ECHO SOUNDING

VI.

Continuing the reports on Echo Sounding appliances already published by the International Hydrographic Bureau (*), extracts from, and summaries of various articles recently received by the Bureau are given below concerning :—

I. The LANGEVIN-FLORISSON ultra-sonic sounding machine.

II. Acoustic Sounding Apparatus by Successive Shocks or Detonations (MARTI system - 1927).

III. The BEHM Echo Sounder, types IV A, IV S and IV N.

I. — ADDITIONAL INFORMATION CONCERNING THE LANGEVIN-FLORISSON ULTRA-SONIC SOUNDING SYSTEM (**)

I. — INSTALLATION OF THE LANGEVIN ULTRA-SONIC PROJECTOR ON BOARD A VESSEL.

Figures 4 and 5, page 9 of Special Publication N° 14 (*Hydrographic Review*, Vol. 3, N° 2, page 76) show the elevation of one of the first models of hull apparatus. At first it was thought an advantage to be able to immerse the projector, whilst in use, at some decimetres below the outside plating (in order that the emitting surface of the apparatus should be below the upper stratum of water adjacent to the hull, as it is assumed that this surface layer of water is generally heterogeneous when underway) and, in spite of the complication and obstruction of such a hull apparatus, adapted to this use, several such installations were fitted. Fig. 4, mentioned above, represents the

(*) *See* Special Publication N° 1 (December 1923), N° 3 (October 1924), N° 4 (March 1925), N° 14 (August 1926) ;

Hydrographic Review, Vol. 1, N° 2 - May 1924, pages 39 to 49, Vol. 2, N° 1 - Nov. 1924, pages 53 to 127, Vol. 2, N° 2 - May 1925, pages 135 to 192, Vol. 3, N° 2, - July 1926, pages 75 to 195, Vol. 5, N° 1, - May 1928, pages 131 to 161.

(**) *See* Special Publication N° 14 (August 1926).
Hydrographic Review, Vol. 3, N° 2, July 1926, pages 75 to 88.

elevation of the immersible projector hull apparatus. The projector is raised and lowered by means of a hand or electric device. The projector, when not in use, is contained in a chamber, closed by a sluice valve.

In ships of which the speed is less than 15 knots, the performance of the sounding machines fitted in this way is excellent, but it is reported that the depth of immersion of the projector, in these vessels, does not influence the working of the apparatus. Soundings are more usually taken with the projector raised inside the vessel.

These results justify the installation of the ultra-sonic projector permanently fixed to the outer plating, to be adopted at least for ships of relatively low speeds.

The case of fast ships was then examined: an ultra-sonic sounding machine, fitted with an immersible projector, was mounted on the steamship *France*, of the Compagnie Générale Transatlantique, and some interesting experiments were carried out at a speed of 22 knots It had been necessary to put the hull apparatus in a cabin situated on the ship's side, forward, almost perpendicularly under the bridge. At this point the outside plating is very much inclined, and experience showed that on frequent occasions there was lack of echo, particularly when the ship rolled It was found that, if the projector apparatus was projected below the outer plating, or raised above the opening in the hull, the functioning of the ultra-sonic sounding machine was unsatisfactory; in these positions the violent whirl of water at the surface of the apparatus produced disturbing impulses on the reception. It was found, by experiment, that the best position for the emitting surface was nearly flush with the outer plating.

Further, the hull apparatus being cumbersome, sufficient room to install it on board the *France* could be found only rather close to the bow Experiment showed that this position was bad; the projector should be mounted almost amidships and near the keel.

Thanks to the co-operation of the *Cie Générale Transatlantique*, the *Société de Condensation et d'Applications Mécaniques* has been able to modify the installation so as to use projectors permanently fixed amidships and in such a way that the interior emitting surface of the projector is in the plane of the hull. This device is much less cumbersome than the device with movable projector. Fig. 4 mentioned above represents the device with detachable projector formerly used and Fig. 1 hereafter the projector mounted as a permanency.

After this complete remodelling of the installation the results obtained have been excellent.

It is extremely interesting to notice this result because, for the first time, it has been possible to record soundings at great speed. The record was, in fact, taken at a *speed of 22 knots*. Results have been so satisfactory that the *Cie Générale Transatlantique* has decided to equip the liners *Ile de France* and *Paris* with super-sonic sounding gear fitted with recording apparatus.

The first band of records of soundings made on board the *Ile de France* during a voyage from Havre to Plymouth, defined clearly the relief during the passage over Hurd Deep.

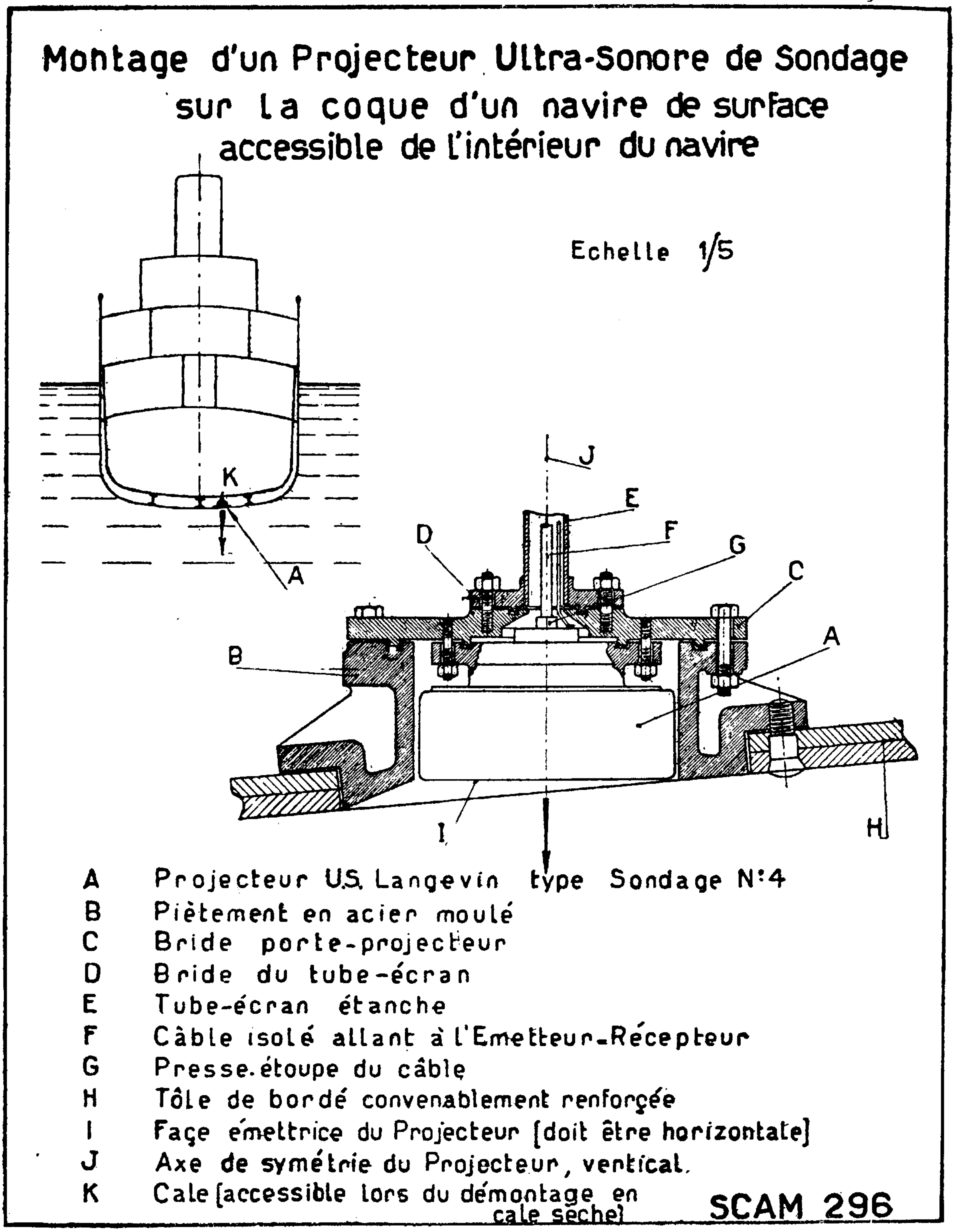

Fig. 1 — FITTING OF AN ULTRA-SOUNDING PROJECTOR TO THE HULL OF A SURFACE VESSEL WITH ACCESSIBILITY FROM INSIDE THE SHIP.

- A. Langevin ultra-sonic projector — Sounding type N° 4.
- B. Cast-steel base.
- C. Projector-bearer flange.
- D. Protector-tube flange.
- E. Watertight protector tube.
- F. Insulated cable connecting with the Emitter-Receiver.
- G. Cable stuffing-box.
- H. Bottom-plating suitably reinforced.
- I. Emitting face of the projector (should be horizontal).
- J. Axis of symmetry of the Projector (vertical).
- K. Hold (accessible for taking down in dry dock).

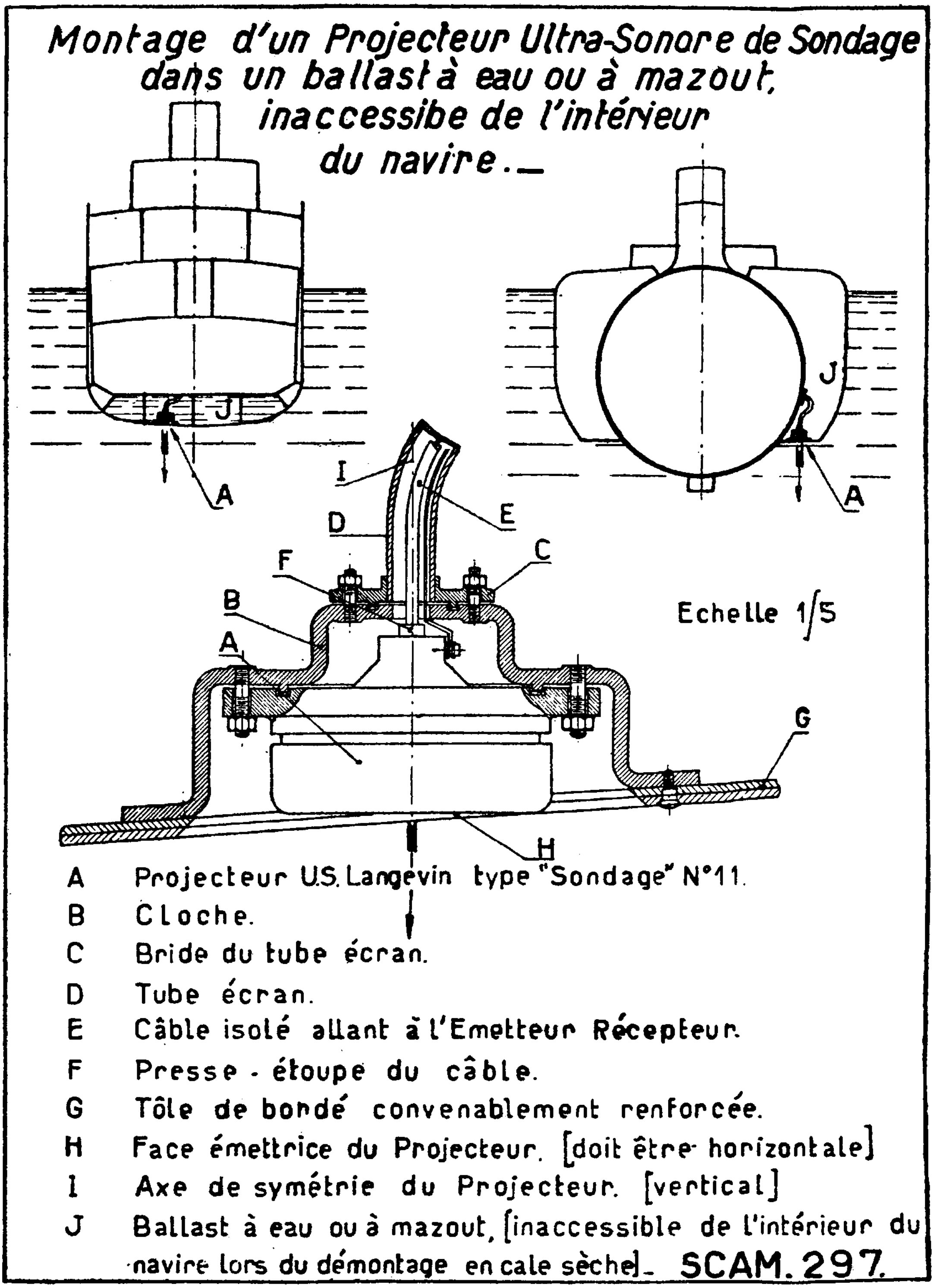

Fig. 2. — FITTING OF AN ULTRA-SONIC SOUNDING PROJECTOR IN A WATER-BALLAST OR OIL-FUEL TANK NOT ACCESSIBLE FROM INSIDE THE SHIP.

A. Langevin ultra-sonic projector — Sounding type N° 11.
B. Dome.
C. Protector-tube flange.
D. Protector-tube.
E. Insulated cable connecting with the Emitter-Receiver.
F. Cable stuffing-box.
G. Bottom plating suitably reinforced.
H. Emitting face of the projector (should be horizontal).
I. Axis of symmetry of the projector (vertical).
J. Water-ballast or oil-fuel tank (not accessible from inside the ship for taking down in dry dock).

