal Italian Navy

weather, when waves break on the forecastle and alongside the ship, making a great quantity of air bubbles which may gather in the chamber and make a screen in the path of the ultra-sonic beam.

Figure 5 gives a view of the installation as fitted on board the "*Ammiraglio Magnaghi*", a surveying vessel of 2.500 tons, of the Royal Italian Navy, and Captain TONTA who was in command, reports that it gave "magnificent results."

II. — ELECTRICAL TRANSMITTING AND RECEIVING GROUP.

This comprises :

a) A TRANSMITTER, CALLED A SINGLE WAVE TRAIN TRANSMITTER.

The Projector transforms the electrical oscillations which are transmitted to it into ultra-sonic oscillations, preserving their shape.

As the Projector is used for transmitting and receiving the echo, it is essential that the transmission of the signal be completed when the echo, as produced by the bottom of the sea, returns to the projector. When soundings are taken in shallow water, the time interval t, which separates the signal from its echo, is very short owing to the high value of the velocity of sound through water (i. e. $t = 1/100$ of a second at a depth of 7.5 metres (24.4 ft).

As soundings in very shallow waters are of extreme interest to navigation, it is necessary to use a very short ultra-sonic signal.

For this reason an emission consisting of a single train of damped ultra-sonic waves (fig. 6) is used. The duration of such a wave train (about 1/1000 of a second) is very short in comparison with duration t corresponding to the smallest depth to be measured. This is produced electrically by means of an exciting pulsation Spark Transmitter which gives a single wave train for every signal.

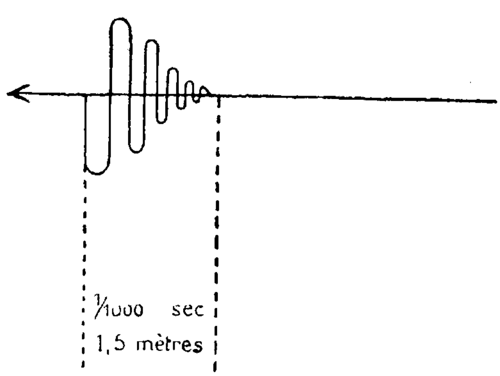


Fig. 6.

This transmitter is fed by a 6 volt battery and its working is entirely automatic and governed by the Optical Analyser.

b) RECEIVING AMPLIFIER..

This is an extremely simple wireless valve Amplifier specially constructed for soundings. It remains permanently connected to the oscillating circuit of the Transmitter, which comprises the Projector. It thus detects first the signal and then its echo from the bottom ; this is registered by the Oscillograph of the Optical Analyser, which is also permanently connected to the outer terminals of this Amplifier.

The electrical Transmitter and Receiver can be placed together in a single box, as shown in fig. 7, or separately.

The Transmitting Receiving Group is placed in the bottom of the ship in the vicinity of the Projector (3 - fig. 1).

III. — OPTICAL ANALYSER. (Figs. 8 - 9 - 10).

This apparatus is, so to speak, the brain of the Ultra-Sonic Sounding Machine. It automatically governs the various operations of the Sounding Machine, and shows the depth on a divided scale placed before the eye of the observer (general view, fig. 8).

Its various functions are as follows :

1) Optical disclosure of ultra-sonic signals and echoes thereof.

2) Measurement of the echo-interval, that is to say, of the depth and exposure of the latter, on a divided scale.

3) Starting of the ultra-sonic emissions equally spaced in time (one emission per second).

4) Centralisation and automatic working of the various operations of the Ultra-sonic Machine. Arrangement of safety devices.

The principle of each operation is as follows : (fig. 11).

A vertical ground glass plate 19 is divided according to the depth with a definite scale ; along this plate a luminous point, to which a uniformly straight motion is given, runs vertically from top to bottom, and taking the fact into account that the ultra-sonic wave train runs twice the distance from the Projector to sea bottom, its velocity equals *half the velocity of sound through water* at the scale of the divisions.

The chronographic device which produces the uniform motion of the luminous point starts the ultra-sonic emission when this point passes the zero of graduation, or rather, passes the number on the scale which corresponds to the depth to which the Projector is immersed, which allows the correct reading of the depth as measured from the surface of the sea. This is indicated to the observer by the appearance of an indentation 20 in the luminous path.

