ECHO SOUNDING (*)

V.

Below is given a summary of the information which has reached the I. H. B. since the last publication issued by the Bureau dealing with this subject, i. e. between August 1926 and 31st December 1927.

In response to a recommendation expressed by the 2nd International Hydrographic Conference at Monaco, November 1926, the Bureau, by Circular-Letter N° 32 of 26th November 1926, requested the countries not having yet sent in reports on the question, kindly to do so.

Certain countries have complied with this request and, also, the Bureau has entered into correspondence with the manufacturers of such appliances, who have been good enough to forward documents.

Replies have been received from the following countries :

PORTUGAL replied that it had not as yet made use of echo-sounding but that, should such become the case, a report would be forwarded.

The HYDROGRAPHIC OFFICE OF THE UNITED STATES sent a report which is reproduced in Special Publication N° 1 of the I. H. B. (p. 9).

CHILE has informed the Bureau that it does not possess a vessel fitted with echo-sounding apparatus.

JAPAN writes that experiments are at present being made.

The COMMONWEALTH OF AUSTRALIA has replied that H. M. A. S. "Moresby" has been fitted with an Echo-Sounder and has promised to forward a report shortly.

GREAT BRITAIN, the UNITED STATES OF AMERICA and GERMANY have forwarded the following comprehensive information :

(*) *See Special Publication* N° 1 — Dec. 1923.
— — — N° 3 — Oct. 1924.
— — — N° 4 — March 1925.
— — — N° 14 — August 1926.

I. — THE BRITISH ADMIRALTY ECHO SOUNDER.

Very precise information on the principle, the description and the working of this apparatus has already been given in the I. H. B. Special Publication N° 4 (March 1925), pages 10 and 15, and in Special Publication N° 14 (August 1926) pages 26 to 28. It has not been considered necessary to repeat here what has already appeared in print and the reader is therefore asked kindly to refer to the publications mentioned for preliminary information under this heading.

The Admiralty has for some time been testing the design, which is the outcome of the work of members of the staff of the Admiralty Research Laboratory at Teddington, and has now adopted a service pattern which will be used not only in vessels of the Royal Navy, but will be available for the ships of the mercantile marine.

The cost of the apparatus is about £ 350. It is made in two patterns, for use in "shallow" water and deep water respectively, in the former case covering all the requirements of ordinary navigation, and in the latter being adapted for great depths, such as would be met with by the cable-laying companies. The sole manufacturers of the design are Messrs. Henry Hughes and Son, Ltd., the well-known nautical instrument makers, of 59 Fenchurch Street, London E. C. 3 (Husun Works, Barkingside, Essex) manufacturers under licence from the Admiralty.

A) THE ECHO-SOUNDING MACHINE (SHALLOW WATER TYPE — MARK II.)

The following particulars have been communicated to the Bureau by the Hydrographic Department of the British Admiralty; they are extracted from the Admiralty Handbook on Shallow Water Type (Mark II), drawn up by Lieutenant ALAN JONES, R. N. This pamphlet may be procured direct from H. M. Stationery Office, Adastral House, Kingsway, London, W.C. 2 — Price 6d. net.

The drawings have been supplied to the I. H. B. by the firm of Hughes and Son, Ltd.

The essential features of this sounding equipment are:

1. Apparatus to produce a sound wave under water, known as the transmitter.
2. A sensitive receiver of the echo reflected from the sea bed, known as the hydrophone.
3. The recording gear for measuring the interval of time between the sound impulse and the sound echo.

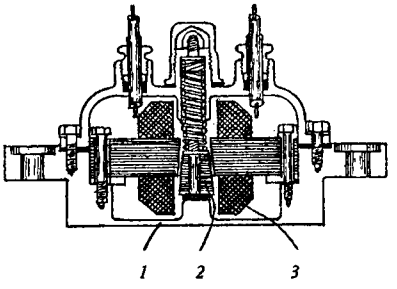


FIG. 1

1. Hammer. Marteau.
2. Solénoïd. Solénoïde.
3. Diagram. Diagramme.

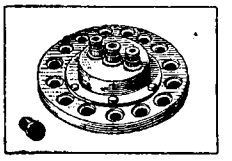


FIG. 1 *bis*

TRANSMITTER :

Figure 1 shows the arrangement of the transmitter which acts at regular intervals 3 times per second.

Figure 2 explains the method of fixing the transmitter aboardship without its being necessary to pierce the hull. A tube-opening permits the pocket to be filled with fresh water.

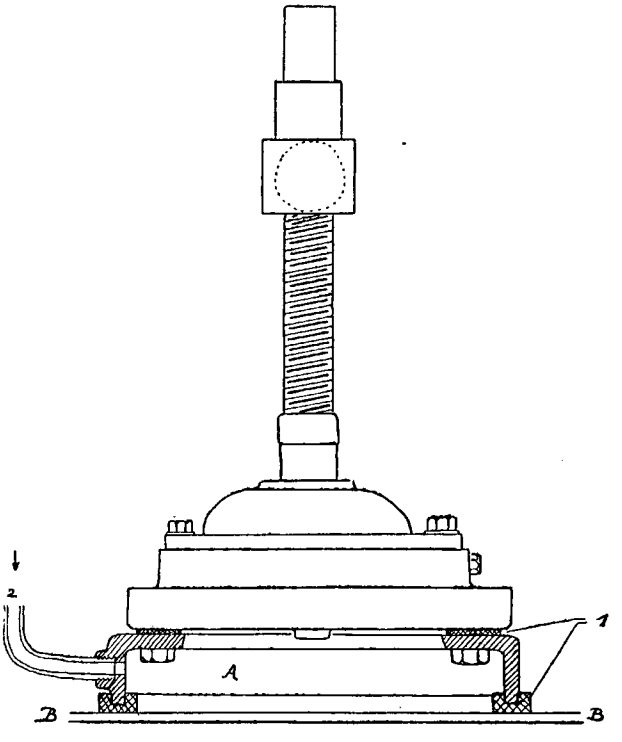


FIG. 2

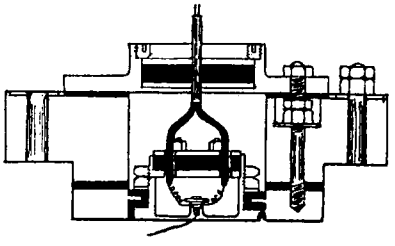
1. Dermatine.
2. Water inlet. Conduite d'eau.