The super-sonic sounding apparatus with the MARTI recording instrument may therefore be used on board all liners without any slackening of the ship's ordinary speed. Liners fitted with super-sonic sounders may thus contribute to a considerable degree towards completing the existing knowledge of depths off the coasts.

The results of experiments, carried out in ships of relatively low speed, as well as in fast ships, having concordance, the hull appliances may be standardised and made as simple as possible.

Two types of mountings, which have been definitely adopted, are represented in figures 1 and 2. The first refers to the attachment of the ultra-sonic projector, used for sounding, to the hull of a surface vessel in such a way that it is accessible from the interior of the ship. The other is a mounting which is inaccessible from the interior of the ship, i.e., the projector is attached to the skin of the ship inside a water-ballast tank, either in a surface vessel or in a submarine.

In the arrangement shown in figure 1, the projector *A* is carried by a disc which is bolted to a cast steel base *B*, which is itself attached to the skin of the ship, the skin being suitably reinforced. The protecting tube, *E*, attached by a water-tight joint to the flange *D*, contains the well-insulated wire and the wire leading to earth which connect the projector to the emitting and receiving apparatus. This mounting is watertight, both with reference to sea water and to bilge water. It should be accessible from the interior of the ship for placing and removing the projector, which operations can be done in dry-dock only.

The ultra-sonic projector requires no other care except that it must be well brushed and have a coat of paint whenever the ship is drydocked.

By way of information, it may be mentioned that the exterior diameter of the cylindrical part of the projectors is 290 m/m (11.4 inches). The "*Sondeur Langevin-Florisson type* 375 *metres*" is provided with this type of projector.

A similar apparatus, which is intended for taking deeper soundings and is called "*Type* 500 *metres*", is provided with a projector of exactly the same form as that shown in figure 1, but the cylindrical part has a diameter of 392 m/m (15.43 inches).

For the seat of the apparatus a nearly horizontal part of the skin should be chosen, somewhere near the centre of the ship. The form of the base is such that the axis *J* of the apparatus is vertical. The apparatus shown in figure 2 which, after the attachment of the steel bell *B* to the suitably reinforced skin of the ship, is practically inaccessible from the interior of the ship, includes an ultra-sonic projector of the same diameter as that which is shown in figure 1, but which is provided with a flange of special form and of greater diameter, which allows the placing and removal to be done from the exterior of the ship only, and that in dry-dock.

Should it be impossible to insert the steel bell *B* into the ballast tank of the submarine, as shown in figure 2, or should the submarine have an interior ballast tank, a very simple arrangement is provided for fixing the projector in the keel.

The hull attachments above described are not very cumbersome, and for this reason they may easily be placed in the bottoms of ships. They do not change the flow line of the hull nor do they weaken the skin.

II. — "SINGLE TRAIN OF WAVES" EMITTER.

Fig. 3 shows the circuit arrangement of the electric Emitter and its connection with the Ultra-Sonic Projector, the Receiver and the Analyser.

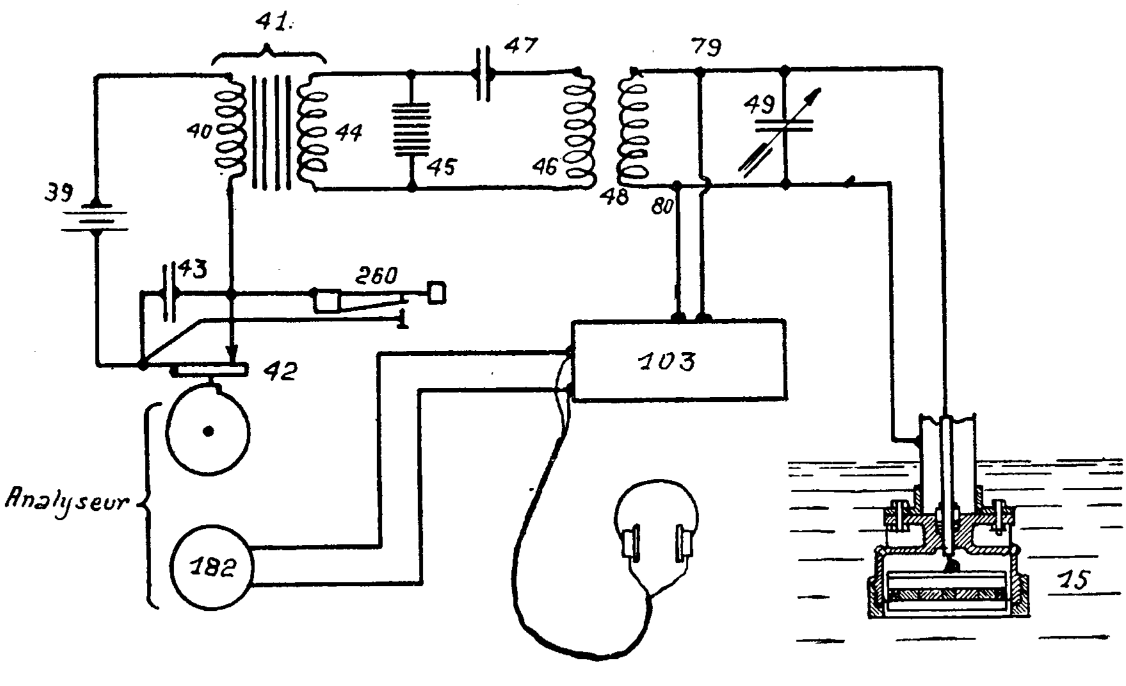

Fig. 3

The discharge circuit of the storage battery 39 consists of the primary 40 of a transformer 41 (induction coil), and of a special key 260 or 42 which is shunted by a condenser 43.

The secondary 54 of the transformer 41 supplies a shock circuit comprising the subdivided spark gap 45 at the terminals of which are disposed the self-induction coil 46 and the condenser 47.

The values of this self-induction *L* and capacity *C* are so regulated that:

$$\frac{1}{N_0} = 2\pi\sqrt{L.\,C.}$$

in which N_0 is the frequency of the mechanical resonance of the Ultra-Sonic Projector.

The oscillating circuit itself comprises the self-induction coil 48 coupled with the shock coil 46; the variable condenser 49 serving to regulate the frequency of the train of waves; the piezo-electric condenser of the Projector 15. The oscillating circuit is tuned by means of the variable condenser 49 so as to obtain a frequency of oscillations, exactly equal to N_0, for bringing into action the properties of mechanical resonance of the Projector.

On closing the key 260 or 42, the current from the battery 39 passes into the primary of the transformer 41.

When the key is opened either by hand or by means of the Optical Analyser, as will be described later, the battery current is suddenly cut off. A rapidly increasing electromotive force is produced in the secondary of the transformer. When the potential difference due to this cause at the terminals of the spark gap 45 attains the limit of disruptive discharge (depending upon the size and number of elementary spark gaps), the condenser 47 is discharged in a few oscillations, thus inducing in the oscillating circuit a single train of damped waves that lasts less than 0.001 second. These waves are transformed by the Projector into a train of Ultra-Sonic waves of the same form, which constitutes the emitted submarine signal.

Description of the Emitter (fig. 4).

The various parts of the device are contained in a metal case.

The impact coil 46 and the coil of the oscillating circuit 48, are mounted by means of the collars 50 on an insulating shaft 51 in a position securing a given mutual induction.

Both coils are disposed in the lower compartment of the case.

The fixed condenser of the impact circuit 47 is a mica condenser of very high insulation. The induction coil in its metallic case of special construction, is shown at 41.

The spark gap of the impact circuit 45 is subdivided into six elementary gaps by seven tungsten cylinders (fig. 5). The number and order of the gaps between the cylinders can be regulated by two contact arms which are controlled by the insulating knobs 52.

An insulating panel 53 protects the operator against any accidental contact with the metal parts of the apparatus. The working of the spark gap can be observed through the glass plate 54.

The spark gap (fig. 5) can be readily taken to pieces by unscrewing the four screws 319 of the ebonite panel 53 and removing the latter.

The distance between the cylinders, which is about 0.1 m/m, is assured by small mica plates 0.1 m/m thick, which are inserted between the ends of the cylinders when the spark gap is being assembled.

III. — OPTICAL ANALYSER.

(*See* Special Publication, N° 14, August 1926, page 10 and fig. 8 to 12, also *Hydrographic Review*, Vol. 3, N° 2 (July 1926), page 78, Fig. 8 to 12).

1° *OPTICAL DETECTION OF THE SIGNALS AND ECHOES.*

The detecting apparatus or Oscillograph must fulfil several conditions :

a) The echo interval (which is measured from the beginning of the corresponding impulse of current) must be determined with accuracy; and this requires an apparatus which clearly indicates the starting points of the signal and the echo.

b) Since these pulsations are relatively weak, the apparatus must be very sensitive.

c) The echo interval may often be very short (some 0.001 second for very shallow water) therefore the indicating apparatus must return to zero in a shorter time than the minimum echo interval to be measured.

These various conditions are fulfilled in a most satisfactory manner in the type of Dubois Oscillograph specially designed for use with the Ultra-Sonic Sounding Apparatus.

DUBOIS OSCILLOGRAPH OF SPECIAL ULTRA-SONIC SOUNDING TYPE (Fig. 6, 7, 8).

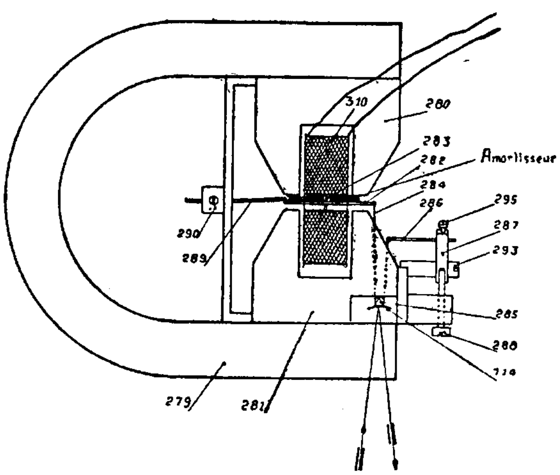

Fig. 7

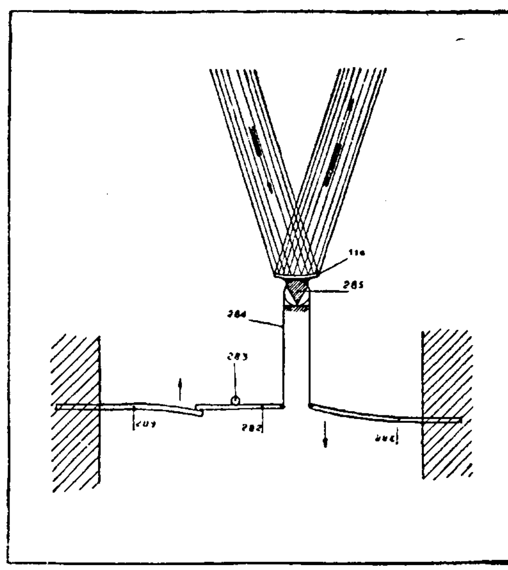

Fig. 8

a) *Description :*

A magnet 279 polarises the soft iron pieces 280,281. At the middle of the air gap between the pieces is a soft iron armature 282 which can rotate about the axis 283. The armature is compelled to remain in a position of equilibrium between the pole pieces by the following means :—