As the echo returns, the luminous point undergoes another

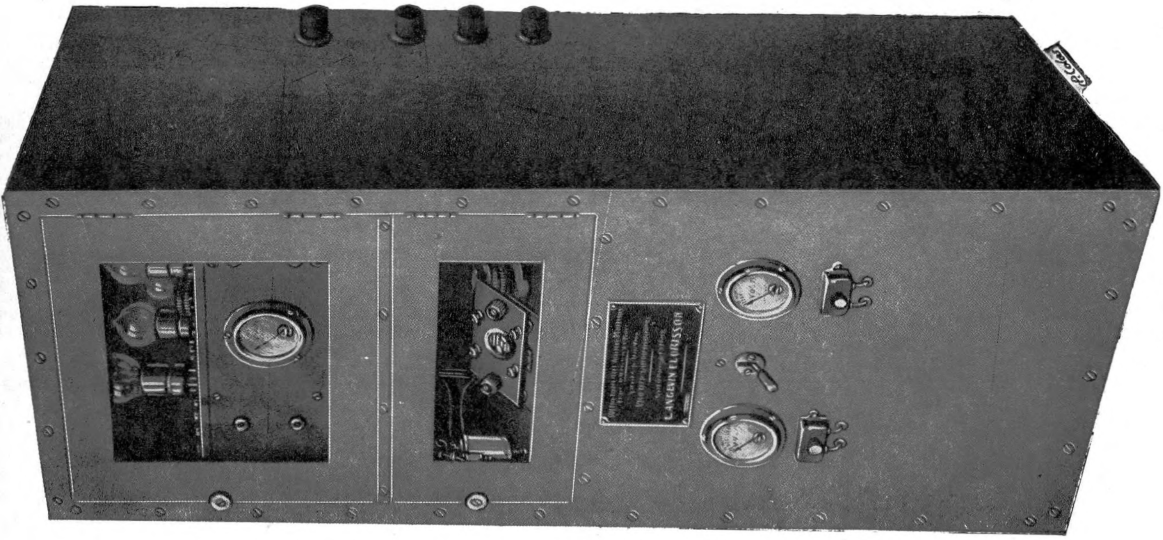


Fig. 7

TRANSMITTING AND RECEIVING GROUP

governed by

the LANGEVIN-FLORISSON

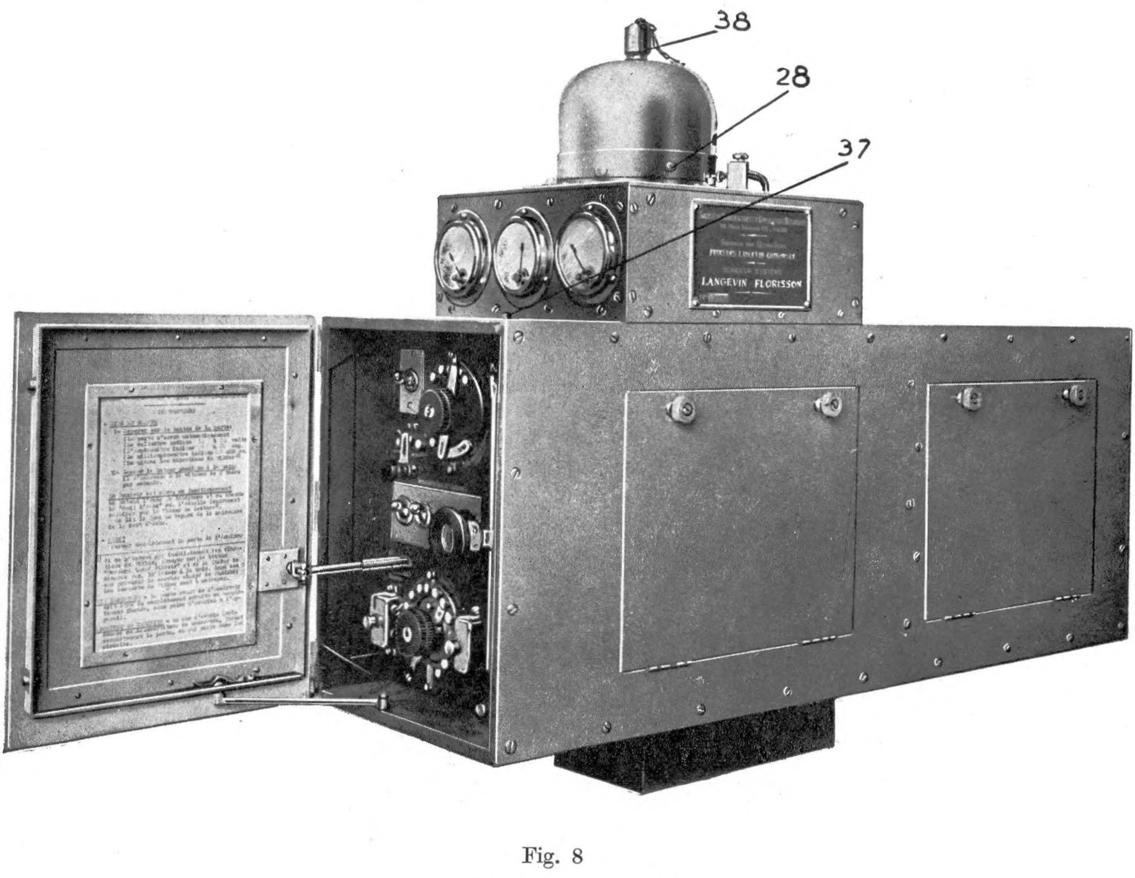


Fig. 8

OPTICAL ANALYSER

LANGEVIN-FLORISSON

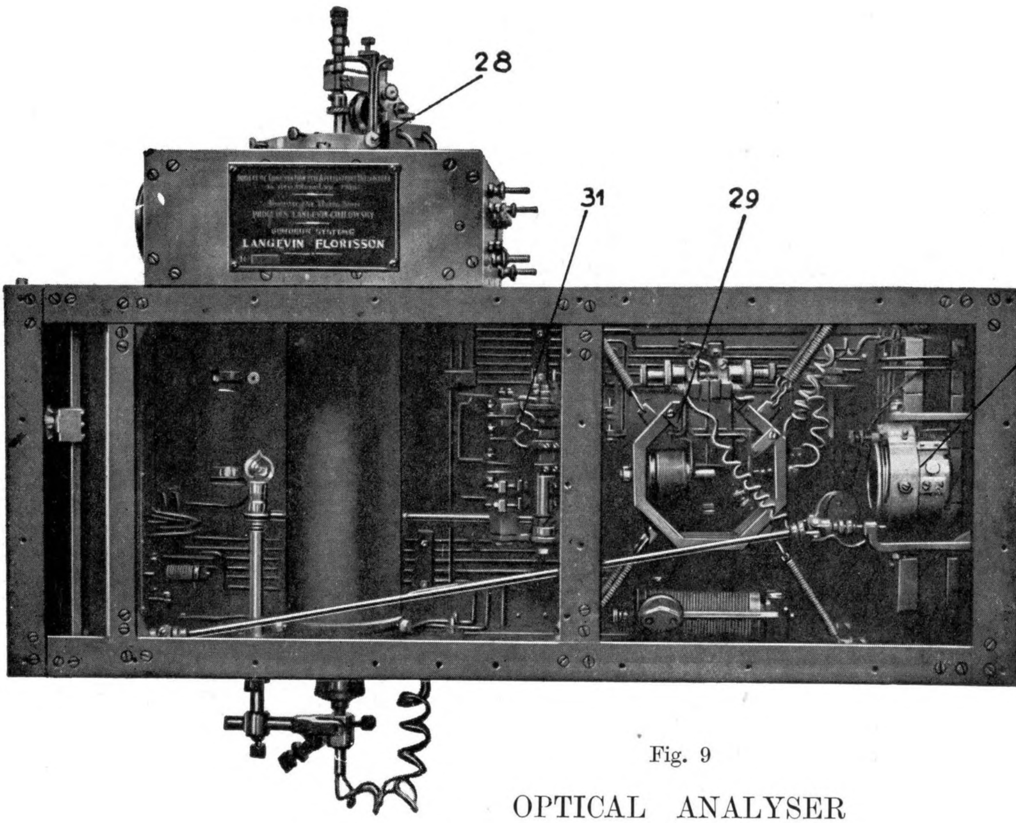


Fig. 9

OPTICAL ANALYSER

LANGEVIN-FLORISSON

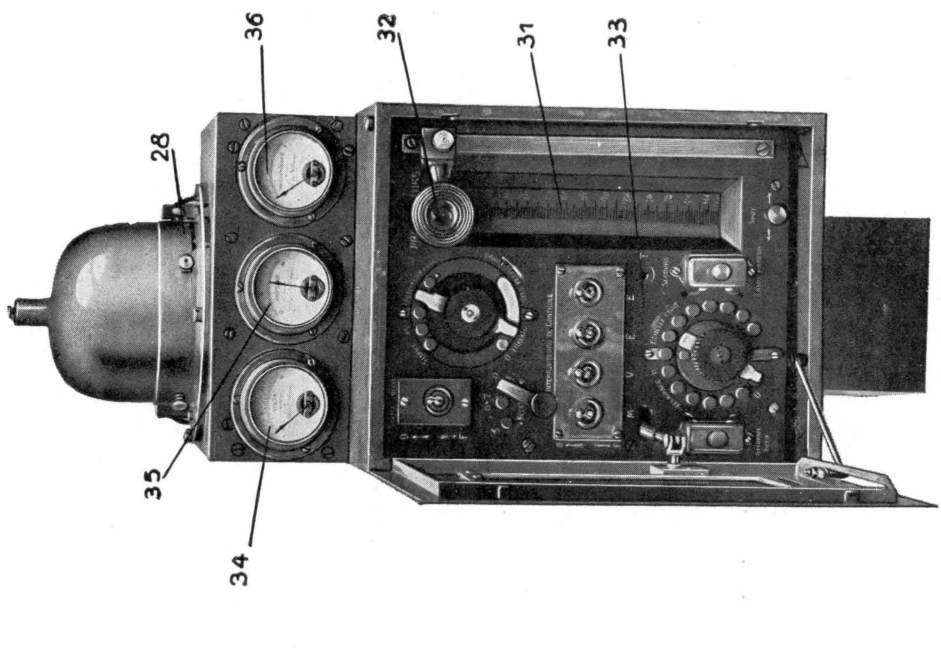
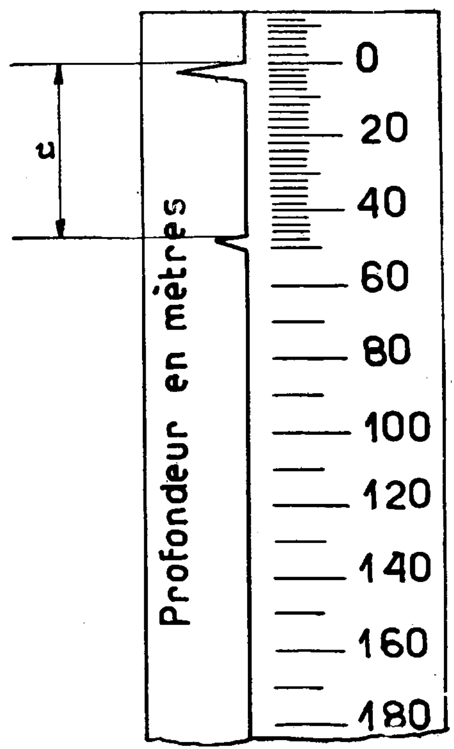


Fig. 10

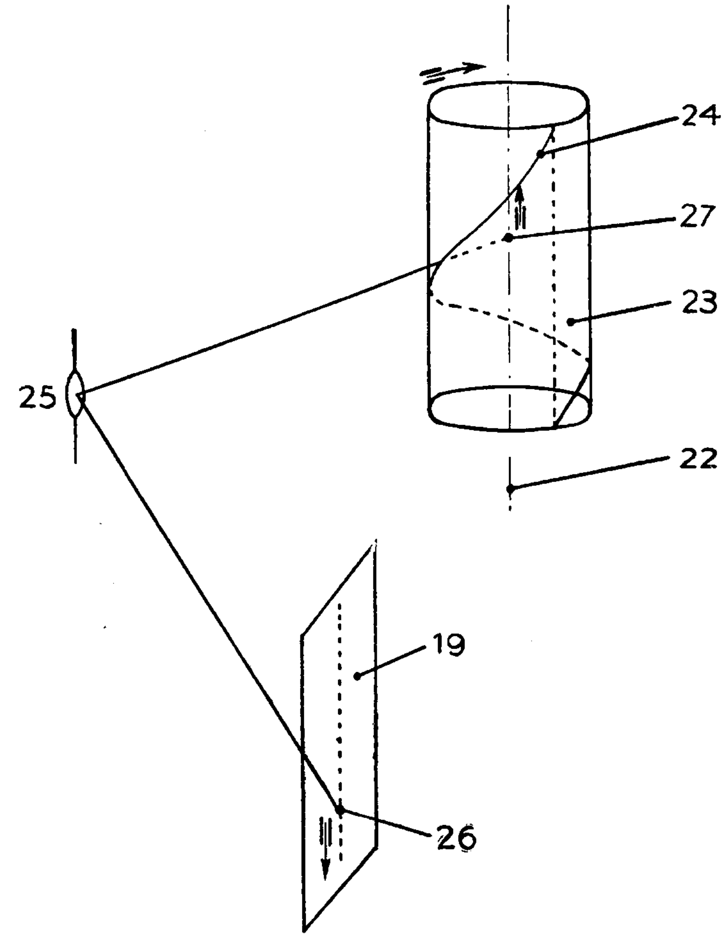
OPTICAL ANALYSER

LANGEVIN-FLORISSON



u
Profondeur en mètres
0
20
40
60
80
100
120
140
160
180

Fig. 11



24
27
23
22
25
19
26

Fig. 12

lateral displacement which shows a new indentation 21 on the scale. *The distance* d *separating the origin of the two indentations* 20 *and* 21 *represents the depth* which the observer can read directly opposite the origin of indentation 21.

The above described operation refers to a single sounding.

The Analyser automatically repeats this operation once per second, *therefore it permanently shows the actual depth of the sea beneath the ship.*

The constant speed of the luminous point is obtained by means of the arrangement shown diagrammatically in figure 12.

The rectilinear filament 22 of an electric lamp is placed along the axis of the opaque cylinder 23, in the wall of which is pierced an helicoidal slit 24, which makes one complete turn round the cylinder. A concave mirror 25 throws a luminous point 26 on the transparent scale 19, *i. e* the image of the point of the filament 27 seen from the summit of mirror 25 through the slit 24.

Cylinder 23 is moved round its axis with a uniform motion by means. of a special small synchronous electric motor, fed by continuous current which is cut off at exact intervals by means of a special tuning fork, the "Guéritot Ticker". This motor, once in step, maintains an absolutely constant speed. No error can occur, because either the motor turns at this exact speed or else it is stopped. Consequently a rectilinear displacement of the luminous point at constant speed is produced (chronographic motion of the apparatus).

The axle of the governed electric motor drives, in addition, a special interrupter, which starts the ultra-sonic emission at each of the successive passages of the luminous point over the zero of the graduation, as mentioned above.

Mirror 25, which produces the luminous point, is part of an extremely sensitive oscillograph, suitably damped, which is permanently connected to the Receiving Amplifier. When the emission and the echo are produced, the latter is subjected to a slight displacement about an axis parallel to the axis of the cylinder 23. This shows the indentations 20 and 21, indicated above on the path of the luminous point on the scale 19 (fig. 11).

An optical manifestation of the signal and of the echo, and their exposure on the path of the luminous point, that is to say, the direct measure of the depth, are thus obtained.

The various parts are mounted as indicated in fig. 9, which shows the Optical Analyser from its right hand side with the front panel removed.

The Phonic Motor 28 governed by the "Guéritot Ticker" 29, the Oscillograph in its adjustable mounting 30, the Automatic Switch 31, and the various parts for adjusting and controlling the Analyser will be seen in the figure.

Figure 10 shows the front of the Analyser. The reading scale 31, with movable eye-piece 32, should be noted. On the panel 33, on the left hand side of the scale, are grouped all the safety devices for governing the Ultra-Sonic Machine. The Analyser is fed by a 12 volt battery, automatically charged, the controlling apparatus of which is shown in 34 and 35.

A milliammeter, 36, for controlling the amplification is shown in fig. 10.

The Sounding Machine is started and stopped by the multiple switch 31, operated by the opening or shutting of the front door.

A six-wire cable connects the Analyser to the group composed of the electric cabinet and the Projector (See 5, fig. 1).

The Analyser, from which the whole Sounding Machine is operated (*one non-specialist observer only is required*), is usually fitted near the bridge ; it may, for instance, be mounted on an anti-vibration frame in the navigating or chart room. *Thus the officer of the watch is personally able to sound or to check at a glance the information given by the observer.*

THE WORKING OF THE SOUNDING MACHINE.

The handling of the ultra-sonic Machine is extremely simple. It requires the following operations :

a) STARTING.

The apparatus being stopped ; to obtain a sounding it is sufficient to :

1. *Press a button* 37 (fig. 8) :

The door of the Analyser will automatically open and with this action the Multiple Commutator sets in motion the various parts of the Sounding Machine (the Analyser, and the electrical apparatus below).

2. *Start the Phonic Motor by hand* by means of the milled wheel 38-fig. 8). It immediately comes into step at a constant speed. The Sounding Machine is thus started and gives one sounding per second. In order to know the depth, it suffices to :

3. *Read the depth indicated on the scale.*

The apparatus then gives continuous soundings.

b) STOPPING.

When it is desired to stop the Sounding Machine only one operation is necessary:

Shut the door of the Analyser.

This operates the automatic switch which stops the different parts of the Sounding Machine. All the circuits are broken and set to the safety position, and the 12 volt battery which feeds the Analyser is charged by the mains (as indicated by the testing lamp).

MAINTENANCE.

All the parts of the Ultra-sonic machine are very strongly built and well protected from corrosion. They are specially fitted for the hard service to which navigating apparatus is subjected.

The general maintenance of the machine is limited to the replacement of the batteries of the electrical cabinet when the latter are discharged, and to a general supervision of the apparatus such as is required by the usual wireless apparatus on board.

PERSONNEL.

The general overseeing of the Sounding Machine may be confided to the radio-telegraphic personnel on board.

The Machine may be operated by any person who has read the directions given above, as shown on the door of the Analyser. No knowledge of its principle or construction is necessary.

INSTALLATION.