A. Filled with fresh water. Rempli d'eau douce.
BB. Ship's shell. Coque du navire.

The motor and transmitter are arranged to work on the ship's mains and dry cells, fixed in the receiving box, supply the Microphone.

RECEIVER.

Figure 3 gives details concerning the receiving hydrophone and Figure 4 explains how it it fixed and suspended in the ship's interior.



Microphone

FIG. 3

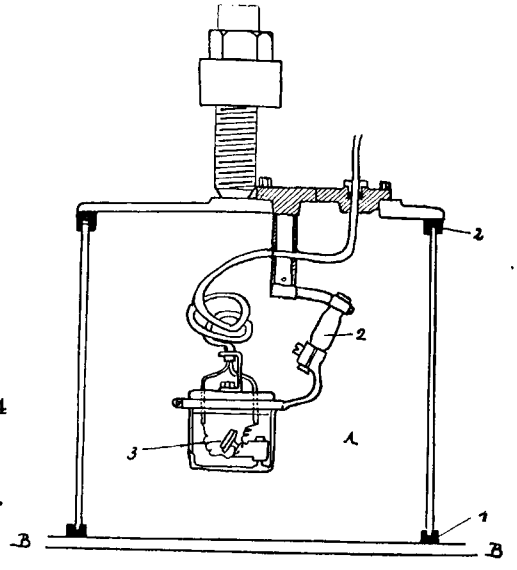


FIG. 4

1. Dermatine.
2. Rubber — Caoutchouc.
3. Microphone facing towards centre of ship. Microphone tourné vers le centre du navire.

A. Filled with water — Rempli d'eau.

BB. Ship's shell — Coque du navire.

The HYDROPHONE is placed on the opposite side of the ship from the transmitter, and consists of the usual type employed in submarine cables.

The receiving hydrophone is a simple microphone enclosed in a rubber body immersed in water. This type of hydrophone is comparatively aperiodic, and has been found suitable for the work, since it is necessary, when one is dealing with such small time intervals, that both the t ansmitter and receiver should act quickly and not confuse the original sound and the echo by continuing to vibrate after an impulse.

RECEIVING GEAR.

The Receiving Gear is enclosed in a watertight case which serves to control the apparatus and to register its indications.

It is placed on the bridge. A writing table is fixed to the front door of the case which has a glass window for reading the fathom scale and a handle at the side of the case for operating the fathom scale without opening the case. In addition, the earphones are attached to this receiver.

Photographs 5 and 6 show the contents of the case.

The 1/8th horse power electric motor running at 1,000 revolutions per minute, drives two switches through a 10-1 reduction gear. Constancy of speed within 1 per cent is obtained in spite of large variations in the supply voltage by the use of a specially designed centrifugal friction governor (Fig. 7).

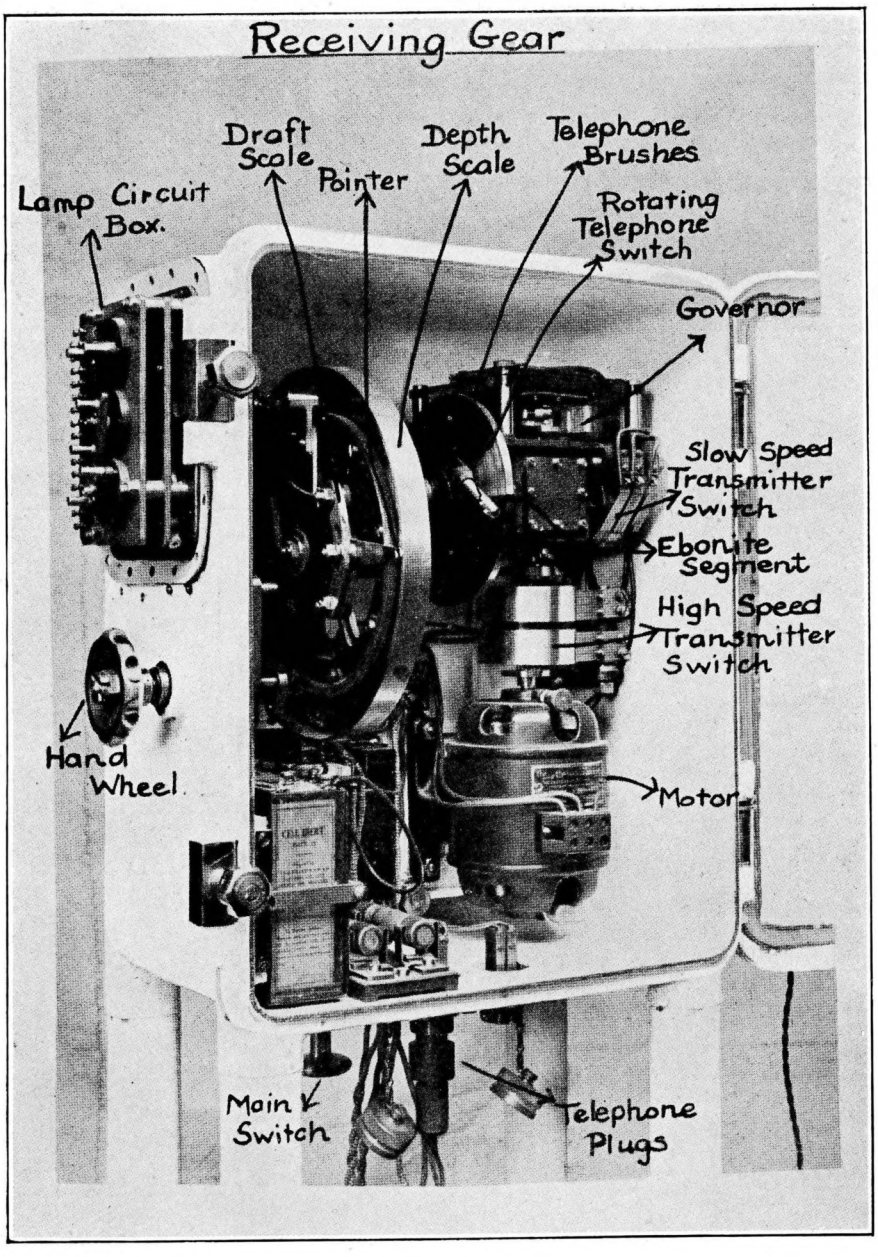


FIG. 5

Receiving gear.
Hand-wheel.
Lamp circuit box.
Draft scale.
Pointer.
Depth scale.
Telephone brushes.
Rotating telephone switch.
Governor.
Slow speed transmitter switch.
Ebonite segment.
High speed transmitter switch.
Motor.
Main switch.
Telephone plugs.