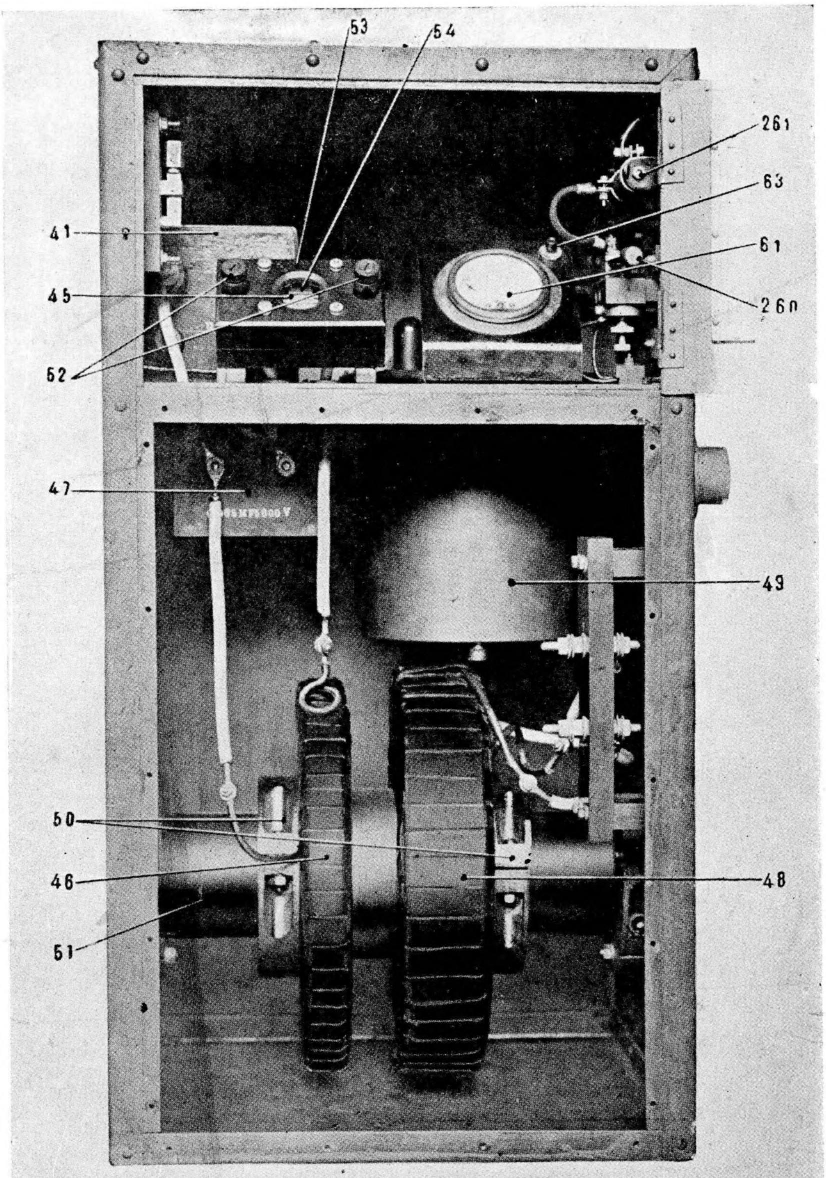

Fig. 4

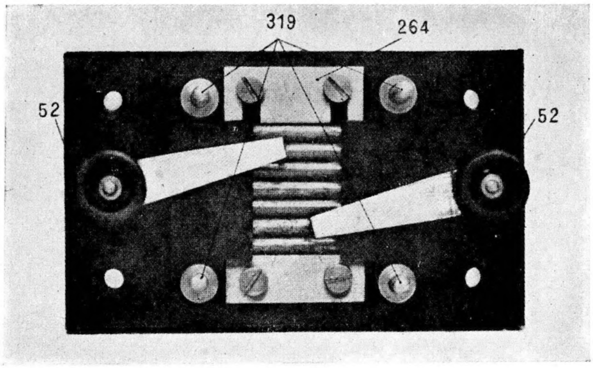
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Fig. 5

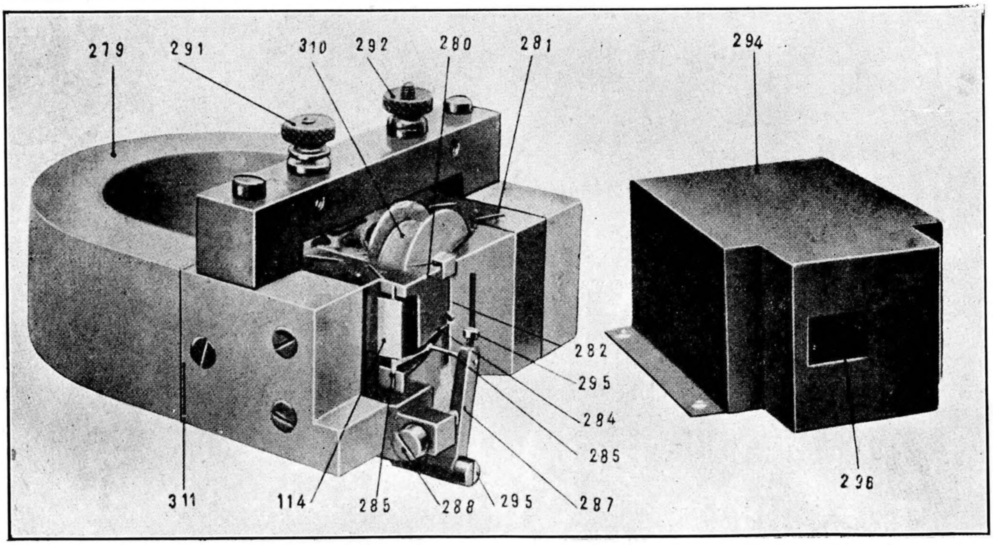
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Fig. 6

To one end of the armature is attached a fine steel wire 284 which after being wound half-a-turn around the shaft 285 is attached to the end of a spring 286 mounted on the adjusting member 287.

The other end of the armature 282 bears on a spring which is fixed at 290 (a general diagram of the movable parts of the Oscillograph is shown in fig. 8).

A coil 310 the terminals of which are shown at 291-292 receives the current to be detected by the oscillograph, i.e. the impulse corresponding to signal and echo. This current magnetises the armature 282, which will obviously turn in either direction on its axis, thereby rotating the shaft 285 by means of the steel wire. The shaft 285 carries a small concave mirror 114 on which impinges a beam of light, so that the beam will be deflected in proportion to the rotation angle of the mirror, i.e. in proportion to the current in the coil.

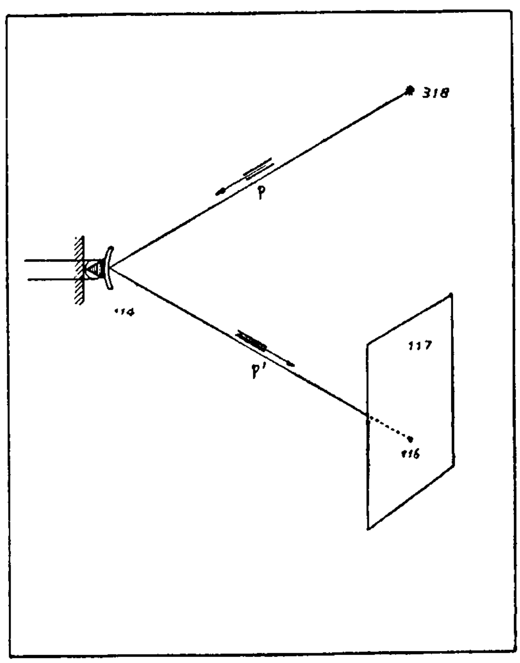

fig. 9

Fig. 9 shows the path of the beam. The mirror 114 throws a real image 116 of the spot of light 318 on the screen 117, so that the motion of the armature is shown by the displacement of the image 116 on the screen.

The movable parts of the oscillograph are protected against blows from outside by a casing 294 having a window at 296.

b) *Operation :*

For sounding purposes, the apparatus is utilised as a veritable ***ballistic galvanometer***. In fact, when in the zero position, it receives for a very short time (i.e. very short as compared with the specific oscillation period of the movable system) a small quantity of electricity, represented by the impulse of signal or echo. This will move the armature 282, which will afterwards return to zero in a time t_0 depending upon the specific motion of the movable system. This motion, as is well known, may be either oscillating or aperiodic. (fig. 10, 11).

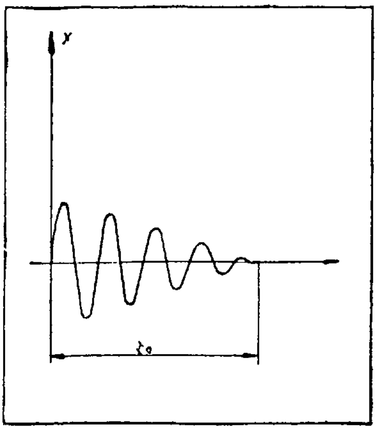

fig 10

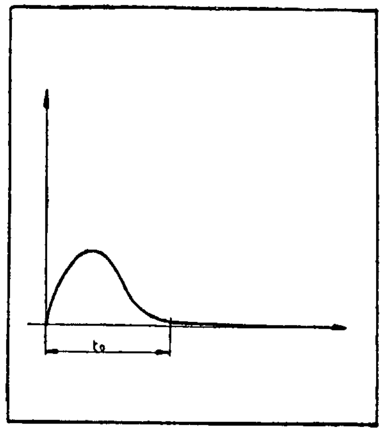

fig. 11

The sensitiveness of the Oscillograph will diminish as the damping of the oscillation system increases.

The damping of the oscillograph is obtained by a drop of thick oil (Mobiloil *C*) introduced between the back face on the palette 282 and the wall opposite of the duct containing it. The drop of oil is kept in place by a very light tuft of cotton-wool.

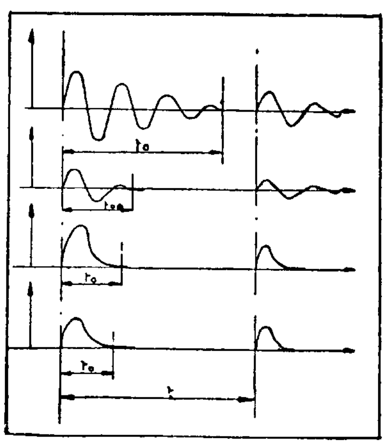

Fig. 12

In a sounding operation, the law of the displacement of the spot of light relative to time, for different rates of damping of the movable system, is shown by the curves (fig. 12).

c) *Support for the Oscillograph* (fig. 13-14).

For purposes of adjustment, the Oscillograph is mounted in the Analyser by means of a universal joint support. The two arms 119 and 120 of this support can be pivoted on the axis 121 and 122 by means of the screws 123 and 124. The spring 126 maintains the contact piece of the arm 119 in continuous contact with the screw 123. The weight of the arm 120 carrying the oscillograph presses its contact piece against the screw 124. The oscillograph is mounted on the arm 120. The screw 125 and the milled nut 298 serve to hold the oscillograph between the clamp 297 and the flat surface 299 of the arm 120. The front face of the oscillograph magnet should be placed against the inner surface of the contact piece 300.

The accurate placing of the oscillograph on the arm 120 is done by bringing the gauge mark 311 on the front face of the magnet in line with the gauge mark 301 on the contact piece 300. In this position, the two axes 121 and 122 of the universal joint device will intersect at the centre of the mirror, so that the adjustments made by the screws 123 and 124 will not affect the focussing of the image. This latter operation is performed once for all during the assembling of the optical Analyser at the works. The distances between illuminant and mirror and between mirror and image have fixed values.

2° *PASSAGE OF THE LIGHT RAYS IN THE ANALYSER* (fig. 15).

(Section on a horizontal plane).

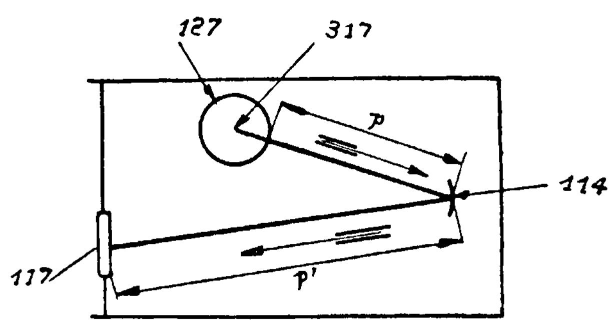

Fig. 15

317 is the filament; 127 the cylinder: 114 the oscillograph mirror; 117 the graduated scale.

3° *ROTATING THE HELICAL SLOT CYLINDER AT CONSTANT KNOWN SPEED.*

A. — Phonic Motor (fig. 16-17-18).

The cylinder 127 is mounted on the end of the shaft 165 of the *Phonic Motor* specially designed for Ultra-Sonic sounding. This is a kind of small alternator, the stator and rotor of which have 20 poles. The stator alone is wound; and is traversed by a battery current which is interrupted at an exactly uniform frequency of 40 complete pulsations per second, by means of a special vibrating strip which is kept in motion by electrical means (Gueritot Ticker). The soft iron rotor cannot start of itself, but it is rotated at such a speed that a pole of the rotor passes in front of a pole of the stator at each pulsation of the current, i.e. if the rotor speed is $\frac{40}{20} = 2$ revolutions per second, the rotor will come into step and the apparatus will operate as a synchronous motor. In such event it will rotate at an absolutely uniform speed.

Since the torque has a period of 1/20 of a revolution, the rotation is made uniform by giving the rotor and cylinder a high moment of inertia, and in this manner they serve as a flywheel.

The Phonic Motor (fig. 16-17-18) is an apparatus of great precision. The axis of the rotor is supported at the lower part by a thrust bearing and a ball bearing, and at the upper part by a ball bearing. The flanges of the motor are solid, in order to exclude all dust.

The advantage in the use of such a Phonic motor consists in the fact that *it rotates at the proper speed or else comes to a stop, and it can never run at any intermediate speed.*

B. — Gueritot Ticker (Fig. 19, 20)

This device comprises a special reed the vibration of which is electrically sustained; the reed is only slightly damped and is adapted to break currents of several amperes. The vibrating unit consists of a triple steel plate 142 (fig. 20) which is provided with a soft iron armature 143. The latter carries a screw 144 on which travels a regulating mass consisting of a pair of nuts separated by a Grover washer.

The reed is held by the nuts 146 and 147 (fig. 19) between the metal plate 148 which is movable and the plate 149 representing the earth connection of the device. The tungsten contact 150 (fig. 20) on the central reed vibrates between two tungsten headed screws 151 and 152 which are mounted respectively on the insulated pieces 154 and 153. The armature 143 vibrates in front of the poles of an electro-magnet 186 which is bolted to the armature 149. Since the axis of oscillation of the reed passes through the attaching points 146 and 147, the armature 143 and the contact 150 will move in opposite directions.

The circuits of the ticker are shown in Fig. 21.