When the ship is in dry dock, the installation of the ultra-sonic Machine is as follows:

First fit the Hull Apparatus which carries the Projector, then lay a six-wire cable between the bridge and the room for the electric cabinet, and lastly, fix, without special fitting, the electrical group in the hold and the Analyser in the place chosen near the bridge.

Plate I shows the diagram of the electrical connections and wires.

Plate II gives, in millimetres, the external dimensions as well as the weight of the various portions of the apparatus, and of the storage batteries

The Projector weighs about 30 kilogrammes (66 lbs) (fig. 2).

USE. — LIMITS OF SOUNDING. — ACCURACY OF MEASUREMENTS.

The ultra-sonic Machine, as shown above, gives the vertical measurement of the depth of water under the ship.

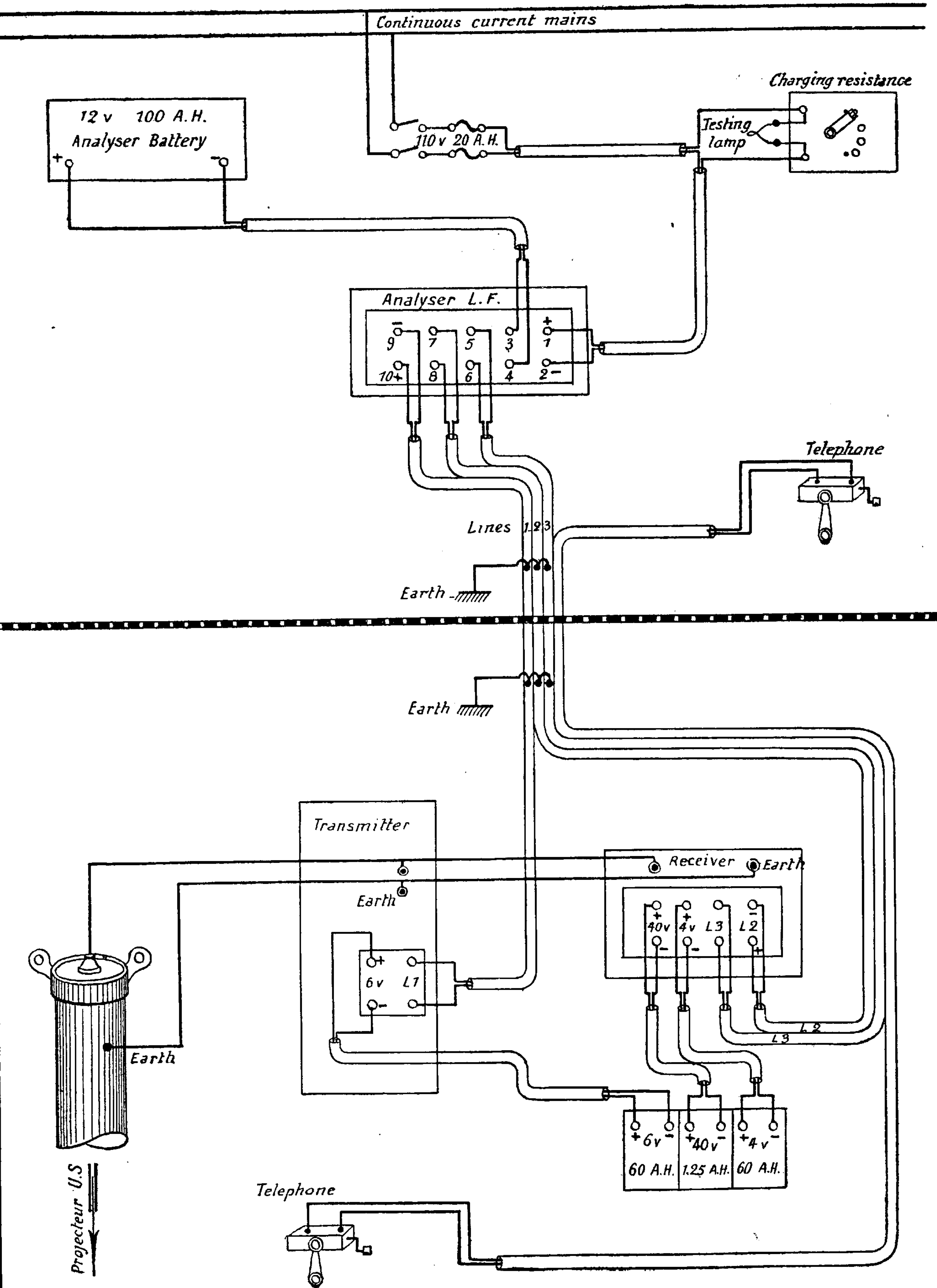
The soundings are made between depths of about 4 metres (13 feet) up to 360 metres (197 fms.) under the projector, which is the highest reading on the scale of the Analyser.

This limit of 360 metres has been determined owing to the construction of the Analyser. It is much greater than the depths which are now ordinarily measured in navigation. (*)

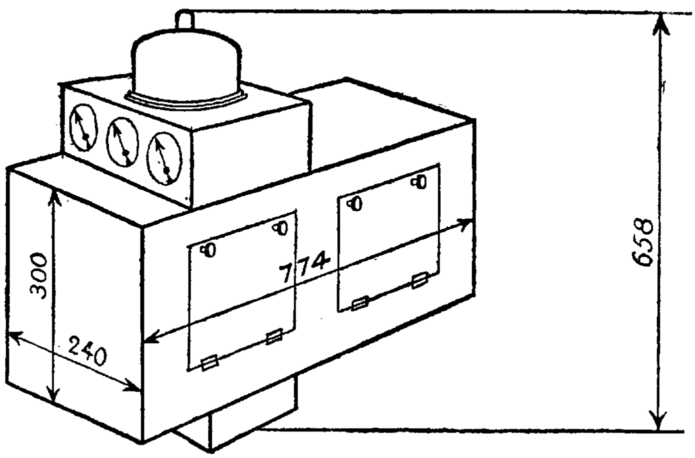
This means that it is possible to obtain echoes in depths exceeding 360 metres, to follow the contours of the bottom, or to pick it up in depths exceeding the limit of the scale. A telephonic binaural allows this observation to be made by acoustic method.

The ultra-sonic Machine gives the depth *without any correction being required,* and with a *relative* error of less than 1 %, the *absolute* error of reading which can occur does not exceed 1 metre (3 ft 3 ins).

(*) The Ultra-sonic Waves allow soundings to be taken at the greatest depths. A special device is being studied in the laboratories of the S C A M for Surveying of great depths, the laying of cables, *etc.,* and also for the use, in the future, of charts showing great depths.

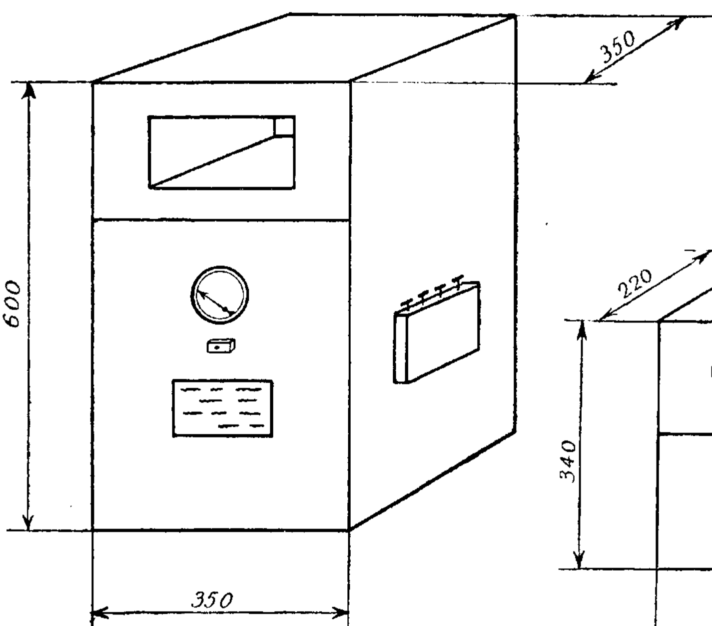

Continuous current mains
Charging resistance
12 v 100 A.H.
Analyser Battery
110 v 20 A.H.
Testing lamp
Analyser L.F.
Telephone
Lines 1 2 3
Earth
Earth
Transmitter
Receiver
Earth
Earth
6 v
L1
40 v
4 v
L3
L2
Earth
L 2
L 3
6 v
60 A.H.
40 v
1.25 A.H.
4 v
60 A.H.
Telephone
Projecteur U.S

Analyser (90 Kilogs)



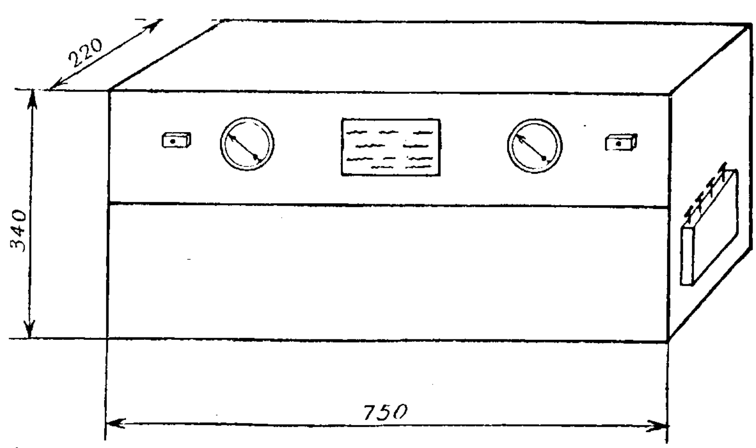
ACCUMULATORS 12 volts – 100 A.H.
700 x 250 x 250 mm. — 70 Kilogs

Transmitten (70 Kilogs)



ACCUMULATORS 6 volts – 60 A.H.
225 x 199 x 228 mm — 17 Kilogs

Receiver (25 Kilogs)



ACCUMULATORS

4 Volts – 60 A.H.
250 x 180 x 230 mm.
13 Kilogs

40 Volts – 1.25 A.H.
250 x 175 x 195 mm.
8 Kilogs

The maximum relative error of 1 % is due to the small difference in the velocity of sound from its mean value of 1.500 metres (4920 ft) per second, which depends on the change of temperature and salinity of the sea, an error practically useless to correct by means of tables.

The accuracy of the ultra-sonic Machine is therefore far greater than that of any hydrostatic Sounding Machine used in navigation up to the present time. It is even superior to that of the deep-sea sounding piano-wire, as used in Hydrography.

The operation of the ultra-sonic Machine does not depend on the speed of the ship.

The influence of average rolling on the ultra-sonic Sounder is nil, because of the large angle of spread which has been given to the ultra-sonic pencil as emitted by the Projector. In very heavy rolling of about 20 degrees the echoes may not return when the ship is heeling well over, but as one emission per second is produced and the period of rolling of a ship is several seconds, the sounding can always be taken by ultra-sonic emissions when passing the vertical, and this suffices for navigation.

The *absolute inaudibility* of the ultra-sonic Sounder is of great value for passenger ships as well as for war vessels.

The Projector, considered as a receiver and as a mechanical oscillating system with very accurate resonance, tuned on ultra-sonic frequency, is not sensitive to any noise or sound. The functioning of the ultra-sonic Machine is therefore independent of noises and vibrations peculiar to a ship, and to all submarine sounds generally.

SPECIAL FEATURES OF THE ULTRA-SONIC MACHINE LANGEVIN-FLORISSON SYSTEM.