Mécanisme récepteur.
Manette.
Boîte de circuit des lampes.
Echelle pour le tirant d'eau.
Index.
Echelle des profondeurs.
Balais du téléphone.
Commutateur rotatif du téléphone.
Régulateur.
Commutateur d'émission à petite vitesse.
Segment d'ébonite.
Commutateur d'émission à grande vitesse.
Moteur.
Commutateur général.
Fiches du téléphone.

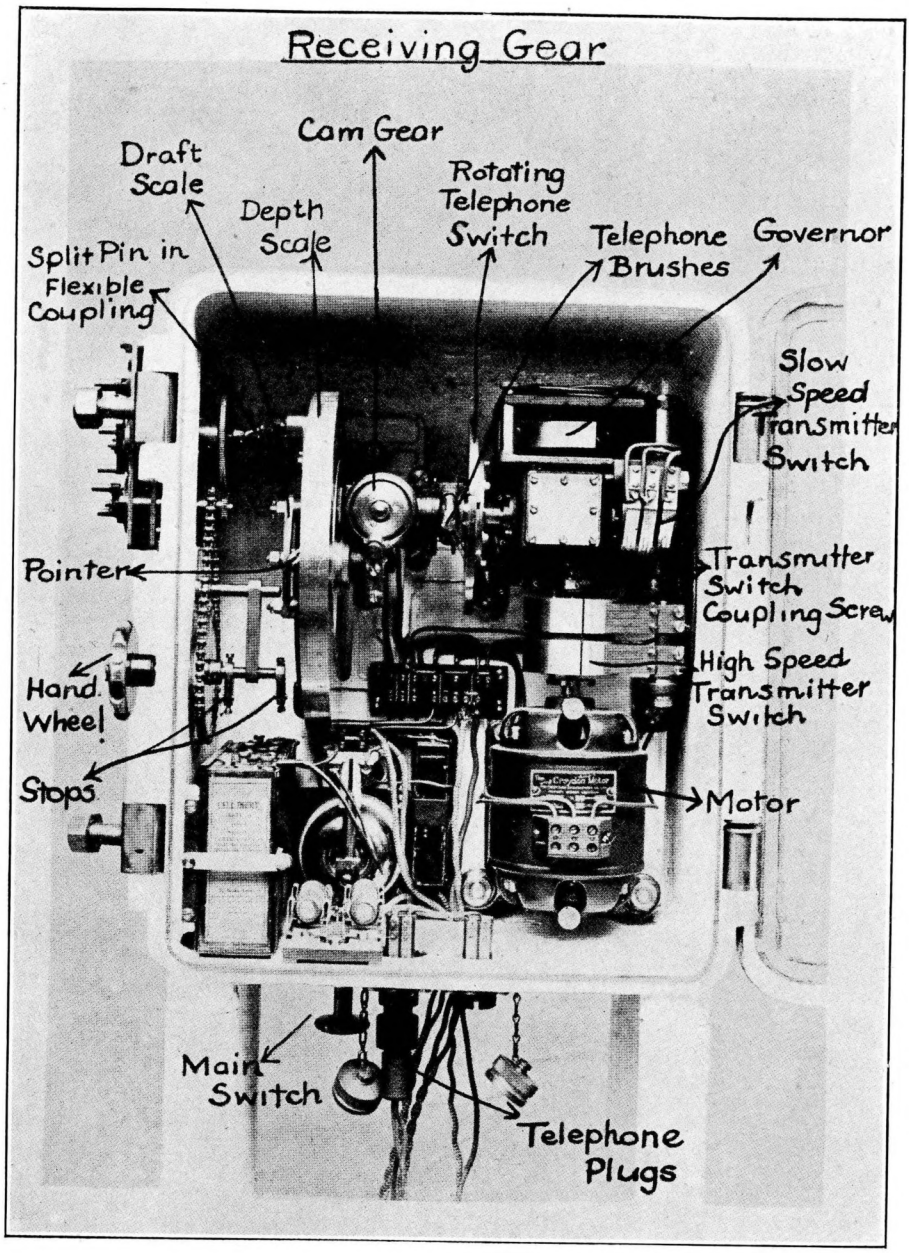


FIG. 6

Receiving gear.
Hand-wheel.
Pointer.
Split pin flexible coupling.
Draft scale..
Depth scale.
Cam gear.
Rotating telephone switch.
Telephone brushes.
Governor.
Slow speed transmitter switch.
Transmitter switch coupling screw.
Motor.
Telephone brushes.
Main switch.
Stops.
Pointer.

Mécanisme récepteur.
Manette.
Index.
Clavette d'accouplement articulée.
Echelle pour le tirant d'eau.
Echelle des profondeurs.
Dispositif à came.
Commutateur rotatif du téléphone.
Balais du téléphone.
Régulateur.
Commutateur d'émission à petite vitesse.
Vis d'accouplement du commutateur d'émission.
Moteur.
Balais du téléphone.
Commutateur général.
Arrêtoirs.
Index.

The governor and worm gear are fitted on a vertical shaft above the motor

The HIGH SPEED TRANSMITTER SWITCH is coupled directly to the motor shaft and has an adjustable coupling to the slow speed shaft, being held by two set screws.

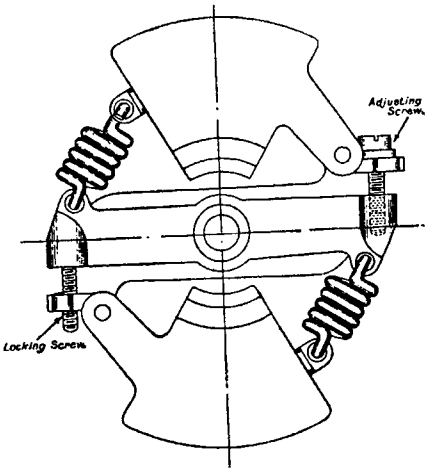


FIG. 7

Adjusting screw.	Vis de réglage.
Locking screw.	Vis arrêtoire.

This switch does the actual breaking of the transmitter circuit and has a 2 mfd. condenser across the brushes.

The SLOW SPEED TRANSMITTER SWITCH is attached to the slow speed shaft and controls the make and break of the transmitter circuit.