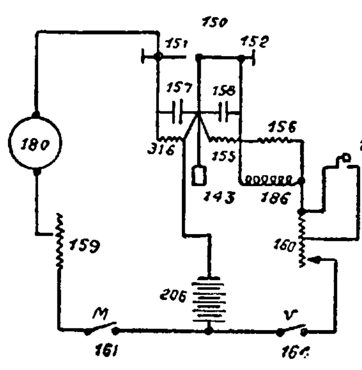

fig 21

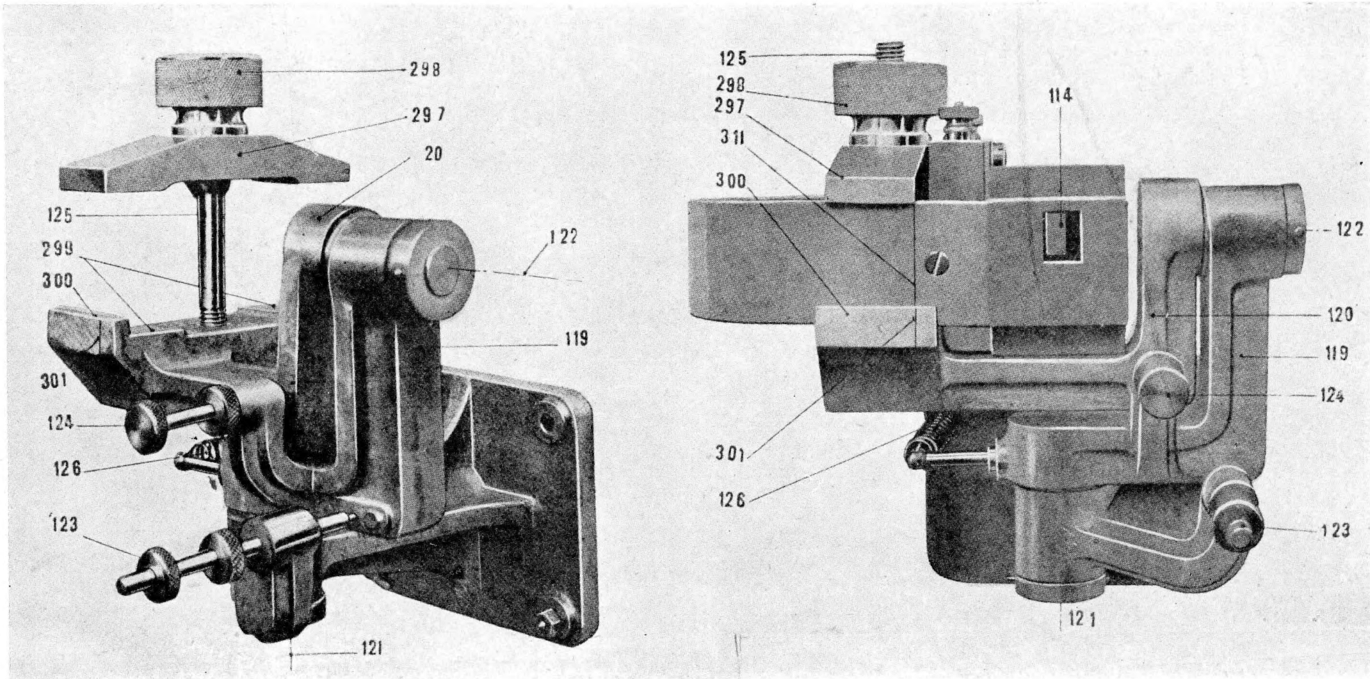
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Fig. 13, 14

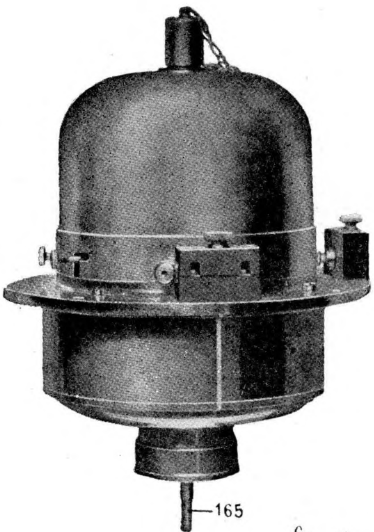


fig 16

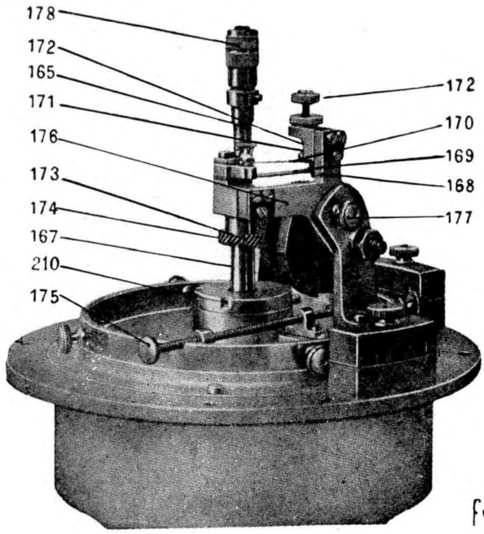


fig. 17

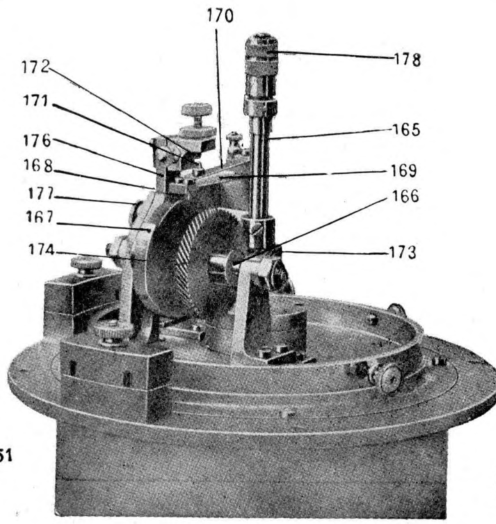


fig 18

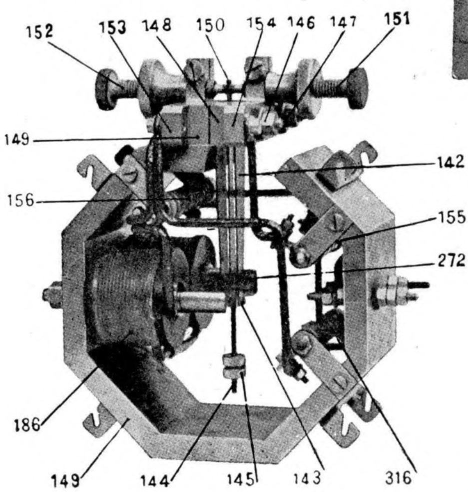


fig 19

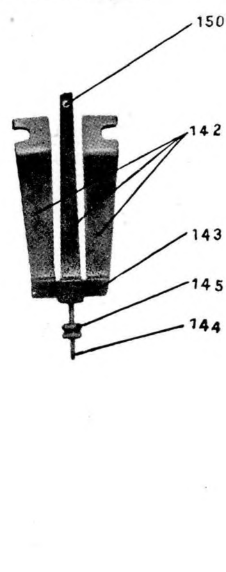


fig. 20

The apparatus is operated by connecting in series a battery 206, the electro-magnet 186 and the piece 153 carrying the screw 152.

The contact at 150-151 is employed to break the continuous current supplied to the stator of the phonic motor. The same battery serves to keep the reed in vibration and supply the motor.

The sparks at the contacts 150-151 are absorbed by the resistances 316-155-156 and the condensers 157-158. The resistances 316-155-156 are mounted on the armature of the ticker itself (fig. 19) and the condensers are mounted in the Analyser.

The resistance 159 is employed to regulate the current in the phonic motor: the rheostat 160 serves to regulate the amplitude of vibration of the reed.

The automatic starting of the ticker, after closing the circuit, is effected by adjusting the screw 152 so that when the device is at rest, the contact 150 presses rather strongly against the screw, and a space of about 0.5 $^m/_m$ separates the screw 151 from the contact 150 of the reed.

In these conditions, when the switch 164 is closed, the battery current flows through the electro-magnet 186 which now attracts the armature 143. As a rule, this attraction will not be sufficient to separate 150 from 151, and set the reed in operation.

Pressing the button 162 to short-circuit part of the resistance 160 will increase the attraction of the electro-magnet on the armature 143, so as to start the ticker. The contact 161 should not be closed until after the device is started, and should be opened before it stops. (In practice these operations are made automatically).

A scale graduated in millimetres 272 (Fig. 19) is placed in front of the reed and serves to indicate the amplitude of the vibrations, which is regulated by the resistance 160.

Normally, this amplitude should be from 8 to 10 $^m/_m$.

IV. — PRODUCING THE ULTRA SONIC EMISSIONS AT REGULAR INTERVALS.

1° Automatic contact breaker for the emission controlled by the Phonic Motor (Fig. 17-18).

The shaft of the Motor 165 actuates, through 2 : 1 speed-reducing gear, the horizontal shaft 166 carrying the cam 167. The latter when rotating will raise the steel friction member 168 (insulated from earth) of the spring 169, so that the spring 170 can rise and thus close the contact 171-172 to supply current to the primary of the coil 41 of the emission outfit (fig. 4). This contact remains closed for about 1/5 second. The cam then releases the friction piece 168, and the spring 169 will fall at a certain velocity, thus abruptly removing the contact 171 from the screw 172, and thereby causing the emission of a train of ultra sonic waves every second. The approximate setting of the emission in relation to the path of the spot of light on the scale is obtained by suitably setting the wheels 173, 174 or 167 on their shafts. The exact setting of the emission is performed by means of the screw 175 which turns the member 176, carrying the springs and the screw 172, around the shaft 166. The screw 177 (fig. 17) serves to hold the member 176 after the adjustment has been made. A hemispherical nickel-plate brass cap protects the breaking device; the milled button provided with a pawl 178 may be protected from shocks (which might bend the shaft) by means of a screw-cap.

The pinion 173 is fitted on the shaft 165 without any special adjustment. The shaft 166 is mounted between adjustable points. If the latter shaft is taken down, care is necessary to see that the median plane of the pinion 174 passes exactly through the axis of the cylinder 165, in order to avoid all abnormal friction and wear of the gearing.

The cylinder with the helical slot 127 is screwed on the lower end of the shaft 165 and is held by the set screw 179.

2° GRADUATED MEASURING SCALE.

The spot of light is projected on to a translucent scale 177. This vertical scale may be given a slight vertical adjustment by means of a screw controlled by the knob 194 on the panel.

3° MULTIPLE COMMUTATOR.

Fig. 22 represents the multiple commutator, which operates the several controls for starting and stopping the sounder by opening and closing the front door of the analyser.

The Société de Condensation et d'Applications Mécaniques, 10, Place Edouard-VII, Paris, has published, under the number N.U.S. 4-3, a full description of the above appliances, giving additional information concerning their working, adjustment and upkeep in every-day use.

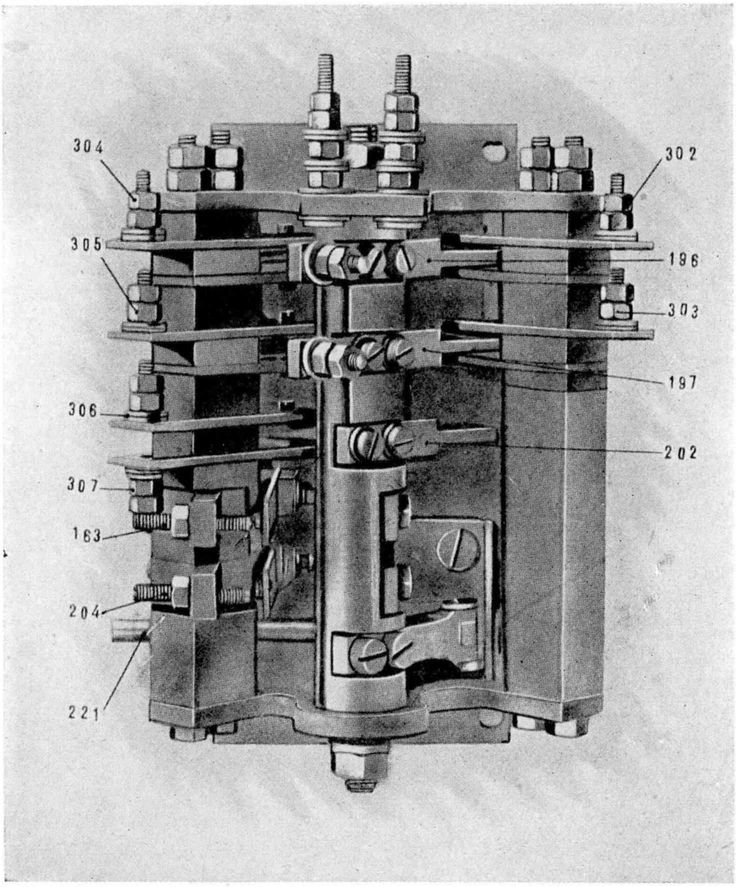


Fig. 22

MULTIPLE COMMUTATOR.
COMMUTATEUR MULTIPLE

II. — ACOUSTIC SOUNDING APPARATUS BY SUCCESSIVE SHOCKS OR DETONATIONS (MARTI System, 1927).

I. GENERAL PRINCIPLES.

The apparatus for continuous sounding, described in the present article, realizes the well known principle of measuring the depth of the sea by the determination of the "echo-time" which an acoustic wave takes to descend to the bottom of the sea, and return to the surface after being reflected by the submarine bed.