As submarine obstructions (hulls of ships, jetties, submarine cliffs, *etc.*) nearer to the sounding ship than the bottom, but situated outside of the ultra-sonic beam, *are not able to give any echoes*, there is no danger that the Sounding Machine will indicate erroneous depths, as is the case with every device using sonic or explosive waves which are spherically propagated.

Besides, the ultra-sonic beam, with an angle of several degrees, "feels" the bottom over a certain amount of surface, depending of course on the depth.

The apparatus, which has a *very accurate* Oscillograph, analyses (the word "Analyser" is derived from this term) the shape of the reflected ultra-sonic wave Train.

This shape, in fact, may be modified by the unevenness of the surface. For instance :

If the bottom be *flat* and *horizontal* : the shape and duration of the reflected wave train remain the same as that of the incoming wave train ; the echo indentation is then identical in *shape and in base length* to the transmitted indentation (this appearance is shown in diagram fig. 13).

If the bottom be a plane much inclined to the horizontal, the progressive reflection by the different levels on the bottom lengthen the reflected wave train, and the echo indentation itself is lengthened and rounded (fig. 14).

If the bottom offer a marked unevenness inside the "felt" surface, the echo indentation is irregular, and gives successive backward thrusts, corresponding to the principle levels of the bottom successively touched by the wave train. This is the case when passing above a submarine cliff or wreck (fig. 15 and 16).

In Hydrography the use of this apparatus increases enormously the output of the surveying vessel and, it may be said, gives accurate sections of the bottom while under way.

The extreme closeness of each sounding, at one second intervals, on every sounded course, does not allow any peculiarity of the submarine relief to escape, which is not the case on rocky bottoms with the wire-sounding apparatus heretofore employed.

The use of this appliance in making Submarine Charts renders the work more accurate, infinitely easier, more rapid and less expensive than previously. (*)

The ultra-sonic Sounding Machine allows sudden unevennesses of submarine bottoms to be searched for, and particularly the location of wrecks.

(*) The S C A M is studying the construction of a Recording Appliance which may be attached to the Analyser already constructed, which will inscribe the depth on a strip of paper at the same time as it is read on the scale. The use of this recording device will augment still more the output of the ultra-sonic Sounding Machine in Hydrography.