The ROTATING TELEPHONE SWITCH is a brass disc with an ebonite segment (Fig. 9). The disc is rotated by the slow speed shaft and is insulated from the shaft by a mica washer. When the telephone brushes are on the brass disc nothing can be heard in the telephones, and it is only when the ebonite segment is passing under the brush that anything is heard. The inter-

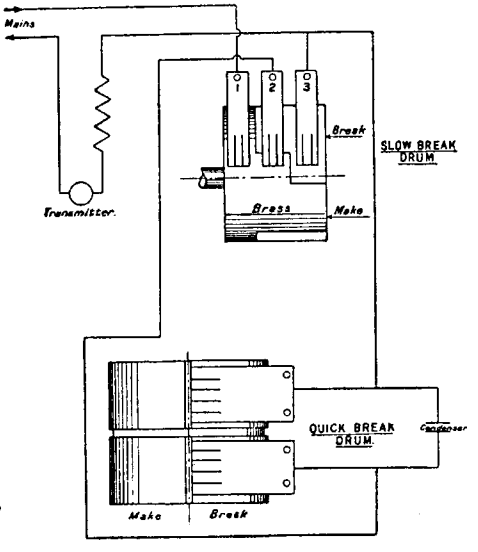


FIG. 8

Main.	Canalisation électrique.
Transmitter.	Transmetteur.
Brass.	Cuivre.
Break.	Rupture.
Make.	Contact.
Slow break drum.	Tambour de rupture lente.
Quick break drum.	Tambour de rupture rapide.
Condenser.	Condensateur.

val of time occupied by the ebonite segment passing under the brush is equivalent to about 1 fathom. This listening period occurs once per rev. of the slow speed shaft, i. e., three times a second.

The HAND WHEEL is situated on the outside of the receiving box on the left hand side and rotates the scale which in turn moves the telephone brushes through the cam gearing. The hand wheel also operates the lamp repeating mechanism if the gear is fitted with the latter.

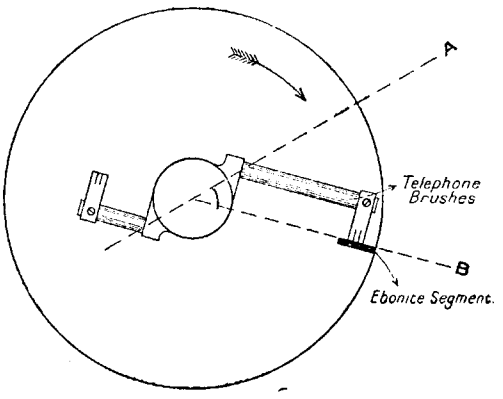


FIG. 9

Telephone brushes.	Balais du téléphone.
Ebonite segment.	Segment d'ébonite.

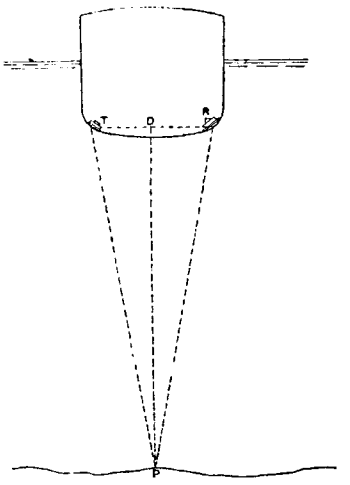


FIG. 10

TR.	Separation.	Ecartement.
DP.	True Depth.	Profondeur exacte.
TPR.	Total sound path	Trajet total du son.

The DEPTH SCALE is a uniformly graduated scale marked off in feet from 0 to 780 feet by 1 foot.

The DRAFT SCALE is set alongside the depth scale and is graduated from 0 to 40 feet.

The pointer is movable and can be adjusted on the scales to allow for alterations in the draft.

CAM GEAR. This is the means employed to correct for errors in the sounding due to the separation of the transmitter and hydrophone, i. e. if DP = the true depth and TP = the sound path to the bottom, the error at a depth of DP would be $TP - DP$. (See fig. 10).

It will be seen from this that the error at any depth is a function of the separation, and is a constant for any particular depth with a fixed separation. The correction required is provided by a cam cut according to distance separating the transmitter and hydrophone on any particular ship, and which performs its duty by altering the relative speed of the scale and telephone brushes as they are turned round by the hand wheel.

TRANSMITTER LAG.

This is the time which elapses between the breaking of the transmitter circuit and the production of sound by the hammer striking the diaphragm.

Transmitters are not issued unless the lag is equivalent to 15 echo feet. (N. B. Echo feet must be remembered as the double journey of the sound waves).

PRACTICAL WORKING OF THE INSTRUMENT.

The observer pulls down the writing-table in front of the instrument, thus exposing to view the depth-scale which he turns back till brought up by the stop at the lower end of the scale. He now switches on the gear by inserting the main-switch, situated on the underside of the receiving box, and puts on the telephone receivers.

A *faint* tapping will be heard but this is disregarded. He now works his hand-wheel, moving up a foot at a time, until the tapping *suddenly* becomes louder, and reads off the depth at this point.

The observer must always read off the depth at the first point where the sound gets louder when working upwards along his scale, this is important.

He then keeps the instrument in step with the echoes by the variation of his hand-wheel position, always turning the hand-wheel below the point at which the echo is arriving and working up to that point and taking his reading as before, i. e., getting the least sounding at which the echo is heard.

In practice no calculation is required, this depth being read directly on a dial.

REPEATING TRANSMITTER.

At the side of the case is attached a recording gear or repeating transmitter, which is connected to a receiver fixed in any suitable position, such as the chart room or Captain's cabin, to enable the bridge reading to be followed immediately by sight and sound.

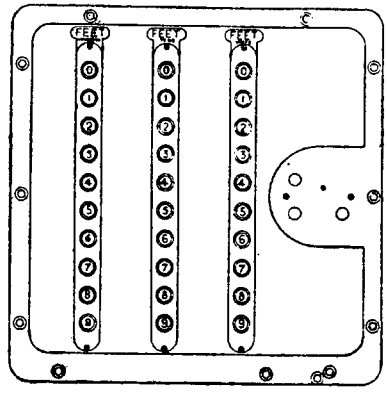


FIG. 11

LAMP RECEIVER.

Figure 11 represents the lamp indicator. This indicator consists of three columns of ten lamps, with numerals marked on them corresponding to hundreds, tens and units of feet, so that the movement in feet of the scale is immediately shown on this illuminated indicator, and at the same time the echo is received and checked by an extra pair of earphones.

The Admiralty booklet explains the details of the manipulation and of the upkeep of the apparatus.