I. PRODUCTION OF THE SOUND WAVE.

The wave used ought to be both powerful and considerably damped, and since the intensity of the echo varies in proportion to the square of the depth, it becomes necessary to use several methods of wave production of different powers, to cover the whole range of depths in which the mariner may have to sound.

In usual navigable depths (from 12 to 200 metres and beyond), a blow struck on the frame of the ship by a metal body is used. This impact produces, in the water, a wave exactly similar to that of a small detonation; either a dead stroke-hammer, controlled by a steel cable, or an electric hammer, is used for this purpose.

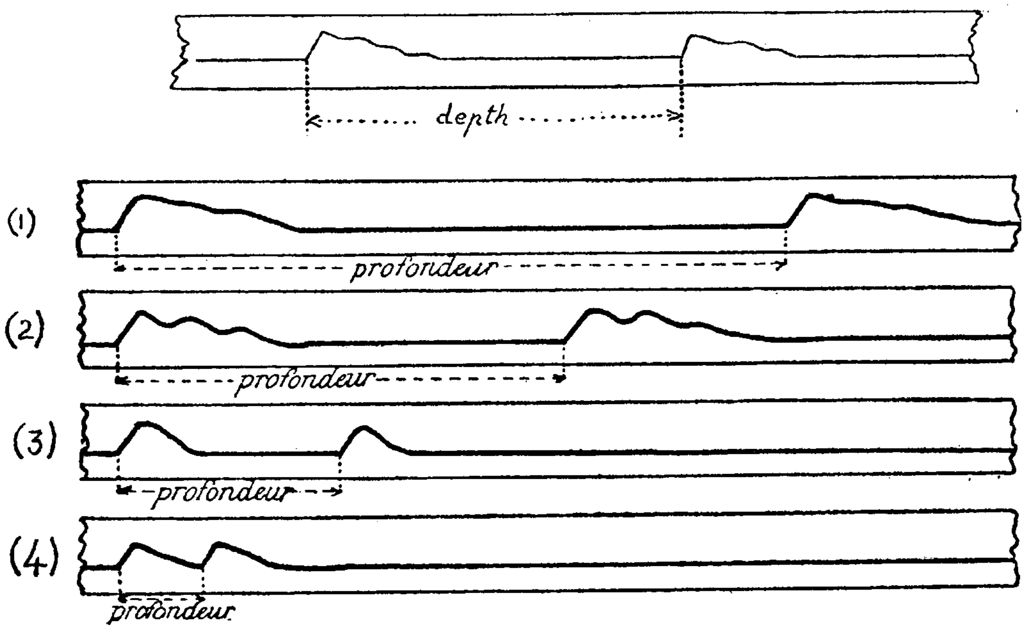
At greater depths (up to 1500 metres and above), the impact of a rifle-bullet on the surface of the water is used; this impact produces a wave of high power; according to the depth to be sounded, either small charges, or large charges firing bullets at high muzzle velocity are used.

At great and very great depths, a charge of explosive material of some tens of grammes is detonated in the water. This charge is fixed to a *"fish lead"* which remains submerged whatever the speed of the ship, and it is electrically fired by means of a cable.

II RECEPTION OF THE SOUND WAVE.

A microphone is mounted on the hull of the vessel at some distance from the point at which the sound wave is produced; in these conditions the microphone records two consecutive noises: the first, at the departure of the wave, the second, at the arrival of the echo.

The determination of the times separating these two noises is effected in the following manner; an amplifier, connected with the microphone, detects the acoustic phenomenon; the amplifier actuates a magneto-oscillograph, the deviations of which are shewn by a pen moving transversally over a paper band. This band unrolls at an absolutely constant speed — each sounding makes, on the trace, two indentations, corresponding respectively to the departure of the wave and to its echo (fig. 1) and the echo-time is deduced from the length of band unrolled between the two indentations. This length is measured by means of a transparent ruler graduated directly to the depth sounded. Shallow waters are accurately measured by means of a graduated magnifying glass.



Fig, 1

SOUNDING RECORDS - TYPES OBTAINED.

(1) Detonating cartridge.
(2) Rifle shot.
(3) Rifle shot-reduced charge.
(4) Blow of hammer.

Under these circumstances the indicated depth H_o should evidently be affected by a correction C depending on the distance D, which separates the microphone from the point of emission, and the respective distances of immersion I and J of these two points.

This correction, the value of which is

$$C = \frac{I + J}{2} + H_o \, (H_o \times D) - H_o$$

rapidly approaches a limit value

$$C = \frac{I + J + D}{2}$$

which is calculated, once for all, and applied when the depth is twice as great as the distance D.

III. INSTALLATION OF THE APPARATUS ON BOARD A VESSEL.

The *microphone* is fixed to the hull at a distance from the bow of about one third the length of the ship, and on the bottom plates, The *amplifier and the recording apparatus* are installed on the bridge, or in the immediate vicinity of the bridge, in a sheltered position:

The amplifier is mounted on a shelf which is fixed to a bulkhead: the recorder is enclosed in a cabinet fixed to a bulkhead or on a table. It is not necessary to fix these two instruments near each other.

The piles supplying the installation (consisting of 2- 4 volts batteries of large capacity, an 80 volts battery and a 40 volts battery) are mounted close to the appliances, in a convenient position. The wires connecting the various appliances (fig. 2) are marked by numbering the terminals, thus preventing any errors in the connections.

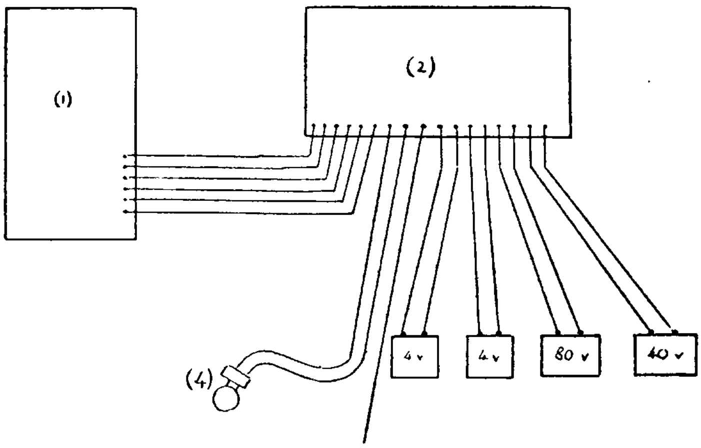


Fig. 2

PLAN OF CONNECTIONS.

(1) Recorder. (3) Earth (Hull of ship).
(2) Amplifier. (4) Microphone.

The 6 terminals $A, B, C, D, E, F,$ of the amplifier are connected to the corresponding terminals of the recorder.

The two terminals $M1$ $M2$ of the amplifier are connected to the microphone.

The terminal T of the amplifier is connected to the hull.

The 8 terminals +4, - 4, +4, -4, +80, -80, +40 - 40 are connected to the batteries, according to their polarities.

Only one insulated cable, with two conductors, passes through the ship from the bridge to the hull; it should be protected by a metal tube to prevent any deterioration.

The *hull hammer* is mounted on the framing of the vessel, below the water-line, at some distance from the microphone, so that the indentation caused by the departing wave may be of the same order as the indentation caused by average echoes. Generally the hammer is mounted at about ten metres from the microphone, so that they are separated from each other by some important mass in the ship (boiler, coal bunker, etc.) (fig. 3). The hand lever actuating the hammer (or the commutator of the electric hammer) is installed near the recording apparatus, so that one man can carry out the sounding.

In sounding by *rifle fire,* the fire-arm is installed, if possible, in the bow of the vessel, so that the bullet strikes the surface of the water some metres in front of the ship. However, shots may be fired from the bridge, by selecting an area free from air bubbles for the point of impact.

In sounding by *detonation* the gear for immersing the cartridge is fixed over the stern of the vessel, so that the wave caused by the detonation may exert a moderate influence on the microphone (fig. 3); the length of the cable should be sufficient to allow the cartridge attached to the lead, to be submerged at a greater depth than the propellers, notwithstanding the speed of the ship; a connection for transmitting orders is established between the bridge and the after part of the vessel.

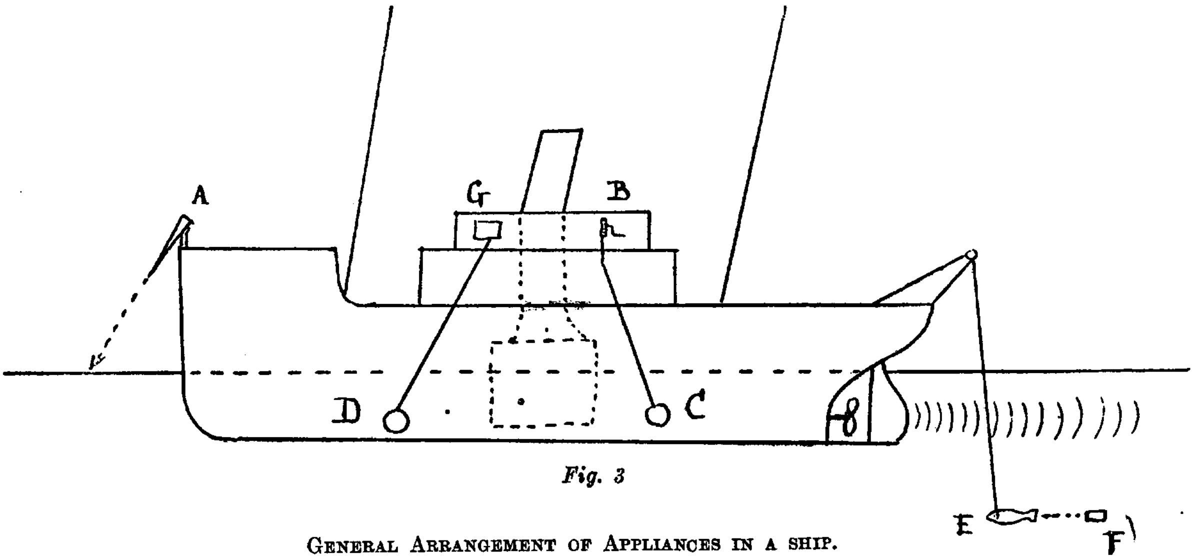


Fig. 3

GENERAL ARRANGEMENT OF APPLIANCES IN A SHIP.

A. Rifle.
B. Hammer handle.
C. Hull hammer.
D. Microphone.
E. Fishlead.
F. Detonating cartridge.
G. Recording appliances.

II. DESCRIPTION AND USE OF THE APPARATUS.

A. HULL HAMMER. (*)

The dead-stroke hammer consists of the dead-stroke hammer itself, which is fixed to the frame of the vessel and of a control handle mounted near the recording apparatus; a steel cable in a tube connects the hammer to the bridge.

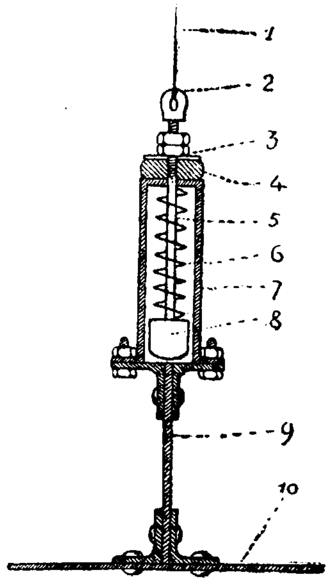
(*) The Bureau is informed by the makers of these appliances (Société Indépendante d'Exploitation Radio-Electrique, 76, Route de Chatillon, Malakoff - Seine, France) that there exists also an electric hull hammer, which operates automatically.

Hammer. (fig. 4). — The hammer consists of a cylindrical tube, having a collar on its lower end, which is fixed on the upper angle-iron of a frame of the vessel. Inside moves a solid steel head mounted at the extremity of a rod, terminated by an eye-bolt to which the controlling cable is secured: a powerful spiral spring, when it is released, drives the head violently to the bottom, thus causing a blow at very great speed.

Fig. 4.

SPRING HULL-HAMMER.

1. Cable.
2. Eye for cable.
3. Nuts and metal washer.
4. Rubber washer.
5. Hammer-rod.
6. Spring.
7. Cylinder.
8. Hammer.
9. Frame.
10. Bottom plating.



To prevent a second blow in rebounding, a thick indiarubber washer, on which rests a metallic washer attached to the rod, is inserted on the upper part of the cylinder; the adjustment is made by means of a nut and lock-nut, so that in the position of rest the head of the hammer is withdrawn about two millimetres from the frame on which it should beat.

Fixing of the hammer. — The position of the hammer on the hull should be chosen judiciously so that the full effect desired shall be obtained.

Firstly, it is fixed at fifteen metres from the microphone with, if possible, some important mass, such as a boiler or bunker, in between. Secondly, it is mounted, preferably, on a frame carefully riveted to the hull, which gives an excellent acoustic result, and avoids any work on the hull itself, and in consequence, dry docking.