ULTRA-SONIC SOUNDING MACHINE

LANGEVIN-CHILOWSKY Method

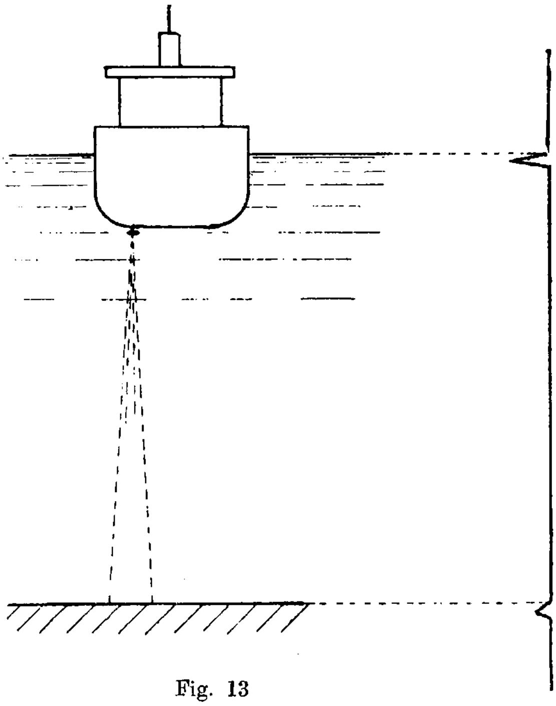


Fig. 13

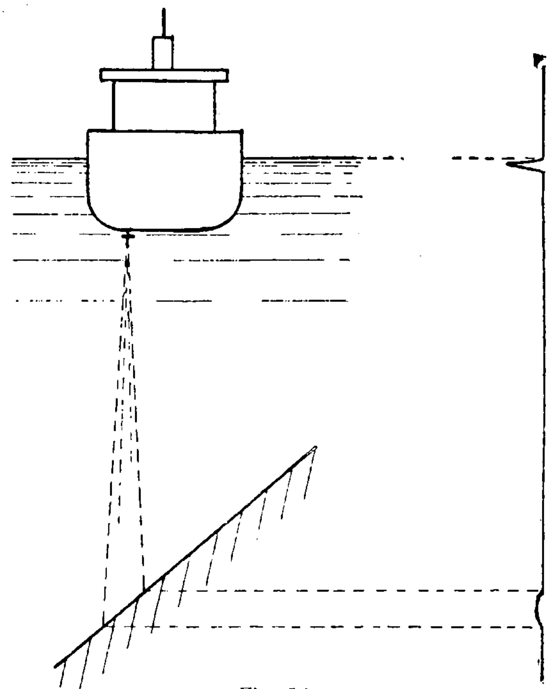


Fig. 14

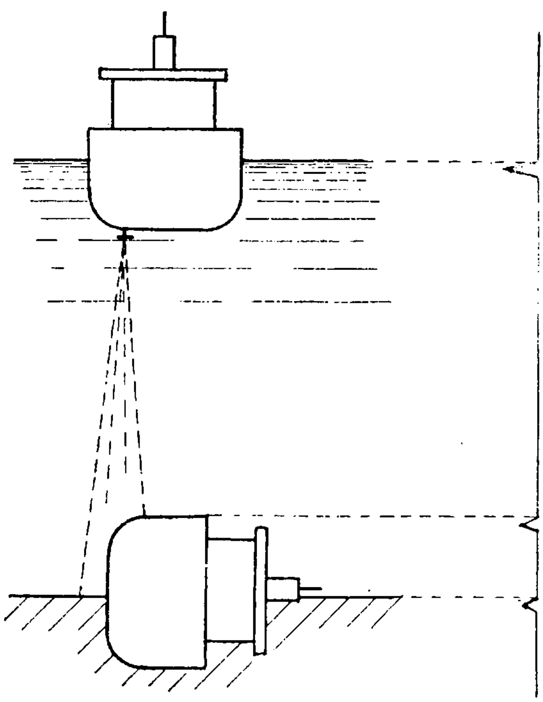


Fig. 15

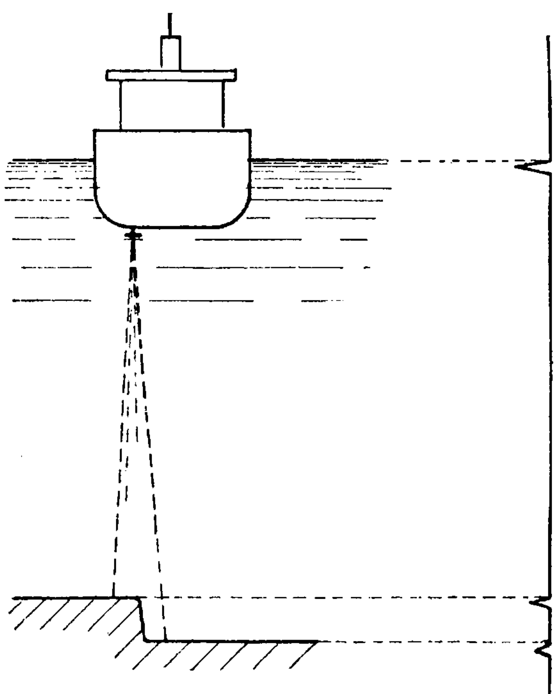


Fig. 16

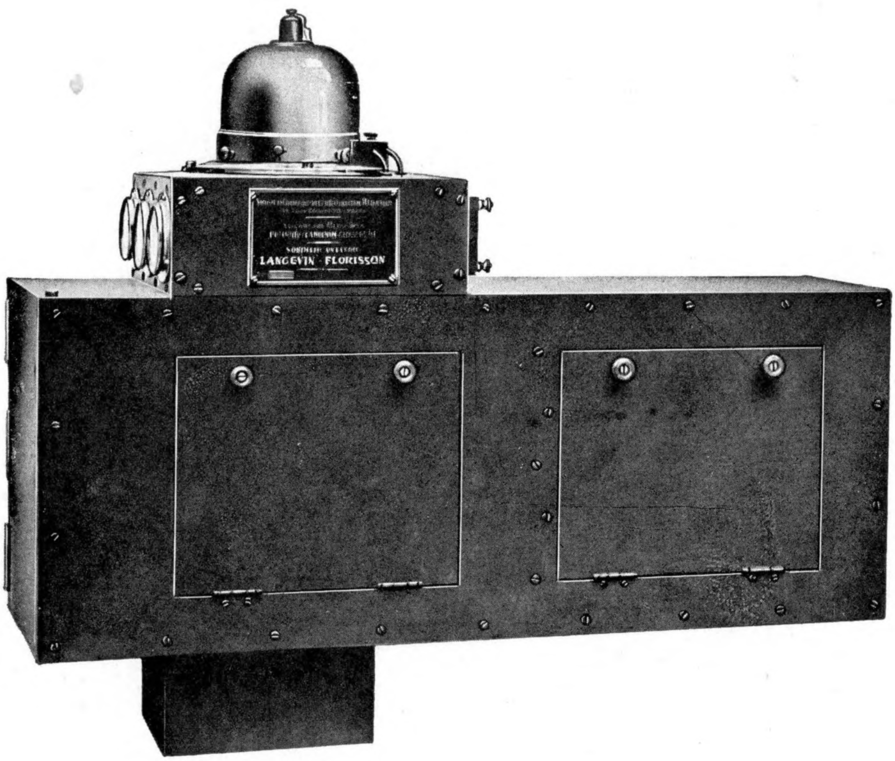


Fig. 17

OPTICAL ANALYSER

LANGEVIN-FLORISSON

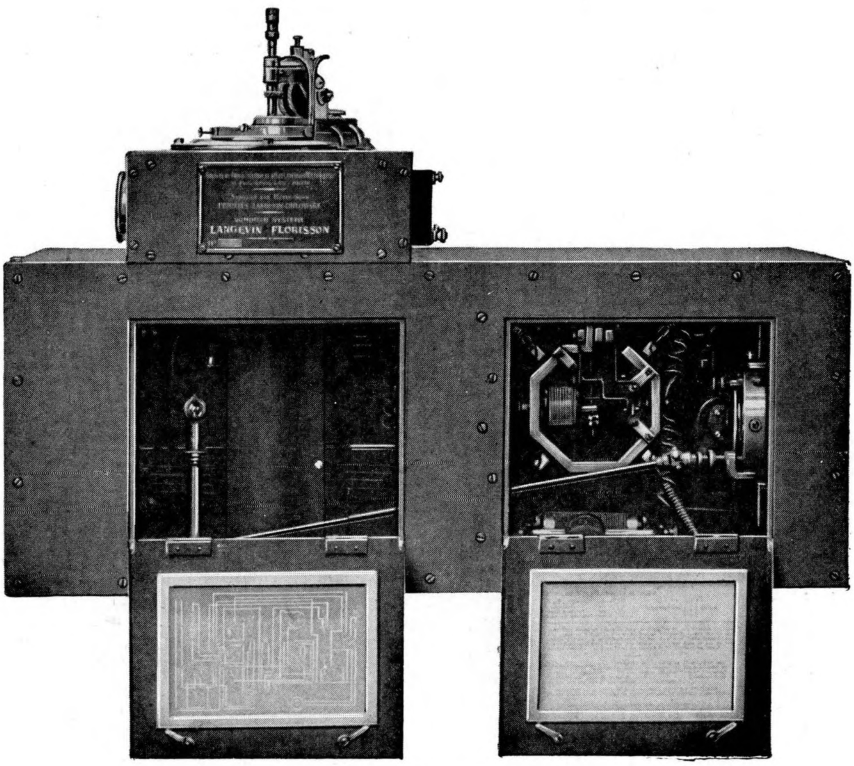
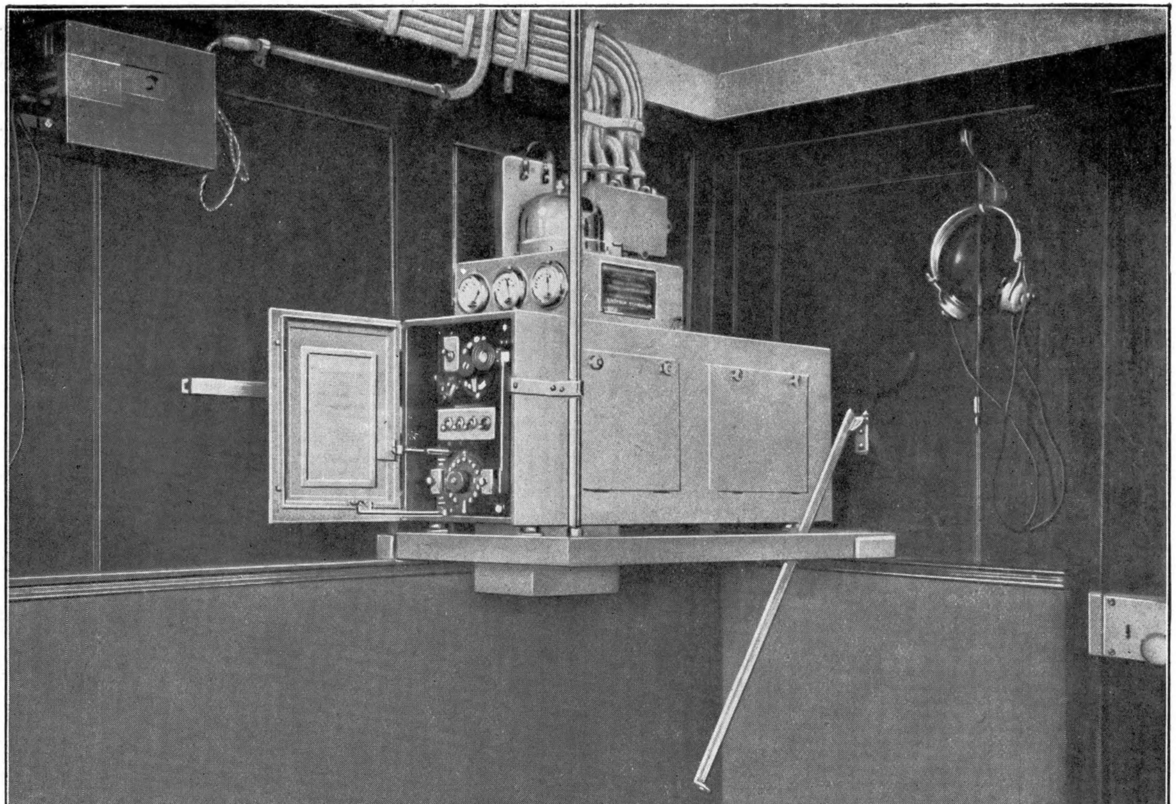


Fig. 18

OPTICAL ANALYSER

LANGEVIN-FLORISSON



OPTICAL ANALYSER

LANGEVIN-FLORISSON

Fig. 19

Installation as fitted
in "AMMIRAGLIO MAGNAGHI"

Lastly, it is unnecessary to dwell upon the comfort and security brought to navigation by the use of this appliance.

Hereafter the officer of the watch will know at every instant the depth of the sea exactly beneath the ship, and he may measure or check it *personally* if he so desires.

The apparatus allows the picking up, without any delay, of continental shelves, and greatly facilitates landfalls on certain coasts.

The possibility, so to speak, of "feeling" the bottom continuously in case of fog, gives to navigation by sounding an accuracy and facility unknown up to the present time. In a word, the presence of the ultrasonic Sounding Machine on the bridge of a ship is a certain guarantee against running aground.

THE MARTI CONTINUOUS SOUNDING RECORDER, SONIC SYSTEM.

The following information supplementing the information given in Special Publication N° 4 March 1925, of the International Hydrographic Bureau, pages 13 and following, with reference to the apparatus by the Ingenieur Hydrographe Marti, has been kindly supplied by the "Société de Condensation et d'Application Mécanique" (S C A M).

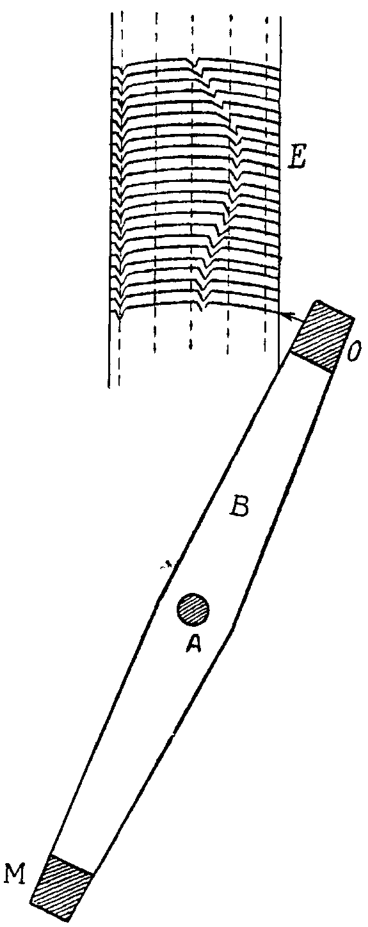


Fig. 1
TRACING OF GRAPH

The Marti Continuous Sounding Recorder, Sonic System, is at present made for sounding in depths varying between 0 and 200 metres (660 ft) in two slightly different types. The large model, used in Hydrography gives one sounding every three seconds, with the curve of the depth on a strip of paper 15 centimeters (5.9 ins) wide ; the small model, for navigational purposes, furnishes ones ounding every five seconds, with the curve of the depth on a strip of paper 8 millimeters (0.31 ins) wide. Another model is intended for deep sea soundings.

ELECTRIC MOTOR AND SPEED REGULATOR.

The motion of the apparatus is obtained by means of an electric motor, with a wheel fixed on its axle, the speed of which is controlled by an electric centrifugal device constructed by Messrs. Boulitte. The motor requires about 1.8 amperes at 35 volts : as a rule it is fed either by an accumulator of 40 volts, the capacity of which is 50 ampere hours, or by the mains of the ship with

80 or 110 volts. The apparatus consists of a three branch switch, each branch controlling one voltage, (40, 80 or 110), the contacts for 80 and 110 volts put in circuit resistances which are also fixed to the instrument. The Recording Device also includes a variable resistance which is permanently inserted into the feeding circuit of the motor. This allows the tension at the motor's terminals to be reduced exactly to the proper amount.

The motor has a speed of 33.3 revolutions per second. It drives, through a leather disc gear, the tangent screw wheel placed in a box filled with oil, the reduction of which is 100, so that the axle of the recorder gives one turn per three seconds.

The regulating device, which is mounted on an extension of the motor axle, turns with this axle, and consists of a contact screw *C* pressed against a contact by means of a leaf spring *R*. It is thrown out from

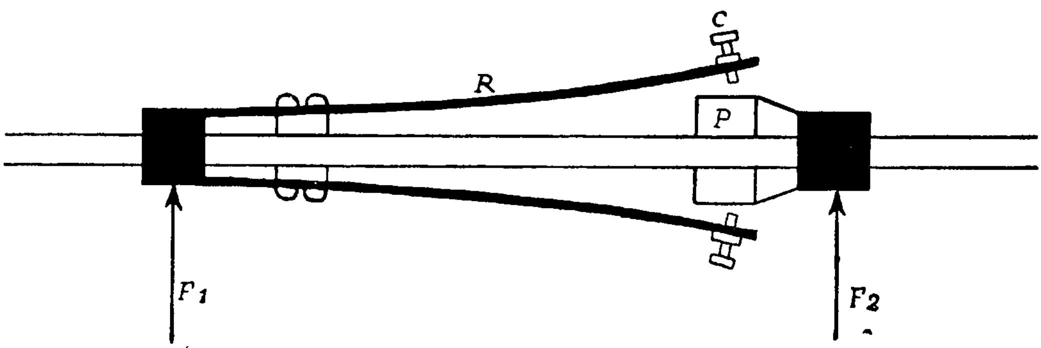


Fig. 2
CENTRIFUGAL SPEED REGULATOR

this contact when the centrifugal force exceeds the force of the spring. Actually, in order to be equilibrated, the device includes two centrifugal contacts opposite to one another, electrically joined in parallel (fig. 2). Though the governing may be operated by both contacts, generally one only is used, the other being stopped by an insulating wedge placed between the screw and the contact, and which may eventually be useful in case of damage to the first. The slip *R* and contact *P* are each connected to rings, to which the current flows by means of the brushes *F*1 and *F*2. The contact thus made is connected in series with the electric motor, after being shunted by a resistance consisting of an incandescent lamp *A* which absorbs the spark at break; another lamp, *B*, of small resistance, is inserted in the same circuit as one of the brushes (fig. 3).

If a low voltage is passed through the apparatus, the motor turns slowly, and screw *C* remains pressed to the contact; lamps *A* and *B* are