1 complete set of Echo Sounding Apparatus as described above, fitting to ship extra. ..... Price £ 300.

Repeating Transmitter and Lamp Receiver, extra ..... Price £ 50.

B) OCEANIC TYPE OF DEEP WATER ECHO SOUNDER (Admiralty System) for depths ranging from 30 to 4,500 fathoms. (Fig. 12.)

DESCRIPTION :

The transmitter or sound producing gear consists of a pneumatic hammer, which is operated by 100 lbs. pressure and Compressor for operating the same. (Fig. 13). The transmitter piston or hammer is controlled by the magnet at

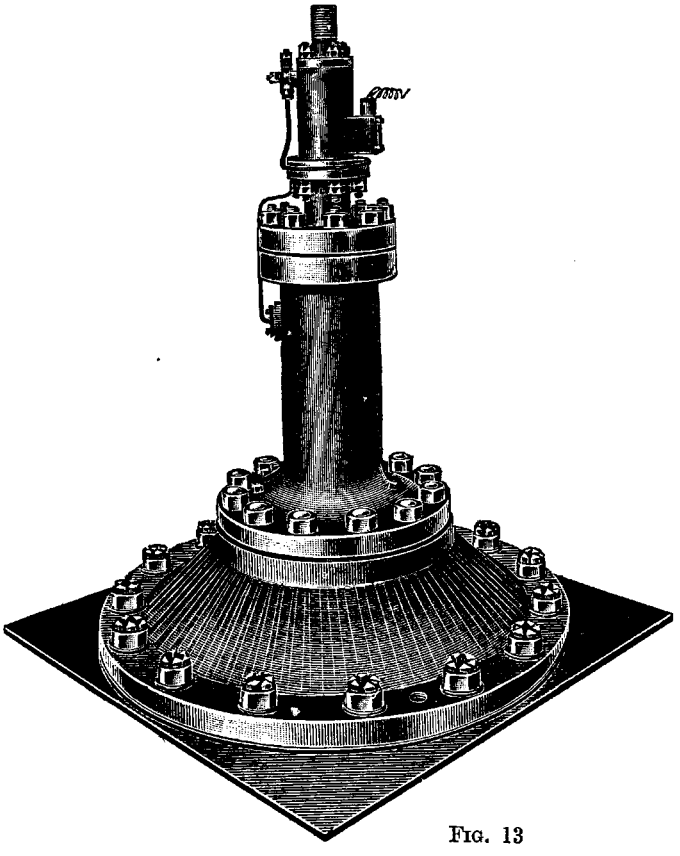


FIG. 13

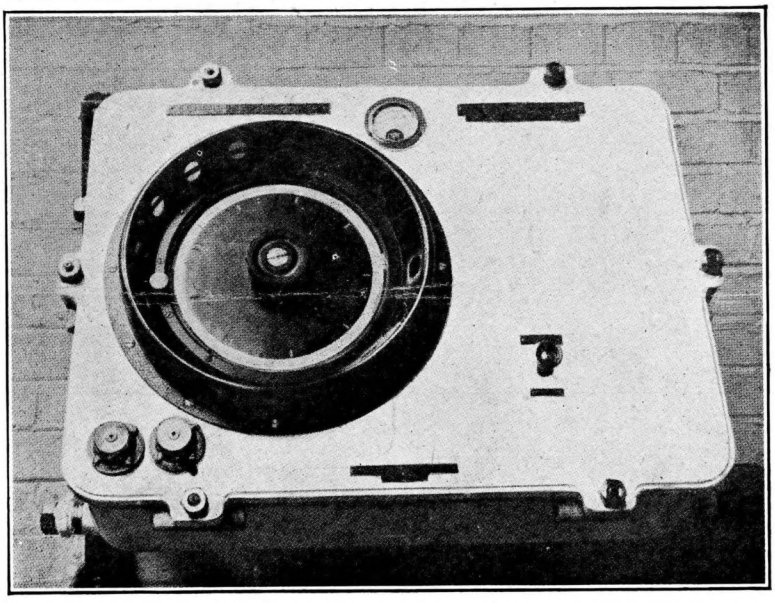


FIG. 12

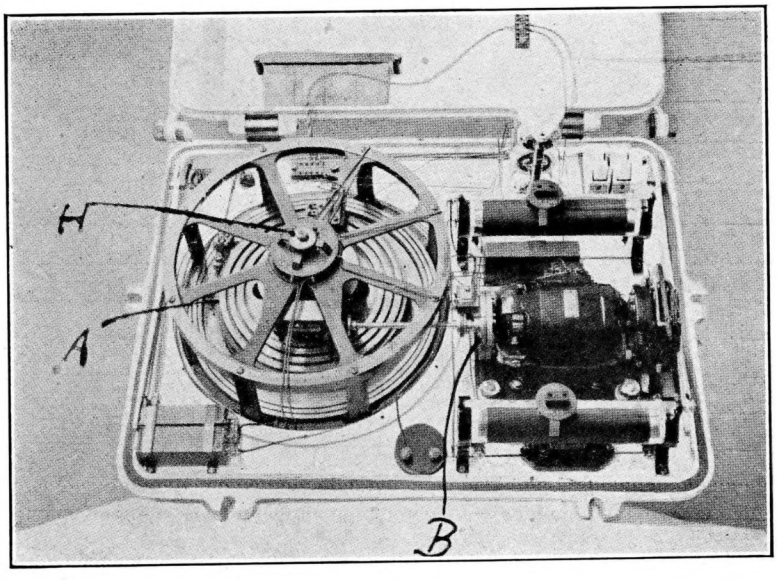


FIG. 15

the top of the cylinder,and when the contact by the transmitter switch in the receiving gear is made, current passes through the magnet windings and holds the piston at the top of the cylinder. Each time the current is broken the piston is forced down against the diaphgram by compressed air. After striking the diaphragm the piston is forced up by air pressure underneath and again held by the magnet on reaching the top of the cylinder.

This part of the apparatus is mounted on the shell of the ship, at about the midship section, and the hydrophone is fitted about 100 ft. forward on the opposite side of the ship. The hydrophone is attached to a sluice valve on the shell of the ship and can be raised when the ship is on the mud. (Fig. 14.)

When in action the sluice valve is opened and the hydrophone lowered sufficiently for the sound wave to reach the diaphragm.