A strong transverse frame of large dimension is selected for preference; the juncture of a transverse frame with a plate of a longitudinal bulkhead would be generally the best.

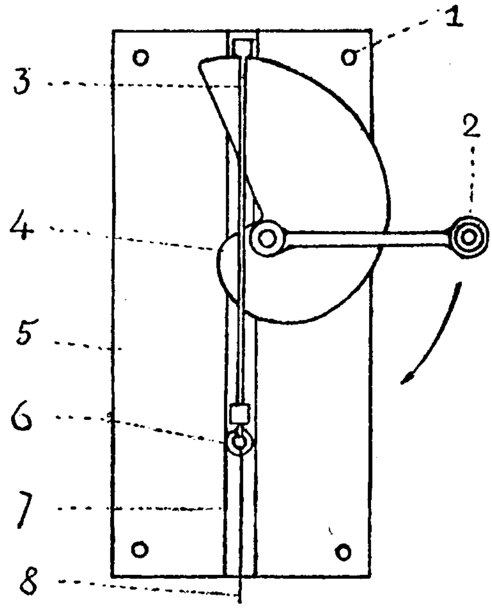
The controlling handle. — The handle apparatus consists of two rectangular plates secured by bolts, a groove running down the length of each of them, to provide a guide in which moves a rod. A spiral shaped cam, actuated by a handle, is mounted on an axle and moves the rod up and down: the rod is fitted with an eyebolt to which the control cable is secured. When the handle is turned the cam moves the rod which compresses the spring by the intermediary of the cable; the sudden fall and hammer blow are produced at the instant when the point of the cam disengages the rod bolt; the manœuvre does not require any special precaution; it may be repeated frequently at short intervals.

Connecting cable. — The connecting cable is a very strong steel cable, enclosed in a protecting tube; leading blocks are placed in positions where changes of direction are necessary.

Fig. 5.

HAMMER CONTROLLING HANDLE.

1. Assembling bolts.
2. Handle.
3. Stirrup.
4. Cam.
5. Plate.
6. Eye for cable.
7. Guide.
8. Cable.



B. THE GUN.

An arm of high muzzle velocity is chosen for preference, such as a rifle: by means of a Lebel rifle, for example, soundings up to 2000 metres have been obtained.

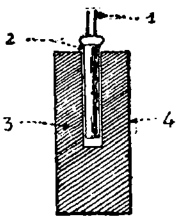
The same arm may be used for lesser depths by employing caliber reducers and smaller charges, which give good results at 400 metres.

When it is unnecessary to use the arm very frequently it may be held by hand, but for systematic use it is better to mount it on a special padded support to prevent the reactions of the recoil.

The best results are obtained by firing it ahead of the ship, from a position in the bow; but for convenience it may be necessary to fire from the bridge, when excellent results may still be obtained by firing in an area of water free from air bubbles.

C. DETONATING CARTRIDGES.

Cartridges. — Either a powder explosive is used, enclosed in a copper case with a receptacle for the detonator, or a gelatinous explosive simply enveloped in parafined paper; in the latter case the detonator is buried in the explosive.



1. Electric firing cable.
2. Detonator.
3. Explosive.
4. Thin walled metal container (fig. 6.).
Waxed paper container (fig. 7).

Fig. 6.

DETONATING CARTRIDGE FOR POWDER EXPLOSIVE.

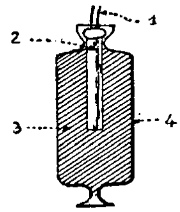


Fig. 7.

DETONATING CARTRIDGE FOR GELATINE EXPLOSIVE.

The charge depends upon the depths to be sounded; at 3.000 metres, a charge of 10 to 12 grammes is sufficient; to penetrate the greatest known depths charges of 100 grammes would be necessary; separate charges of, for example, 30 grammes each might be adopted, two or three of these charges being used simultaneously, according to the depth of water to be reached.

Electric detonators. Detonators with a strong charge of fulminate (2 grammes) are used, similar to those employed in mines. Electric wires, of 1 metre or 1 metre 50 in length, are used to bind the cartridge to the detonator; thus the cartridge is towed by the electric wires, without any direct pull on the detonator itself.

Immersion of the cartridges.

When sounding under way a "fish lead" is used; the insulated core of the cable suspending the lead, forms the firing circuit. (Fig. 9).

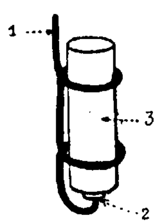


Fig. 8

METHOD OF ATTACHMENT OF THE CARTRIDGE TO THE FIRING CABLE.

1. Electric firing cable.
2. Detonator.
3. Cartridge.

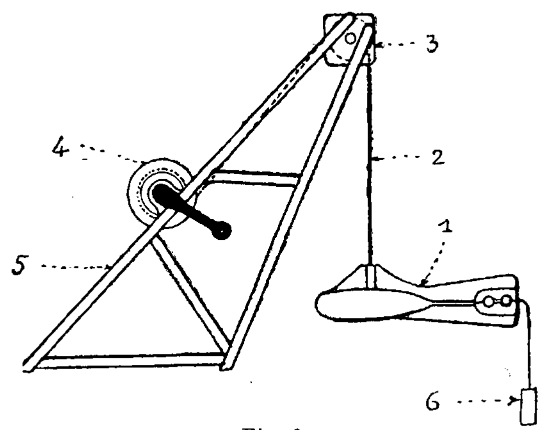


Fig. 9.

FISH-LEAD GALLOWS.

1. Fish-lead.
2. Suspending wire.
3. Sheave.
4. Hand-winch.
5. Gallows.
6. Detonating cartridge.

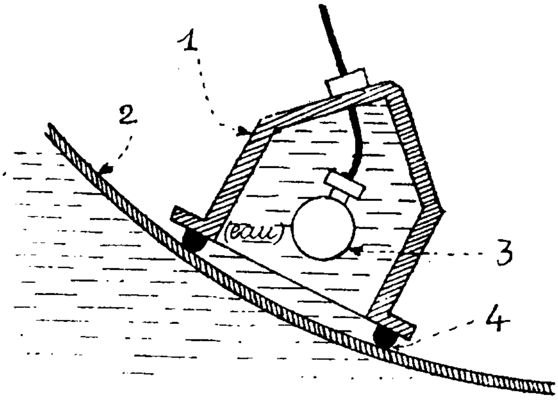
D. HULL MICROPHONE.

The microphone itself resembles a small watertight metal box, inside of which is fixed a microphonic capsule; this little box is contained in a thick cast iron case full of water, secured to the inside of the hull, and a rubber ring is placed between the case and the hull plating (Fig. 10) ; the electric cable is lead out of the case through a stuffing-box. In these conditions the apparatus receives, through the hull, the acoustic waves from the water in a very satisfactory manner ; moreover it may be examined or dismounted very rapidly without any difficulty.

Fig. 10.

MOUNTING OF MICROPHONE ON THE HULL

1. Metallic casing.
2. Bottom plating.
3. Microphone.
4. Rubber ring.

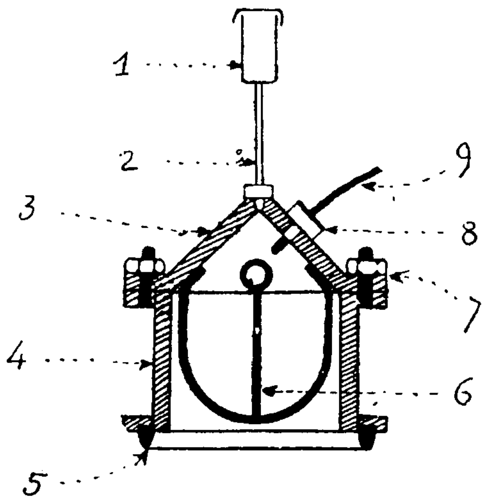


Microphonic case. — It is composed of a cylindrical cast iron case with collars, the lower collar being grooved to fit an indiarubber ring, which assures the water tightness. A conical castiron cover is fitted on the upper collar, water tightness being obtained by a greased paper washer (Fig. 11).

Fig. 11.

SECTION OF MICROPHONIC CASE.

1. Small reservoir.
2. Copper tube.
3. Conical cover.
4. Sleeve.
5. Rubber ring.
6. Small arches.
7. Cover tighteners.
8. Stuffing-box.
9. Electric cable.



At the top of the conical cover is an aperture, in which is screwed a hollow plug, to which is soldered a copper tube terminated by a small reservoir used for filling purposes when the case is first filled, and again for refilling after examination. In addition, on the side of the cover there is an aperture, with stuffing-box, for the passage of the electric cable ; inside the cover are two crossed arches to which the microphone is suspended.

Mounting of the microphonic case.

A position is selected for the case, away from the junctions of the plating; at the place chosen, the plating is cleaned over the necessary surface, the cement, should there be any, being removed with a chisel; the iron work inside the case should be covered with a coat of paint only.

The case is secured to the hull by means of two iron bar supports and clamping screws; the ends of the bars are fixed to adjacent frames by means of cast iron flanges with square holes; the two clamping screws of the case should be well tightened, so that the indiarubber is well squeezed between the case and the hull.

Microphone itself. The microphone consists of a small watertight bronze box, which is reinforced in the centre of its posterior side, on which is screwed a microphonic capsule. (Fig. 13). An electric cable with two conductors is led out of the box through a stuffing-box, and the two cables are soldered to the electrodes of the microphonic capsule, one of which is on the body of the box.

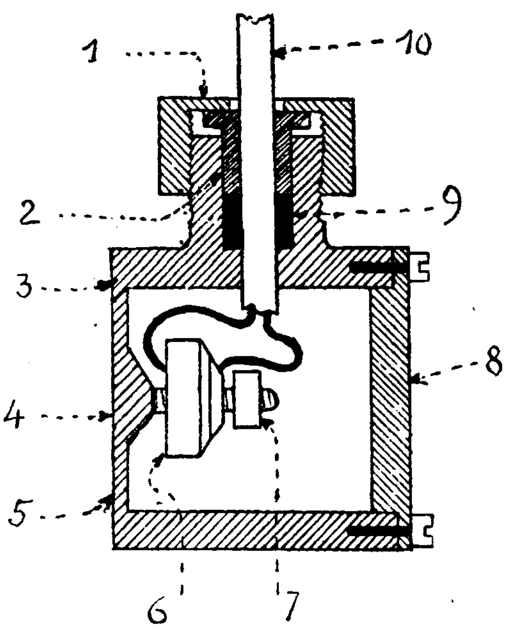


Fig. 13.

MICROPHONE.

1. Cap.
2. Stuffing-box.
3. Thick casing-side.
4. Reinforcement.
5. Thin casing-side.
6. Microphonic capsule.
7. Inertia-weight.
8. Cover.
9. Rubber packing.
10. Two-core cable.

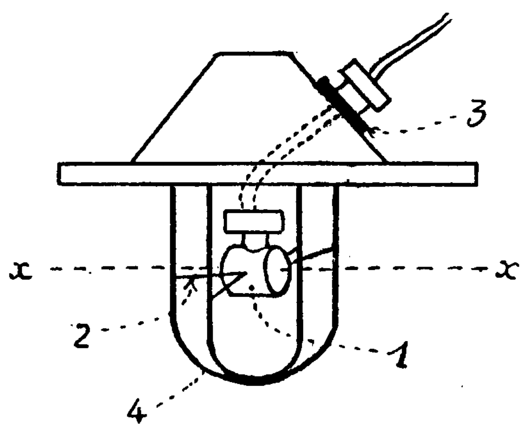


Fig. 14.

SUSPENSION OF MICROPHONE.

1. Microphone.
2. Steadying strings from microphone to arches.
3. Greased leather washers.
4. Small arches.

x-x. Parallel to fore and aft line of vessel.

The anterior side is secured to the cylindrical part by eight screws, a greased paper washer assuring the watertightness of the joint. The box is suspended over the arches of the case by means of two bronze eye bolts fixed to it, and oiled string. (Fig. 14).

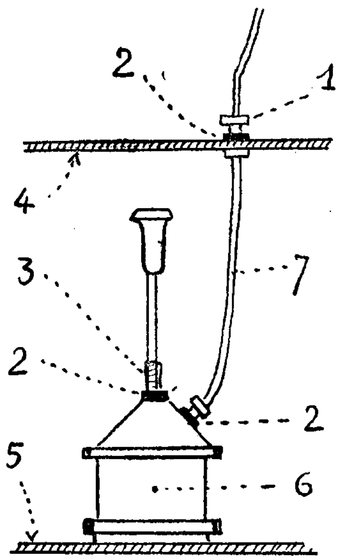
When the case is mounted it is filled with fresh water, to which a little lime has been added. The copper tube, with its reservoir, is then fixed in an accessible position; nevertheless, if the case is mounted in a tank it is preferable to shorten the tube so that the reservoir itself is in the water. (Fig. 15).

An important improvement is effected by fixing, around the microphonic case, a wooden box of about 1 metre cube, filled with sand. This arrangement would shield the microphone from the influence of noises of the ship, and would increase the sensibility.

Fig. 15.

MOUNTING OF MICROPHONE IN DOUBLE-BOTTOM

1. Stuffing-box.
2. Greased leather washers.
3. Rubber joining piece.
4. Inner bottom.
5. Outer bottom.
6. Microphone.
7. Electric cable.