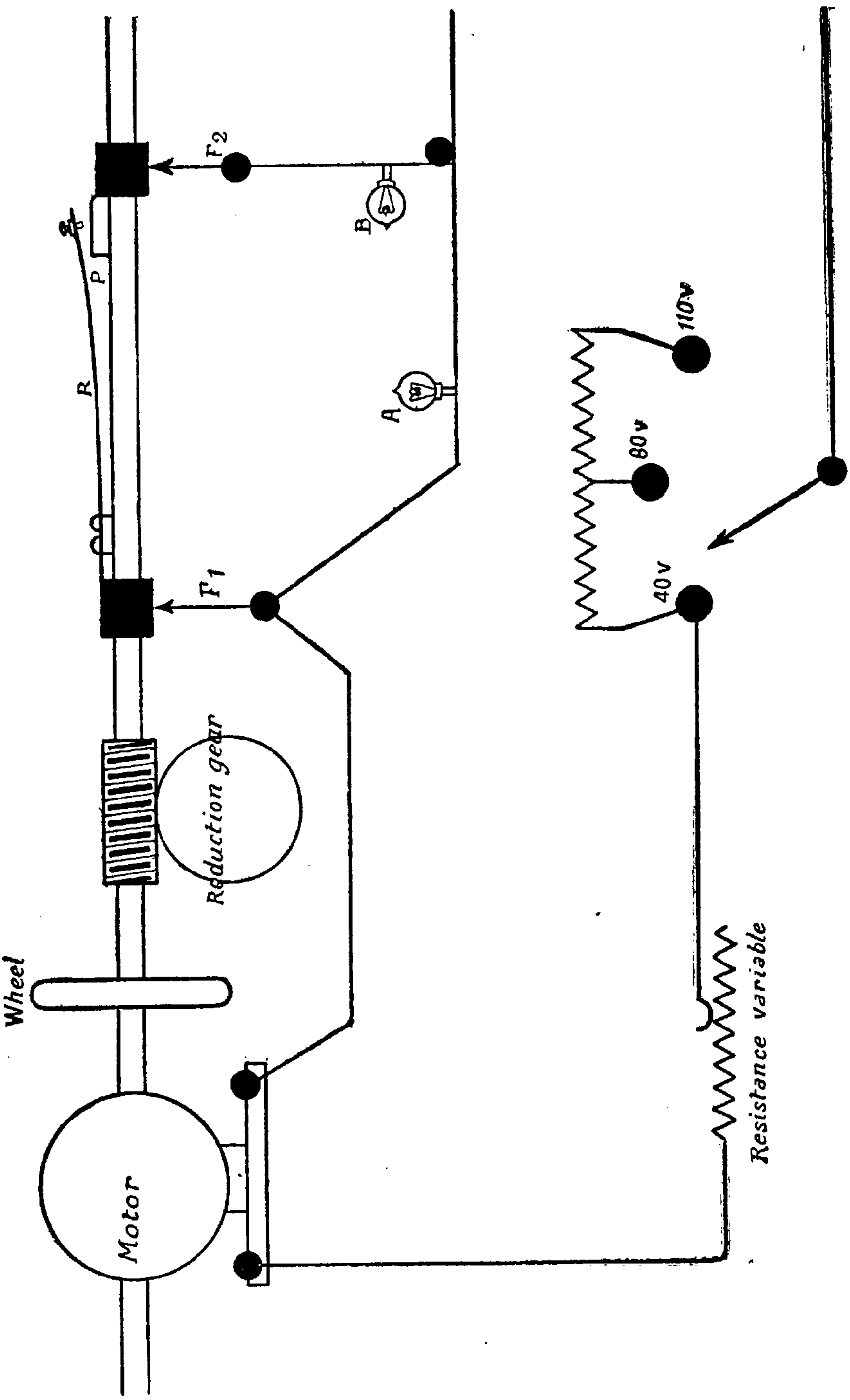


Fig. 3.

DIAGRAM OF RESISTANCE CONNECTIONS.

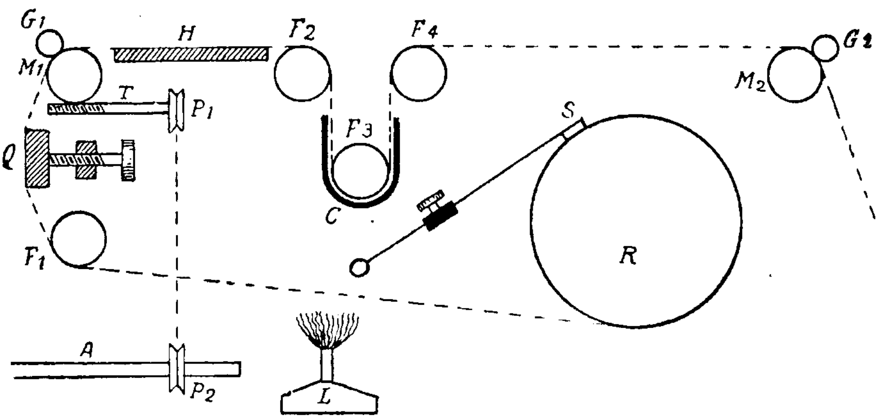


Fig. 4.

DIAGRAM SHOWING MOVEMENTS OF PAPER STRIP.

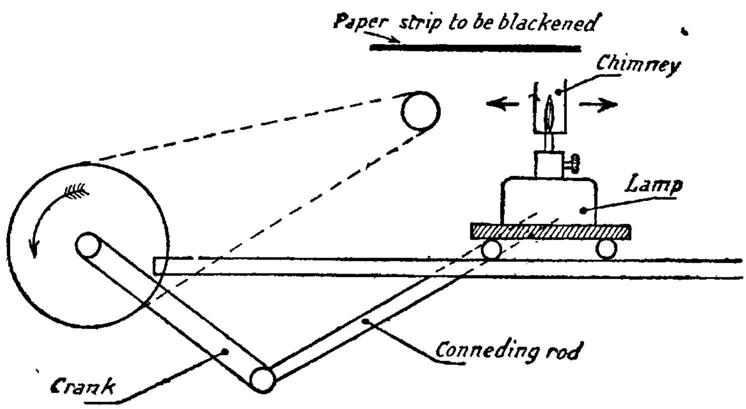


Fig. 5.

AUTOMATIC SMOKING DEVICE

then electrically coupled in parallel, and, as the resistance of lamp *B* is much lower than that of lamp *A*, lamp *B* alone is lighted, *A* remaining unlighted.

If, on the contrary, a high voltage is passed through the apparatus, the motor runs very rapidly, and screw *C* remains permanently separated from its contact ; lamp *B*, the circuit of which is broken, then remains unlighted, and lamp *A* only being lighted.

If, finally, the voltage passed through the apparatus is kept between definite limits, which in practice is between 35 and 50 volts, the motor is obliged to turn at a speed at which screw *C* remains pressed to its contact in the upper part of its trajectory, where it is submitted to centrifugal force diminished by its weight, and thrown off its contact in the lower part of its trajectory, where it is submitted to centrifugal force augmented by its weight. Then lamps *A* and *B* both remain lighted. Their brilliance varies inversely one from the other when the voltage sent through the apparatus varies between the above limits ; it is therefore very easy always to maintain the requisite number of revolutions of the instrument under the same conditions, and exactly at the same speed, by altering the variable resistance of the feeding circuit until the brillance of both lamps is the same. This precaution is necessary only if great accuracy in depth measurement is desired, because experience has shown that the speed of the motor varies, on the whole, but one per cent of its value when a change is made from the origna l voltage (at which lamp *A* shines brightly and lamp *B* is only faintly reddened) to the voltage at which *B* shines brightly and *A* is only faintly reddened. Therefore, in practice, it is sufficient that the two lamps be lighted in order that the apparatus revolve at the desired speed.

BLACKING OF STRIPS OF PAPER.

The strip of paper is 15 centimeters (5.9 ins) wide. The paper spool is placed on the wheel *R* suspended in bearings placed at the extremities of the bracket of the apparatus. The wheel is so arranged that the strip starts from its lower part when passing towards the apparatus : the glazed side of the paper, which is on the outside of the spool, runs downward to where the strip is to be blackened. It is recommended that the rolls of paper be manipulated with care because any tears on the edge of the strip may cause uneven rolling. The cost of the paper is high (75 francs per roll). A brake *S*, pressed by means of a weight on the spool *R*, prevents a too rapid unrolling of the paper. (Fig. 4).

The strip passes first over a roller *F*1 which is used as a support for the rake which traces the graduation on the diagram, it then passes over the front of a block of wood *Q*, which holds it under the pen of the oscillograph, the paper also being kept to this block by means of small lateral guides. Finally, the strip passes over a driving roller *M*1, to which it is linked by means of two spring friction rollers *G*1 pressing on the edge of the blackened strip of paper. The driving roller *M*1 is set in motion by means of a tangent screw wheel *T*, the axle of the tangent screw carries the pulley *P*1 connected to pulley *P*2 by means of a driving belt *I*. The pulley *P*2 is fixed to the axle *A* of the recorder ; the driving belt *I* is tightened by a double stretching pulley. It is important to note carefully the way in which this belt is placed on pulleys *P*1 and *P*2, and the direction in which the apparatus, in turning, drives the strip of paper from bottom to top along the table *Q*. If the apparatus turned in an opposite direction, the device for graduating the strip of paper as described below, would be damaged, as the cog-wheel on the axle of roller *M*1 would be held by its pawl. The reduction of pulleys *P*1 and *P*2 and the tension screw *T* is such that the strip of paper advances one millimeter (0.039 in) with each turn of the apparatus (the strip on the small model Recorder advances 0.83 m/m (0.0335 in) per turn).

The paper is blackened between *R* and *F*1 by means of a petroleum lamp *L*, with a wide wick, which is provided with the instrument and which is purposely set to smoke abundantly. The lamp is moved by hand under the strip of paper, holding it relatively low in order that the upper part of the flame only slightly touches the strip. In fact, when the paper smothers the flame too much, it becomes yellow under the lamp black, which spoils the clearness of the inscriptions. It is important to place the flame in such a way that it will not set fire to the paper. While the apparatus is working the blacking operation must be renewed at least every half hour (the interval necessary for the paper to go from *R* to *F*1), in order that the portion which reaches *F*1 be always blackened.

The small model Recorders are fitted with an automatic blacking device consisting of a lamp with a small wick, mounted on a carriage which is alternately moved on a slide perpendicular to the strip of paper, the motion being obtained by means of a crank and a connecting rod driven by a belt passing over a pulley clamped to the axle of the apparatus. The path of the carriage is much greater than the width of the strip to be blackened, so that the flame of the lamp always crosses the strip at a certain speed. The flame is surrounded by a glass the height of which is such that its upper edge passes several millimeters under the strip of paper (fig. 5). Therefore the wick may be easily regulated so that the lamp smokes only when passing under the strip of paper, the draught being impeded at this instant by the strip itself. Under these conditions a regular and proper deposit of lamp black is obtained.

This device has not yet been installed on the large model.

After passing under the driving roller *M*1 the strip runs on a table *H* where it may be examined at leisure, and any useful notations may be added to it. It then passes over a second free pulley *F*2 and under a third pulley *F*3 which immerses it in a fixing bath, contained in a basin 6, and then to a fourth roll *F*4. The fixative employed consists of an alcoholic solution of ordinary shellac (20 grammes (308 grains) of gum lake to one litre (1.76 pt) of alcohol) — (the solution may be slightly heated in a double-boiler and stirred from time to time). The fixative is poured into the basin until the lower part of pulley *F*3 is covered. This fixative may be used indefinitely. The shellac becomes too concentrated if allowed to remain long in the basin, as the alcohol evaporates n spite of the cover with which the basin i; provided. If it becomes too concentrated and reddens the diagrams during the fixing process, some alcohol must be added. The paper must be slightly red when taken out of the bath. The fixative should be poured back into its bottle at the end of every sounding operation by opening the tap of the basin (to which a small rubber tube may be attached, if necessary), to avoid evaporation and deposits of shellac in the basin and on the roll *F*3. These latter must always be kept clean.

When the lamp black deposit becomes too thick, the pen of the oscillograph raíses small heaps of lamp black on either side of the line which it is tracing on the diagram. The lamp black thus raised does not adhere to the paper and falls off when the strip enters the fixative, which soils the latter. It is therefore necessary to be careful to blacken the paper only slightly, but if the black deposit becomes too thick, the dirtying of the fixing bath can be avoided by blowing lightly on the diagram from time to time, as it passes over the platform *H*, to rid it of the non-adhesive masses of soot before it enters the fixing bath.

On leaving the fixing bath the strip is stretched horizontally between pulley *F*4 and the driving pulley *M*2 on which, as before, it is pressed by means of two spring rollers *G*2, bearing on the edge of the blackened strip. The driving pulley, *M*2, is moved by a belt passing on pulleys of the same diameter fixed on the axles *M*1 and *M*2. On leaving the bath, the paper dries during the interval it takes to go from *F*4 to *M*2. After passing *M*2 it finally falls into a basket.