The head phones attached to the receiving gear in the wheel house are connected to the hydrophone and the battery of dry cells through a telephone induction coil and condenser. A plug switch is provided so that the phone

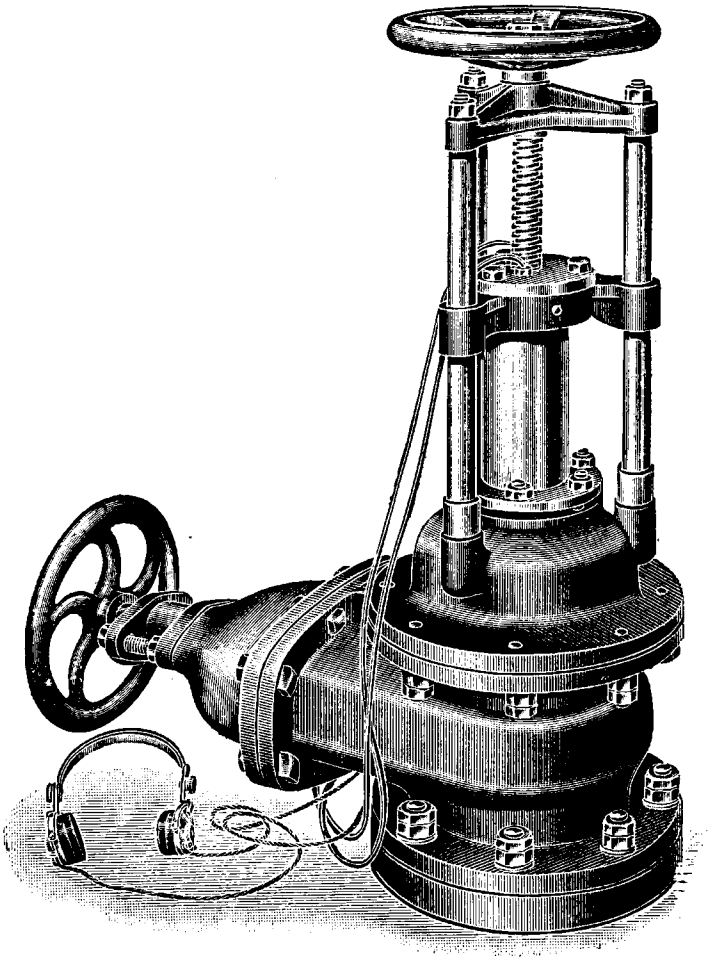


FIG. 14

may be either in circuit all the time, i. e., when transmitter switch is operating once in 11 ¼ seconds, or it may be only opened for a short time, i. e., when the transmitter switch which also operates the phone sorting contacts is operating 9 or 10 times per 11 ¼ seconds.

It is necessary that the transmitter circuit should be broken rapidly, and this is arranged in the receiving gear by having 2 drums *A* and *B*. (Fig. 15). The drum *A* rotates once in 11 ¼ seconds and the drum *B* at 9 times this speed. The actual break takes place at *B*. The drum *A* consists of 3 rings, one being a complete ring of brass and the other two having 9 or 10 insulating segments respectively. In this way, the transmitter may be made to operate once, 9 or 10 times per revolution. To effect the change from one rate to another, a switch is provided.

The method of operation is as follows: — Switch on the transmitter from the receiving gear in the wheelhouse and set the switch to its centre position so that the hydrophone circuit is open all the time and the transmitter is operating once in 11 ¼ seconds.

Listen-in on the head phones and the echo will be heard at a certain position on the scale which is approximately the depth. (Turn the vernier on hand wheel to that position). The difficulty of locating the exact point is solved by increasing the number of blows to 9 or 10 in the 11 ¼ seconds, after the approximate depth position has been found on the scale. By this means, the exact point of change from water noise to water noise and echo in the phones can be obtained and the depth is then exactly located.

The Deep Water Echo Sounding Gear has been installed on board H. M. S. *"Ormonde"*, and S/S. *"Giralda"*, Spanish Navy.

OBSERVATIONS ON THE WORKING OF THE BRITISH ADMIRALTY ECHO-SOUNDING APPARATUS

(*Extract from a report received from* Messrs H. HUGHES & SON, Ltd, 59, *Fenchurch Street, London, E. C.* 3, *who manufacture and fit this apparatus*).

The first Echo Sounder to be fitted by Messrs HUGHES & SON in a Merchant vessel was installed on board the Royal Mail Motor Ship *"Asturias"*. In this installation it was discovered that the hydrophone was liable to be screened from the echo by air pockets, due to the skin of the ship below the water line being covered with air bubbles. This discovery led to investigation, with results which proved highly satisfactory, so that since the first installation was successfully completed no further interference by air has been experienced, *and in the Admiralty Gear no false echoes are possible.*

In view of the fact that the Hydrophone and Transmitter are below the water line the question of fitting these without cutting holes in the shell of the vesel was considered. The problem has now been solved, both the Hydrophone and Transmitter being built into the skin of the ship without perfo-

rating the shell and with a water chamber intervening which increases the strength of the sound wave. *The echoes are now obtained with perfect ease and accuracy.*

Certains points in connection with the electrical part of the apparatus may be noted. Constancy of speed in the electric motor is important and is obtained (within 1 %) by the use of a specially designed centrifugal friction governor, which prevents large variations in the supply voltage from affecting the even running of the rotating disc. Instantaneous make and break is provided to prevent sparking; if attention is paid to the insulation and capacity of the Transmitter Cables, *absolute accuracy can be guaranteed.*

The Admiralty Echo-Sounder was first installed in British Surveying Vessels and in addition a large number of installations have been made abroad.

It may be noted in particular that the shallow water type has been installed on a surveying ship belonging to the Government of Finland and on the Spanish surveying ship "*Giralda*". A deep water model is in service on a Dutch surveying vessel, on a Japanese surveying vessel, and also on the "*Giralda*".

South Africa and Australia are both using Admiralty Echo-Sounders with continual success in surveying work.

It must be realised that the application of Echo-Sounding in Hydrographic Surveys will enable officers engaged in this work to obtain soundings at very frequent intervals. Charts of the future constructed from these surveys will show variation in depth in greater detail and enable the Navigator, when out of sight of land and in foggy weather, to plot his position by Echo Sounding as readily and reliably as he does with Sextant and Compass in fair weather.

The class of vessel in which the installation of the Echo Sounder has proved invaluable is the Cable Ship; when sounding in depths of over 100 fathoms much tedious work and enormous loss of time have been eliminated.

Now that the Loud Speaker has been successfully introduced, it is possible to provide an amplifier which will produce a loud signal on the bridge the moment a certain depth is reached, thus providing a danger or warning signal.