E. AMPLIFIER.

The amplifier is of the special M. S. type, (constructed by S.I.E.R.) (*). Specially designed for detecting acoustic soundings, it amplifies and detects the oscillations to which the current passing through the microphone is subjected in order to deflect the stylus of a magneto oscillograph traversed by this current.

F. RECORDER.

The Recording Apparatus. The measurement of the time which separates departure of the wave from its echo is effected by means of a recorder with special paper band. The organs of this apparatus are enclosed in a cabinet which may be placed on a table or fixed to a bulkhead.

The paper band unrolls at an absolutely definite speed. By means of a stylus, a magneto oscillograph inscribes on this band, in the form of indentations, the variations which the current from the amplifier undergoes under the influence of the acoustic phenomena.

This specially prepared paper band, owing to its capillary properties, rapidly absorbs the ink. The band issues from a serpentine roll of paper,

(*) Société Indépendante d'Exploitation Radioélectrique, 76, Route de Chatillon, Malakoff (Seine).

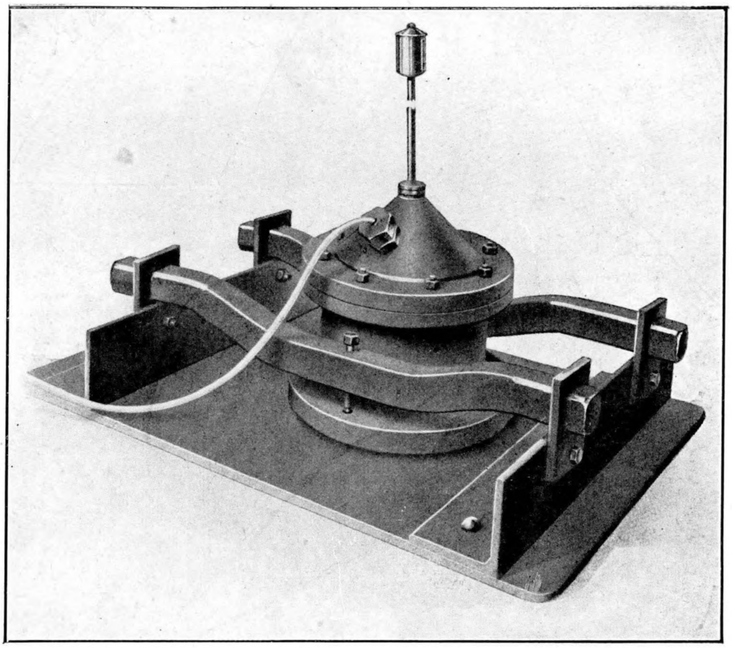


Fig. 12

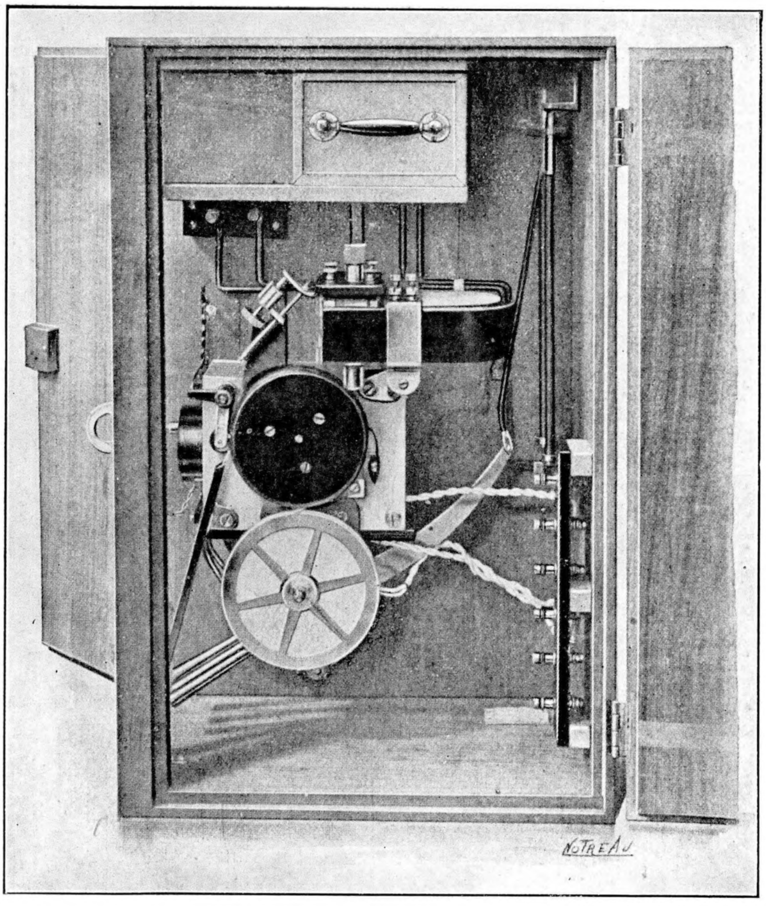


Fig. 16

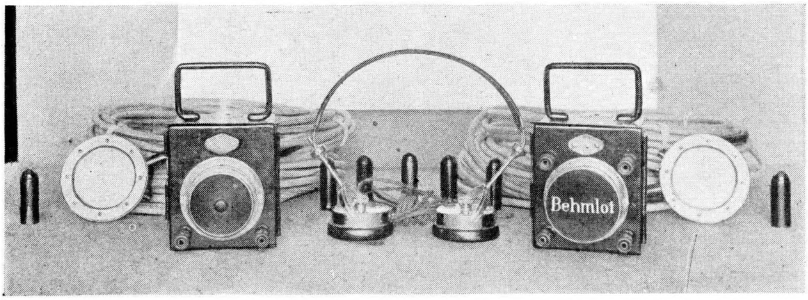


Fig. 1

Behm Deep Sea Sounder for Amundsen's journey to the North Pole.
Sondeur Behm par grands fonds utilisé pendant le raid d'Amundsen au Pôle Nord.

Fig. 6

Original Sounding near the North Pole
Sondage effectif près du Pôle Nord.

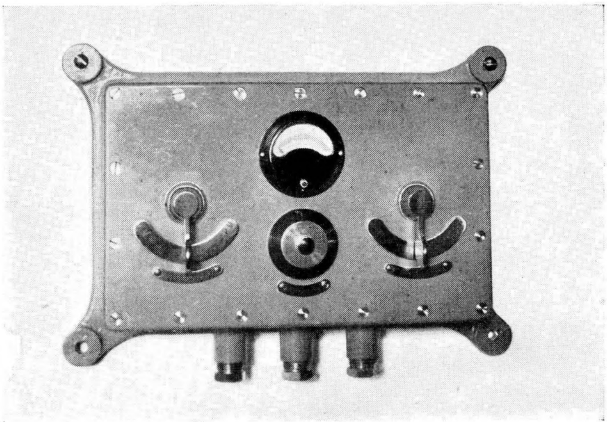


Fig. 8

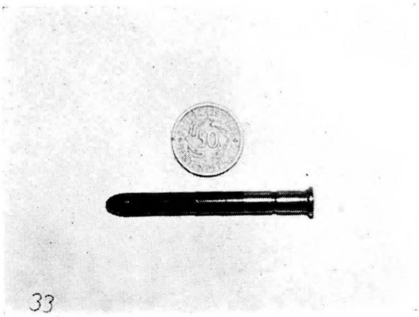


Fig. 10

Type iv. S. Cartridge

Cartouche, type IV S.

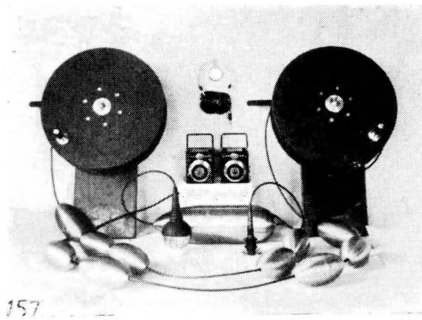


Fig. 12

Behm Sounder for General Nobile's Airship Journey to the North Pole, 1928.

Sondeur Behm
pour l'expédition au Pôle Nord en dirigeable du Général Nobile, en 1928.

passes onto a driving drum, then falls outside the box, between small lateral guides.

The rotation at constant speed is obtained by means of clockwork mechanism, the spring of which is wound up by hand; the regularity of the speed, which is absolutely necessary, is assured by a regulating contrivance based on centrifugal force, the action of which is entirely mechanical; this regularity may, moreover, be controlled at any instant by the device of a coloured mark. The speed can easily be regulated to within less than one per cent of its defined value and, in consequence, accurate indications of soundings may be obtained.

The magneto oscillograph (Abraham type) is fixed to the frame of the clock-work mechanism; its stylus is a very fine nickel tube, one end of which rests on the paper; the other is connected by a rubber pipe to an ink-well sliding along a guide fixed on the bottom panel of the chest so that the ink may be brought into use only at the moment when the apparatus is used.

The general working is controlled by 3 hand-levers, mounted on the same axis; the first controls the clock-work mechanism; the second closes the microphone and heating apparatus circuit; the third controls the paper connecting gear and the flow of ink.

III. — USE OF THE SOUNDING MACHINE.

Generally the extent of the depths to be sounded is known, and therefore the source of sound to be used may be selected; as a rule the hammer is used for depths below 200 metres, the gun below 1500 metres, and the detonating cartridge for the greatest depths. If, on the contrary, there is no indication of the depth to be sounded, the most suitable source of sound is first sought; a start is made with the feeblest source (the hammer) and if it does not give an echo the gun is then tried, and lastly the detonation cartridges — which should give an echo whatever the depth.

The head phones should always be used during the first attempts at sounding; the phenomenon may easily be discerned by ear, even in the midst of parasitic noises should there be any, due to heavy weather, and a clear idea may be got by ear of the proper functioning of the apparatus.

The sensitiveness to give to the apparatus obviously depends on the depth. If a superabundant energy is determined upon (for example the hammer at 50 metres or the gun at 400 metres) a moderate sensitiveness of the reception suffices. If, on the contrary, the echo is feeble a great sensitiveness is necessary; this is obtained by increasing the variable capacity of the amplifier.

Nevertheless, it must never reach a sensitiveness such that parasitic noises appear on the trace; the latter should remain quite rectilinear except for the indentations; thus very clear indentations are obtained, and the reading is made with the greatest accuracy between the starting points of the indentations.

The execution of the soundings is quite a simple operation, as it can be done as frequently as desired, several times a minute. The three hand-levers of the recorder are lowered, and the moment is awaited when the mark of of the regulator indicates, by the appearance of the white spot, that the apparatus has attained its normal speed. Then an acoustic sound is sent out; when the echo is recorded, which is immediate except for great depths, the recorder is stopped by raising the three levers; the end of the band is then cut off, and the distance which separates the two initial points of the indentations is measured by means of the transparent rule, graduated directly in depths, or by the graduated magnifying glass for shallow depths.

III. — THE "BEHM" ECHO SOUNDERS, type IV. A, IV. S, IV. N.

Among the numerous types of Behm Sounders which have been created by Behm, a physicist of Kiel, the type IV. A is especially adapted and designed for scientific exploration expeditions into regions which are uninhabitable and difficult of access. It was constructed by Behm for Amundsen's first aeroplane journey to the North Pole, his equipment onboard the aeroplane including this type of Behm Sounder which he used for deep sea soundings at his landing places. (fig. 1 & 2). The weight of this Behm Sounder type IV. A, shown in Figure 1, is only 9 kilos, and it is operated in the following manner:— A Behm Sounder cartridge is attached to one end of the firing head cable provided with a clamp (fig. 3. Behm Sounder cartridge). The other end of this cable

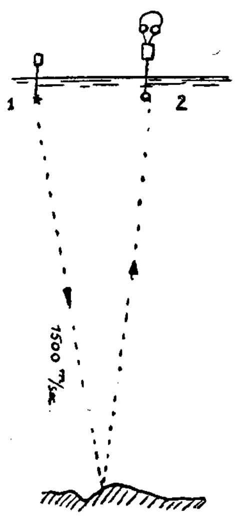


Fig. 2.

1. Cartridge.
2. Receiver.

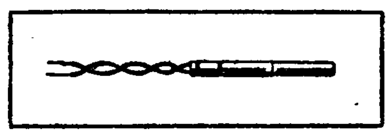


Fig. 3. — Cartridge.

is connected to a small battery casing containing a dry battery for firing the Behm Sounder cartridge electrically. This battery case has on its front side a switch and a push button in order to have a double security against accidental firing of the cartridges. When soundings are to be taken, the cartridge is fired by pressing the front button after the main switch has been connected. The echo-receiving device consists of a special echo receiver which, when soundings are to be taken, is placed about three to four metres deep into the water, in the same manner as the cartridge. The sensitivity of the echo sounder may be adjusted by varying the position of the receiver as shown in Fig. 4. This is practical, as the explorer will not always have perfectly calm weather and water for his soundings, and as complicated contrivances for adjusting the sensitivity must be avoided. The electric current for the echo receiver is also supplied by a dry cell contained in the same casing that has been mentioned above in connection with the firing outfit.