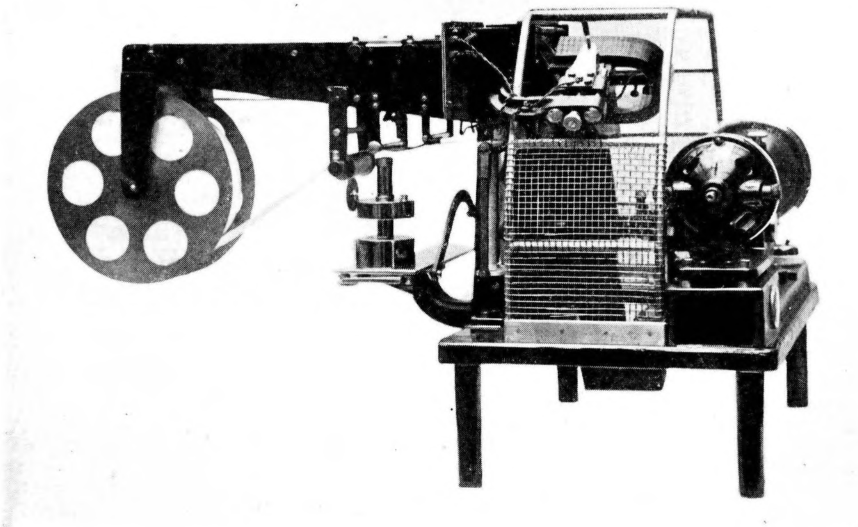
When the soundings for the time being are finished, the apparatus must be left turning for about twenty minutes, so that all useful parts of the strip can pass through the fixative.

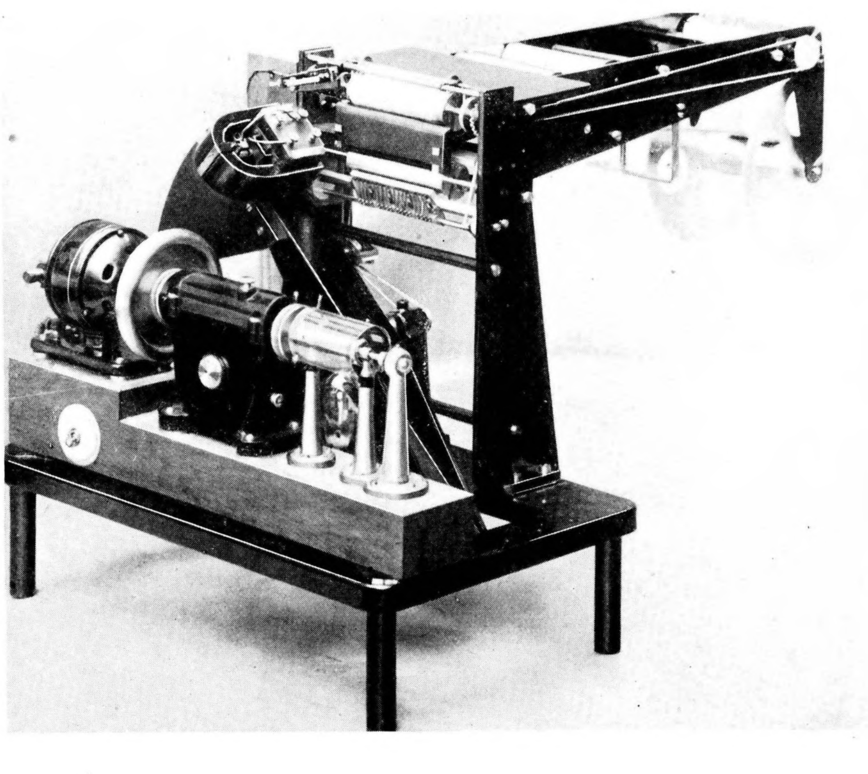
ADJUSTMENTS TO THE RECORD.

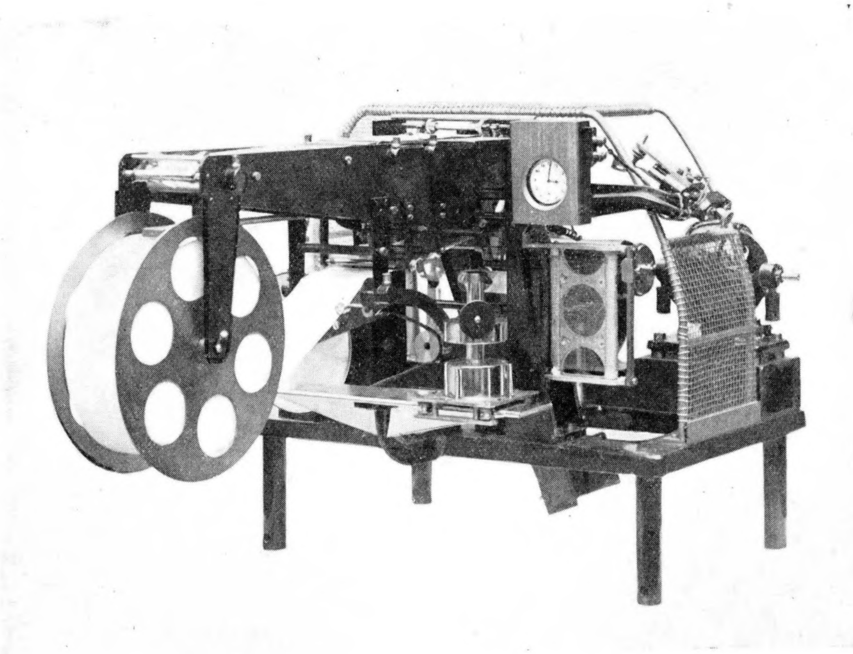
It is necessary to alter the position of equilibrium of the pen of the oscillograph by adjusting the torsion spring of the instrument until the record is produced at a distance from the axis of rotation, so that the indication of the graduation of the strip of paper be exact. This graduation is made for a distance of inscription of 225 millimeters (8.77 ins), (180 m/m (7 ins) for Small Model Recorder), assuming that the velocity of sound through water is 1.500 meters (4.920 ft) per second, the mean value. When the velocity of sound is not exactly 1.500 meters (4920 ft) per second, rather than change the comb which traces the graduation, the radius of inscription is slightly altered. For this purpose the portion *Q* carries, at its left extremity, several arcs of circles as indices indicating the different distances of inscription to be employed for the different velocities of sound. This adjustment may be made after the amplifier, to which the oscillograph is connected, is lighted and adjusted, for the current output of the amplifier, which is normally 1 milliampere, gives a slight permanent deviation to the pen of the oscillograph. It is not necessary that this regulation be carried out very accurately. It is sufficient to note, during the working of the apparatus, that the last arc of the circle being traced and prolonged, passes less than 2 millimeters (0.078 ins) from the arc of the circle chosen as an index. The apparatus thus indicates accurately the depth of water within 1 % of its amount.

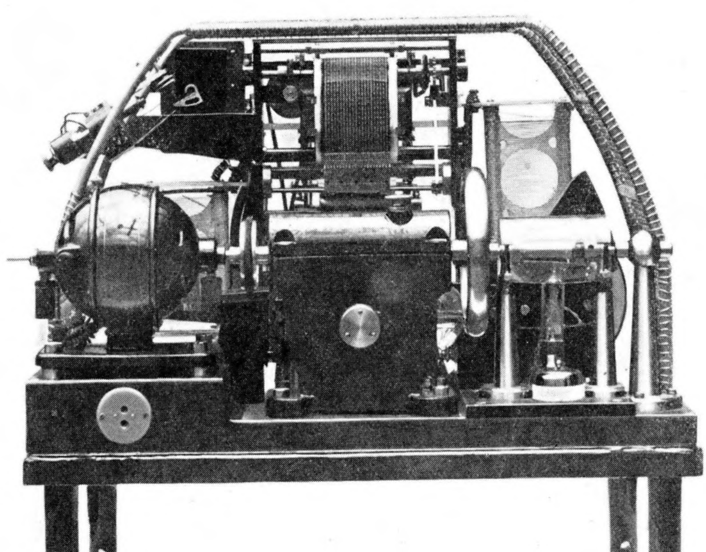
DIVISION OF THE BLACKENED STRIP.

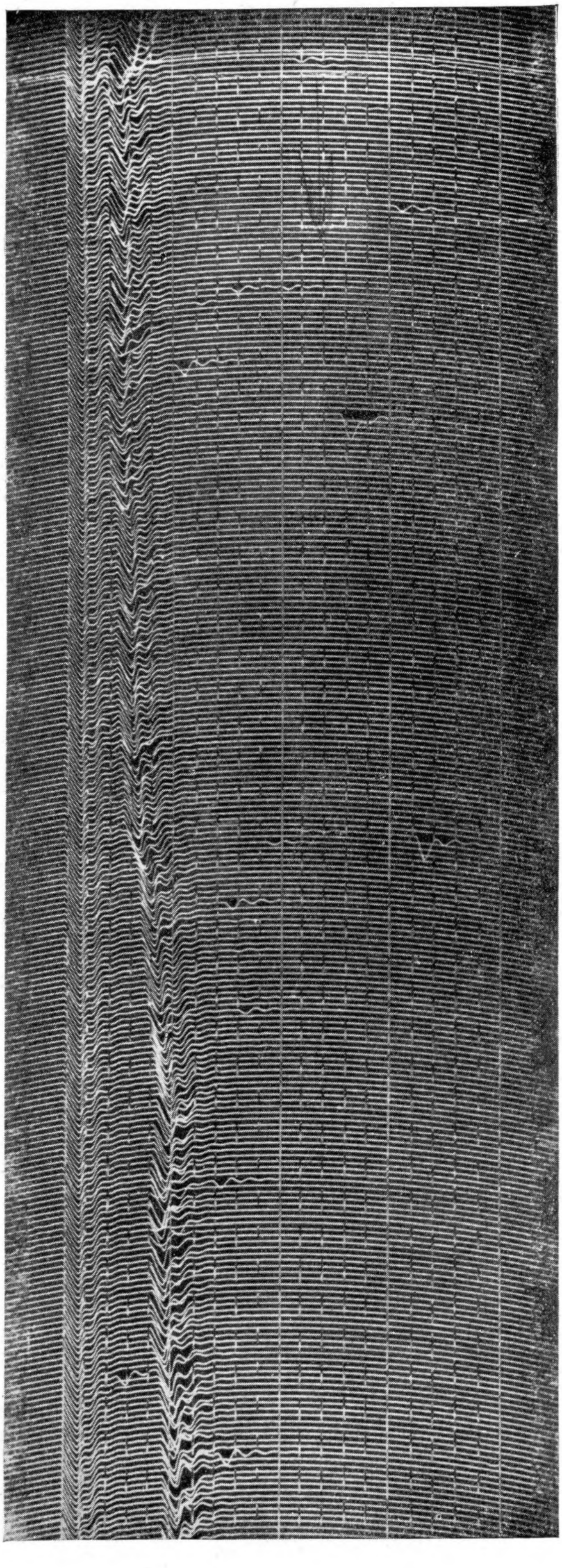
The diagram is automatically divided, according to the depth of water, by a special rake trailing on the blackened surface and pressing on roller *F*1. The intervals between the teeth, each corresponding to ten meters depth, take into account the curvature of the arc as traced by the oscillograph. The teeth referring to depths of water 0, 50, 100, 150, and 200 meters (0, 164, 328, 492 and 646 feet) keep permanently bearing on the paper, and trace continuous lines thereon. The other teeth, on the contrary, are mounted on a block which a cam device, driven by a cog-wheel which is clamped to the axle of roller *M*1, revolves from time to time. These teeth alternately press on and withdraw from the paper, so that the corresponding lines appear interrupted. This facilitates the reading as compared with the continuous lines referring to divisions of 50 to 50 meters (164 ft) round.