The following observations on Echo-Sounding have reference more particularly to the British Admiralty Echo-Sounder.

It must be noted that the accuracy of Echo-Sounding depends very largely on the ability of the listener to detect the increase of sound in the microphone circuit, i. e. the return of the transmitted sound wave in the echo path.

This is to be detected in two ways, by the change of note and the increase of sound, and the listening must be acute till the echo is clearly recognised.

The Microphone contained in the Hydrophone circuit is disturbed mechanically by the water passing across the diaphragm surface, also by the general shaking or vibration of the ship, and it is also disturbed acoustically by the noise of the ship arising from pumping or refrigerating machinery.

All these disturbances create an acoustical atmosphere or "water noise" in the midst of which the return of the transmitted Sound wave in the Echo path can be clearly detected.

This "water noise" is present all over the scale and should be equal in intensity; by disconnecting the Transmitter mains at certain contacts and starting the motor, a good idea of the "water noise", as it is generally called, can be obtained.

It is important to get this clear, that the "water noise" is only heard at each revolution of the rotating telephone switch during the time that the Telephone Brushes are passing over the Ebonite Segment.

By taking out the fuses and pushing in the switch, the "water noise" can be heard continuously when the Telephone Brush is on the ebonite segment.

Attention is drawn to this "water noise" and its intensity because it is best for the listener to know how much disturbance is being created, in the Microphone, before any effect is created by the *vibrations of the Echo.*

To take soundings: — having made sure that the Microphone is sensitive and obtained an idea of the amount of "water noise", replace the fuses, reconnect the Transmitter at the Contacts, and start the Machine.

It is recommended that Echo Sounding should be practised, but it must be noted that soundings in Docks and Rivers are no test because of echo possibly coming from walls and banks.

Immediately a shallow water sounding has been obtained in which the listener is able to have confidence, it should be repeated at short intervals or for some minutes at a time — listening to the gradually increasing or changing depth detected by the echo.

The handle should be turned slowly, always working up from zero, and when the first increased sound and the unmistakeable echo note is heard, the reading on the scale is observed.

Practice is everything at the outset, and by the time deeper water is reached, by following the depth from the beginning it becomes possible for the listener to realise what audibility and contrast of echo to the "water noise" are to be obtained.

This is the great feature of Echo Sounding, the contrast of sound between "water noise" and "water noise" plus echo, and it must be followed closely by reference to the chart and listening at the point just about where echo should come in.

Great facility can be obtained if the listener persists until the contrast is clearly recognisable.

D THE FATHOMETER OF THE SUBMARINE SIGNAL CORPORATION (Boston, U. S. A.)

The Fathometer has been briefly mentioned upon page 12 of I. H. B. Special Publication N° 4 (March 1925).

Since then the Bureau has been in communication with the constructor of the apparatus, the "*Submarine Signal Corporation*", 160, State Street, Boston, Massachusetts (U. S. A.) from which the following information concerning this apparatus has been received :

The fathometer, Sonic Depth Finding, and Echo Depth Sounding all refer to the same thing — taking soundings by means of sound waves.

The discovery of this method of depth sounding is linked in its history with the "*Titanic*" disaster of 1912. It was this appalling disaster that led Professor Reginald A. FESSENDEN of Boston to propose experimenting with his oscillator for the purpose of detecting the presence and nearness of icebergs.

In March, 1914, Professor FESSENDEN accompanied the Revenue Cutter "*Miami*" to its station off the Grand Banks, and there conducted researches as to the possibilities of his oscillator.

During the course of his experiments, Professor FESSENDEN discovered the principle on which the Fathometer is based. By measuring the elapsed time between the sending out of the sound of the oscillator and the return of the echo from the bottom of the ocean, he was able to determine the depth of water the "*Miami*" was in.

The Fathometer, the subsequent development of Professor Fessenden's invention, is now known throughout the world, as it has accomplished the hitherto impossible — instantaneous visual soundings.

The fathometer itself, a neat and substantial box containing the controlling and recording mechanism, is placed in the wheel-house or chart room. It is mounted on a bulkhead, and takes up a space of approximately 11" × 13" × 17".

The essential elements of a Fathometer installation are the "*Fathometer Indicator*", which indicates depths, the submarine sound producer, called an "*Oscillator*", and the submarine sound receiver, known as a "*Hydrophone*".

FATHOMETER INDICATOR.

The Fathometer Indicator contains the time-measuring apparatus, together with most of the switches and other devices used in indicating depths.

The essential function of the Fathometer Indicator is to measure the time elapsing between the creation of a submarine signal and the return of the echo of such signal from the bottom of the ocean.

This is accomplished by revolving an opaque disc at a uniform and known speed. This disc carries a pointer, in reality a narrow slot in the disc, which passes near a fixed scale on the front of the Indicator calibrated in fathoms. At the instant that the slot in the disc passes the zero of the scale a circuit is closed by a cam, which energizes the oscillator for an instant and

causes it to emit a very short train of submarine sound waves of a frequency of 1050 cycles per second. These sound waves are reflected from the bottom of the ocean and, when they reach the vessel, actuate the hydrophone, thereby causing a light back of the slot to be illuminated and thus indicate to the observer their arrival. The position of the slot relative to the fixed scale can then be read and that reading indicates the depth of water.

Submarine sound travels at the rate of about 4900 feet a second so that, to make soundings in shallow water, very short intervals of time must be measured. Thus, if a depth of 10 fathoms is to be measured, the Fathometer must be capable of indicating accurately an interval of less than one-fortieth of a second. This means that the arc traversed by the slot in that short time must be long enough to be readily apparent to the observer. This is accomplished in the Fathometer Indicator by using a disc of fairly large radius and by revolving the disc with its slot pointer at a fairly high speed. The Fathometer Indicator is designed in such a way that the disc, when used for measuring shallow depths, makes nearly four complete revolutions a second.

For measuring the depths of shallow water, the illuminant, used back of the slot, is a Neon tube which is connected with the hydrophone in such a way that the tube is lighted when the hydrophone is agitated by the echo of the submarine signal created by the oscillator. The rapid succession of signals makes it extremely easy for the observer to read the depth on the scale at a point where the light flashes. This light is reddish in colour so that the scale for shallow depths, i. e. from 10 to 100 fathoms, is frequently spoken of as the "*Red Light Method*".