Soundings are taken in the following way :- The observer places the Behm Sounder cartridge and the echo receiver in the depth of water given above, leaving a space of about 30 m. between cartridge and echo receiver. He then takes a stop-watch for readings of one-hundredths of a second, and fires the

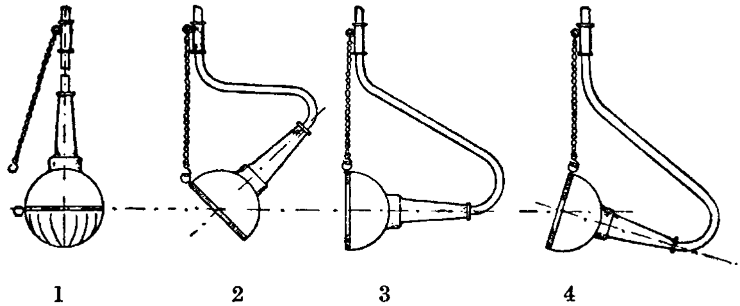


Fig. 4. — RECEIVER FOR BEHM SOUNDER TYPE IV. A.

1. Insensitive.
2. Sensitive.
3. Highly sensitive.
4. Excessively sentitive.

Behm Sounder cartridge by pressing the firing button fitted to the firing cable. At the moment the detonation is heard by him in the head-phone connected to the echo microphone, he starts the watch, and stops it immediately he hears the echo reflected by the sea floor. Remember that both the firing detonation and the echo are heard by the observer. As the time interval

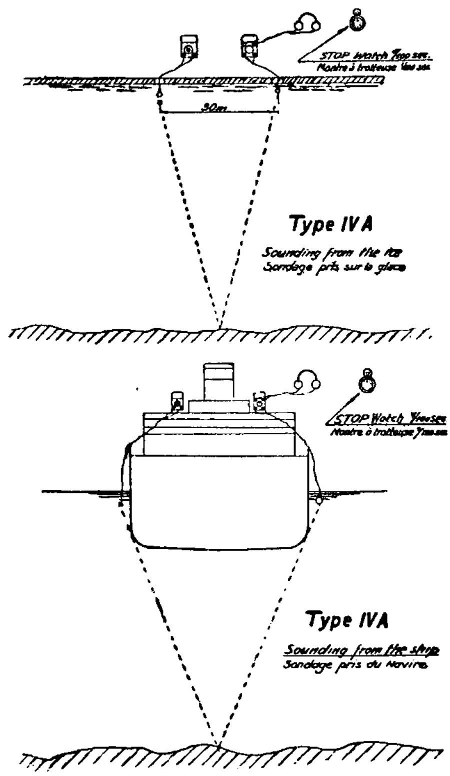


Fig. 5

which elapses until he starts the stop watch is equal to that which elapses until he stops it when the echo is received, the personal equation in starting and stopping the watch cannot have any influence on the measuring results, the delay in starting the watch being equal to the delay in stopping it. In 1926, AMUNDSEN took soundings near the Pole, recording 3,750 m. and, with reference to this, he writes to BEHM the following :-

> "Owing to the apparatus we were able to take deep-sea soundings at our landing-place. Naturally, we would not have been able to take onboard the aeroplane the usual sounding outfit of lead and line. Without your excellent device, we would have had to refrain from obtaining this interesting information."

Considering the small weight of this type of Behm Sounder, it had even been contemplated by AMUNDSEN, should extraordinary circumstances make it necessary, to make his way back on foot, and to carry the outfit with him for the purpose of taking deep-sea soundings at reasonable distances apart (fig. IV.)

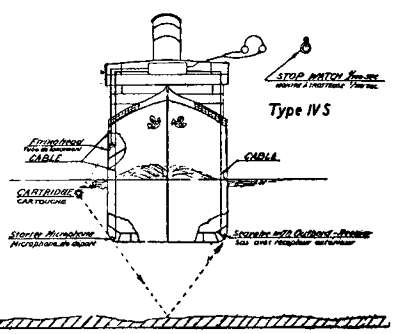
In 1927, Captain WILKINS used a type IV. A Behm Sounder which had been placed at his disposal by the *American Geographical Society* of New-York, and with this instrument he recorded as much as 5,625 m., which is the greatest depth ever ascertained by soundings in the Arctics. With reference to this, the *American Geographical Society* published in the *Geographical Review* of July, 1927, the following:- "Captain WILKIN'S Arctic Expedition of 1927"-

> "..
>
> "Through a hole cut into the ice, here 3½ feet thick, soundings were taken by a Behm Sounder, the light portable type of Sounder being employed, which was supplied through the *American Geographical Society*. By the echoes received, a depth of 5,625 m. or 18,450 ft was recorded, this being the greatest depth hitherto ascertained in the Arctics". (*)

Needless to say, this type of Behm Sounder may be used not only for soundings to be taken from the ice, but also from ships by simply hanging the firing head and the receiver overboard, the size of the vessel being immaterial in this case. It is only necessary to stop the vessel while the soundings are taken.

Fig. 7.

BEHM SOUNDER
TYPE IV. S.



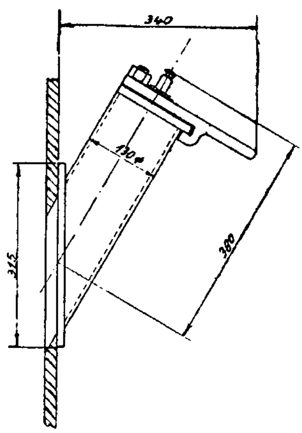
(*) The BEHM ECHOLOT GESELLSCHAFT informs the Bureau that the same instrument will be used by Captain WILKINS on his projected flight from Ross Sea to Graham Land during the coming Anctartic Summer — A second instrument, belonging also to the *American Geographical Society*, has been taken by the Stoll-Mc. Cracken Expedition which left early this summer under the command of Captain R. A. BARTLETT for Bering Sea and the Arctic Sea north of Eastern Siberia.

If it is desired to take soundings from the moving vessel, the type IV. S of Behm Sounder (fig. 7 et 8) is required.

The difference between the outfit of the type IV. A and that of the type IV. S is that for the latter type an echo receiver of another construction is permanently fitted into the hull of the vessel (which fitting work can, of course, only be done while the vessel is dry-docked), instead of the portable receiver for hanging overboard. The type IV. S is also equipped with a stationary Firing-head (fig. 9.) fixed to the shell plating, a different type of Behm Sounder cartridge from that for type IV. A being used for this firing-

Fig. 9.

FIRING HEAD.



head. This cartridge (fig. 10) consists of two parts, namely the shell with the propelling charge, and the detonator with the detonation charge and time fuse. By pressing the firing button, the propelling charge of the cartridge placed in the firing-head is fired electrically, and the explosion of the gases developed by ignition of the propelling charge, forces the detonator into the sea. The casing of the detonating charge is made of aluminium and is the size of an army rifle projectile. In its after end there is a time fuse which is also ignited during the firing process. The time fuse continues burning on its own oxygen after the detonator has been shot into the water. As soon as the time fuse stops burning, which will be the case in about 2 m. depth of

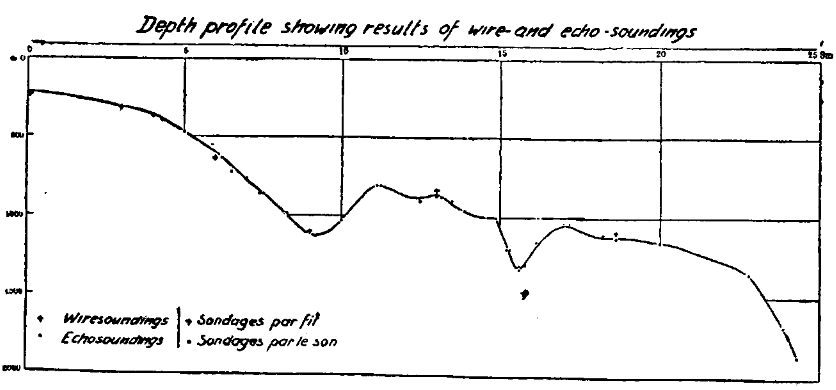


Fig. 11

water, the detonating charge will explode, generating the sound-wave required for taking the echo-sounding.

The first time that this type of Behm Sounder was employed was in 1926 when the track for the German submarine cable to the Azores was surveyed.

The tables given in the annexes show part of the results of the Behm Soundings which were checked by wire soundings. (fig. 11. Depth profile - Table n° 1 Sounding Results).

TABLE No. 1.

WIRE AND ECHO SOUNDINGS ON MAY 23rd AND 24th, 1926.

No	*Position of Vessel*		*Distance between Positions Miles.*	*Depths in metres.*		*Difference Percentage*	*Samples of Bottom Soil.*
	Latitude North.	*Longitude West.*		*Wire Sounding.*	*Echo Sounding.*		
	Degr.	Degr.					
1	47.86	7.53	-	206		—	—
2	47.83	7.59	3.0	324	—	—	Sand, Mussels.
3	47.80	7.65	3.0	630	616	— 2,2	—
4	47.77	7.71	3.0	1115	1122	+ 0,6	Mud, Clay.
5	47.74	7.79	4.0	825	864	+ 4,7	do.
6	47.71	7.85	2.8	1460	1298	—11,0	do.
7	47.68	7.90	2.8	1085	1128	+ 4,0	—
8	44.50	9.67	—	5007	4904	— 2,0	Mud.

Table N° 1. shows the results of the wire and of the corresponding echo soundings taken on May 23rd and 24th, 1926. Between the individual wire soundings, echo soundings were continuously taken, the depth profile of the track covered by soundings being drawn up according to the wire and echo soundings taken.

The depth figures in Table N° 2 ascertained by the echo sounder are average values from various soundings. The differences in the depths recorded by wire and echo soundings may also be seen from Table N° 1. With the exception of sounding N° 6, all the sounding results are within 5 % of the wire soundings.

TABLE No. 2.

RESULTS OF SOUNDINGS OBTAINED BY THE BEHM SOUNDER FITTED ON CABLESHIP "*NORDERNEY*", ON AUGUST 29th and 30th 1926.

N°	*Position of Vessel.*		*Depths*	*Remarks.*	*N°*	*Position of Vessel.*		*Depths*	*Remarks.*
	Latitude North.	*Longitude West.*	*metres.*			*Latitude North.*	*Longitude West.*	*metres.*	
	Degr.	Degr.				Degr.	Degr.		
1	39.21	24.76	3819	stopped.	12	38.30	27.12	1478	vessel moving
2	39.25	25.03	3855	»	13	38.30	27.22	1573	stopped.
3	39.07	25.35	3075	»	14	38.30	27.33	1730	vessel moving
4	38.92	25.67	2749	»	15	38.28	27.50	1593	»
5	38.73	26.03	2361	»	16	38.28	27.60	1551	stopped.
6	38.55	26.35	1985	vessel moving	17	38.28	27.70	1665	vessel moving
7	38.47	26.48	1679	»	18	38.30	27.92	847	»
8	38.35	26.68	2167	»	19	38.30	27.98	1732	stopped.
9	38.30	26.85	918	»	20	38.33	28.40	1348	»
10	38.30	26.94	907	»	21	38.44	28.55	719	vessel moving
11	38.30	27.03	1103	»					

The deviation of minus 11 % between the wire sounding and the Behm sounding N° 6 is due to certain circumstances. An explanation for this deviation will be found if one stops to consider the following: As shown by the depth curve given with table N° 1, the sounding N° 6 was taken in a narrow channel on the sea bottom. The sound waves of the echo soundings are reflected by the two borders of this channel sooner than from the bottom of it. This accounts for the fact that in this place the depth was recorded with a lower figure than the actual depth figure. For this reason, the depths ascertained by the echo sounder are marked on the chart not as the actual depths but as echo sounding depths. The soundings given in Table N° 2. have been taken partly when the vessel was stopped and partly on the moving vessel, and about one-half of the number of soundings were checked by wire soundings.

For General NOBILE's recent journey to the North Pole by airship, a special type of deep-sea sounder has been constructed by BEHM (fig. 12.), with which it is possible to take deep-sea soundings in elevations up to 200 m. in the air from the stopped or very slowly-moving airship, the type IV. A of Behm Sounder described before having been suitably modified for that purpose. This modified type IV. N differs from the type IV. A in that the cables of corresponding length for the cartridges and the echo receiver are provided with a number of floats by which the cables are kept floating on the water surface (fig. 13). In order to prevent the cartridges with the clamps on the

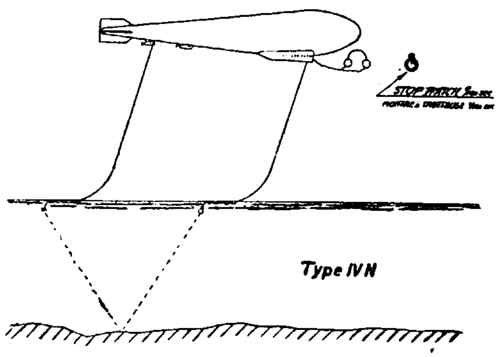


Fig. 13. — Behm sounder, type IV. N.

one hand, and the echo receiver on the other hand, from sinking, a large stream-line shaped float is arranged for each. Two cable reels of light weight allow the firing head and the receiver to be conveniently lowered into the water and to be wound up again. Otherwise the method of operating this type is exactly the same as that of type IV. A.