HOUR INDEXES OF THE DIAGRAM.

Finally, the apparatus is completed by a watch with electrical contact which marks the time on the diagram. This watch short-circuits the oscillograph every five minutes during one turn of the apparatus, *i. e.* for three seconds (five seconds in the small model apparatus). The pen of the oscillograph, which is permanently slightly deviated by the current output of the amplifier, returns to its resting place during one revolution of the apparatus, and the arc which is traced on the strip of paper during that revolution is thus delayed in comparison with the others. As in the next revolution, the pen again takes its proper place, the characteristic black trail appears on the diagram as if the sounding were missing from the record. Asthe same phenomenon is reproduced every five minutes, it is sufficient to inscribe on the diagram from time to time, by hand, when it passes the table *H*, the exact time of one of these time indexes.

The watch makes its contact when the second hand passes through the division *O*. In Hydrographic work, therefore, the operator who superintends the working of the recorder, is able to warn the observers in charge of determining the ship's position, several seconds before every time index. In this way the observers may fix the "station" exactly for the time marks traced on the diagram by the watch. When setting the watch, before beginning soundings, it is recommended that the watch be set exactly with the minute hand at a graduation of the dial when the second hand passes the zero division, so that the apparatus traces time marks for full minutes of the dial. It is, besides, advantageous that the time marks should occur, not for one full minute of the dial, but for five full minutes of the main dial.

Sometimes it is preferable to make time marks at moments which are not spaced regularly every five minutes. This occurs frequently in Hydrographic work because the first and last "station" of every line of sounding are usually determined compulsorily when the ship crosses its extremities, the intermediate stations, being, according to circumstances, distributed along the line at fairly close and often irregular intervals. In this case, instead of the contact watch, or in addition to it, a small switch or button is fitted, allowing the operator to short-circuit the oscillograph at will, therefore causing time marks at moments at which the observers fix the ship's position.

The photographs reproduced herewith show various aspects of the apparatus, as well as a sample of a diagram obtained during a sounding operation.

ECHO SOUNDER

(British Admiralty Pattern)

Some additional information is given below in order to supplement the information which has already been given on he subject of the Echo Sounder, British Admiralty Pattern, in Special Publication N° 4 (March 1925), of the International Hydrographic Bureau, pages 10 and 15.

The makers of the apparatus are Messrs. Henry Hughes & Sons, Ltd 59 Fenchurch Street, London, E. C., 3, and we take the following passages and photographs of the apparatus from the "*Nautical Magazine*" for January 1916.

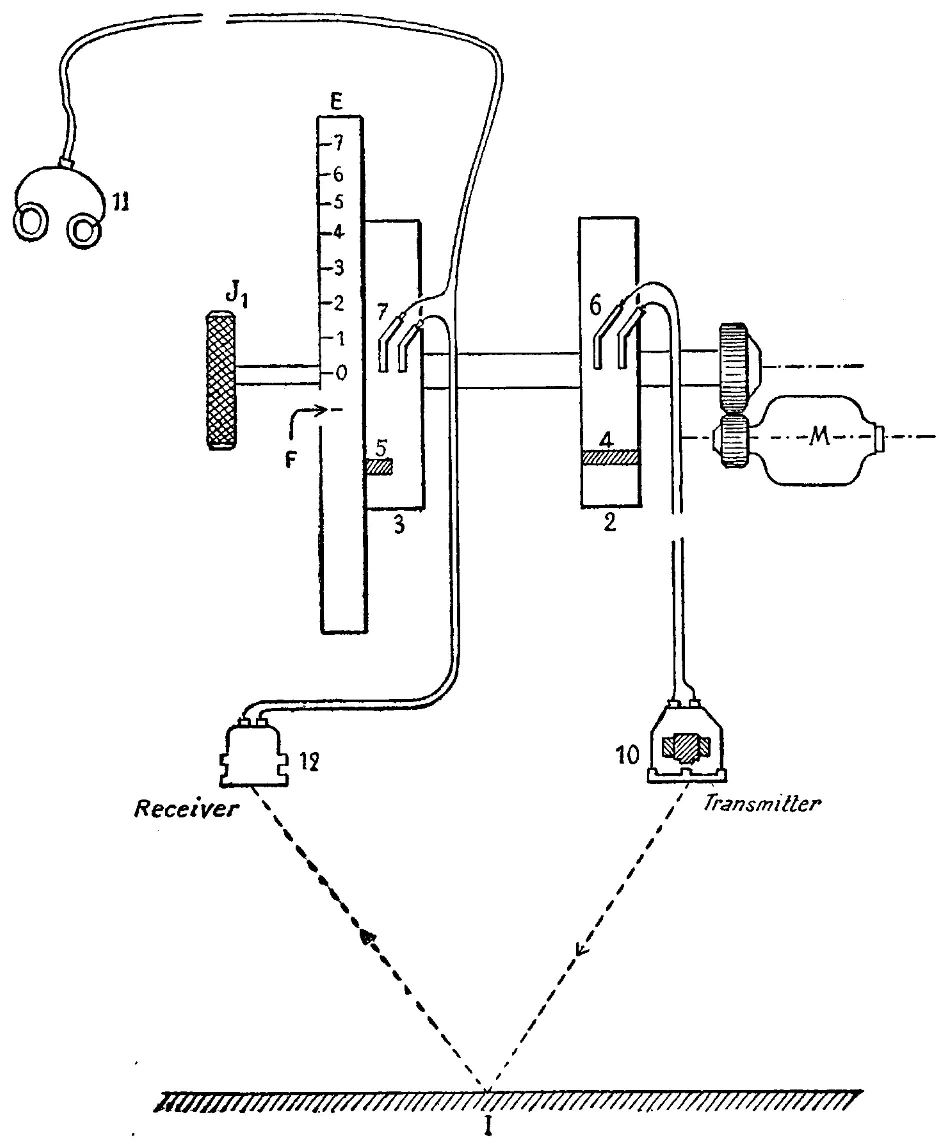


Fig. 1

The attached figure 1 reproduces and supplements certain details, with the same numbers of reference as those which have been employed in fig. 4 (page 11), in Special Publication N° 4. In fact, the apparatus allows the measurement of intervals of time, which may be very short, (of the order of $\frac{1}{300}$ of a second for depths of 5 metres (16 ½ ft)) which elapse between the start of the sonic signal from the transmitter (10), and the return of the echo reflected at I on the bottom of the sea, to the receiving hydrophone (12); this echo is perceived by means of the telephone (11).

The apparatus actually makes a measurement of angle (θ), the wheel of which has revolved with a uniform movement of rotation during this interval of time.

For this purpose a large wheel *E* is connected to the switch (3), its edge is divided in divisions representing feet. The handle *J*1 allows the displacement of the contact (5) -- (or brushes (7), which is, in effect, the same) with reference to contact (4) of the desired angle (θ). The pointer *F* gives a reading of angle (θ).

The uniform rotation of the apparatus causes, by means of the distributor (2), an electric hammering of the transmitter (1) three times per second.

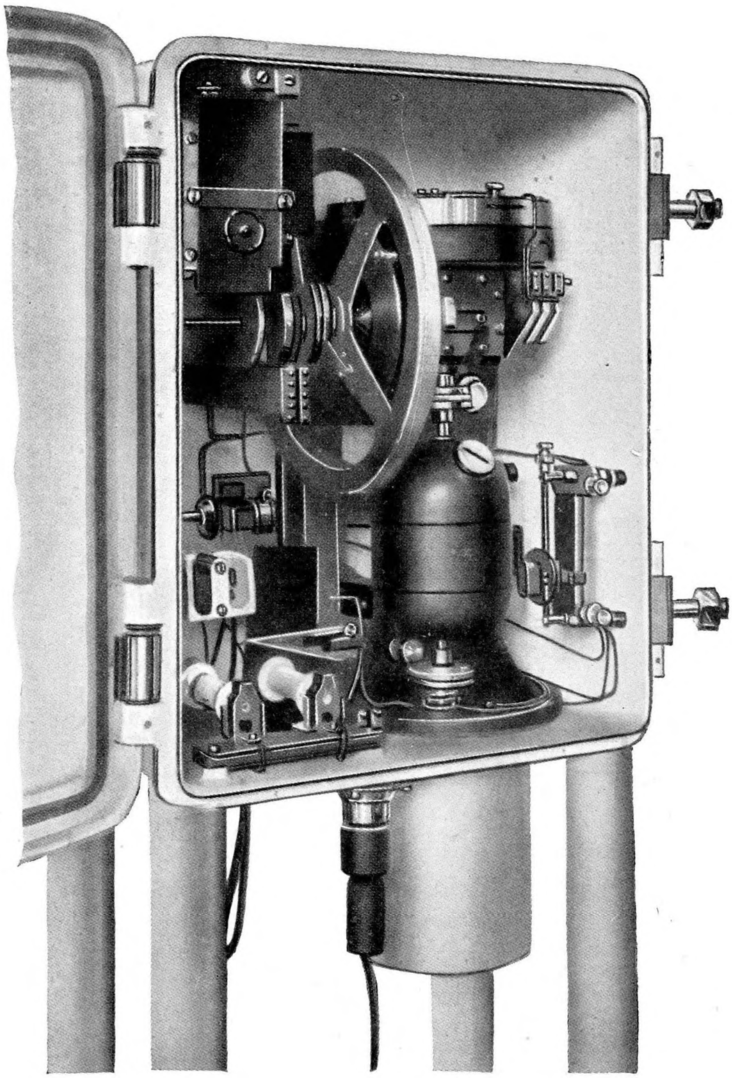
The working is as follows :

1) Let us first suppose that the path (10) — 1 — (12) between the transmitter and the receiving hydrophone be so small that the interval of time taken by the sound to make this traject be negligible (in other words, that the ship is lying on the bottom). If contacts (5) and (4) are in the same line, the sound will be heard through the telephone every time the hammer strikes the transmitter, and the pointer *F* will show zero on the scale of wheel *E*, thus indicating that the depth is nil.

2) If there is a certain amount of water under the keel of the ship, for the same position of the contacts or of the brushes, no sound will be heard in the telephone because, from the start of the sound and the return of the echo, the rotation of the axis has driven the contact (5) beyond brush (7) from the angle (θ), so that the connection is cut.

In order to re-establish the connection, it is sufficient to advance the handle *J*1 in order to draw back the contact of angle (θ). When this angle is reached, the echo of the strokes is heard suddenly, clear and sharp. The pointer *F* than indicates the depth, which is read on the divided edge of the large wheel *E*.

The accompanying photograph gives a general view of the receiving gear which may be attached to a support, or chart-house wall.



ECHO SOUNDER

(British Admiralty Pattern)

In order to take into account, in shallow water, the distance which separates the transmitter and the receiver and the errors of parallax therefrom, it is possible, in certain cases of installation, to introduce near the needle a correcting device in order to obtain directly an exact reading of the depth.

Short of damage to the instrument, or carelessness on the part of the operator, accuracy, in shallow waters, may be relied upon within 1 foot, and soundings may be obtained in two feet of water or even less.

The difference in velocity of transmission of sound through sea water caused by various conditions of marine salinity, may cause maximum errors in soundings of about 5 %, which in shallow water is negligible for navigational purposes. It is also possible to correct the soundings, if so desired, by using the Echo Sounder in fresh water.