The disc in the red light method makes about one revolution in one quarter of a second which corresponds with the time which it takes a submarine sound to travel to and from a reflecting surface 100 fathoms distant. If greater depths are to be measured, it is necessary to revolve the disc less rapidly. Provision is made in the Fathometer Indicator whereby the trains of gears employed can be quickly changed so that the disc, instead of revolving four times each second, makes a single complete revolution in one and one-half seconds. This change in speed necessitates a new scale on which depths can be read directly up to six hundred fathoms. When the disc is revolving at this slower speed and measurements are to be made in deep water, a second slot on the disc is employed which is diametrically opposite that used for shallow water. Therefore, when the gears are shifted to cause the disc to revolve more slowly, a small incandescent lamp back of this second slot is lighted permanently and, shining through the slot, makes a finger of light which moves over the outer scale of the Fathometer once in every one and one-half seconds. This light is that of an incandescent light, hence this method of reading depths is frequently spoken of as the "*White Light Method*".

Attention should be called to the fact that in the red light method the zero of the scale, i. e. the instant when the submarine signal is created, is at the top of the inner scale, whereas the corresponding point in the white light method is at the bottom of the outer scale. This prevents any confusion between the two scales.

In the white light method the observer uses one or two telephone recei-

FIG. 16

FATHOMETER.

External view. Vue extérieure.

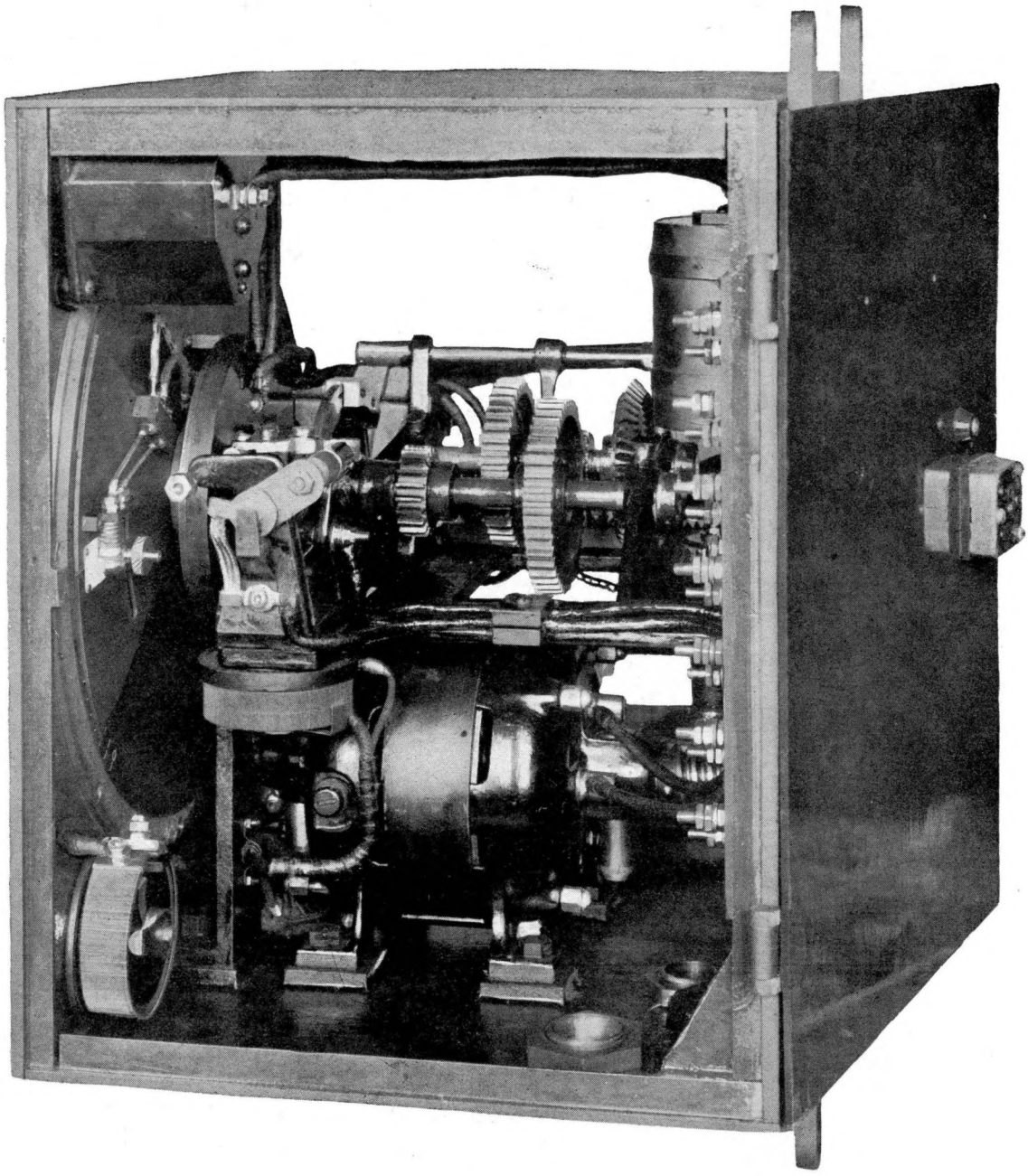


Fig. 17

FATHOMETER

Interior view. Vue intérieure.

vers so connected that they are responsive to the echo. The observer, when he hears the echo, notes the position of the illuminated slot pointer on the outer scale. Thus for depths less than 600 fathoms a depth measurement can be made in this way once in every secound and one-half.

It must be clearly understood that the two methods are not rigidly confined to the depths above described, i. e. red light from 10 to 100 fathoms and white light from 100 to 600 fathoms. On the contrary, if properly operated, the two may be made to overlap to a very considerable extent. Thus with the white light method readings have been made at depths of less than 50 fathoms, and with the red light method, when proper precautions are taken, depths far greater than 100 fathoms have been read.

The necessity for taking proper precautions arises from the fact that in the red light method a second submarine signal is emitted at the end of each quarter second, i. e. the time required for the signal to pass from the sender and return when the depth is 100 fathoms. In depths of about 100 fathoms, therefore, there would be ambiguity as to the Fathometer indication. To avoid this ambiguity a push button is provided which, when depressed, reduces the number of submarine signals emitted from four to two each second. Thus, by the red light method depths can be measured up to 200 fathoms without danger of confusion. The observer notes the number of revolutions of the disc between the emission of the submarine signal and the signal created by the echo. He then knows that the depth is the reading of the Fathometer plus 100 times the number of complete revolutions of the Indicator disc.

To still further guard against an ambiguity of this kind, a second push button is provided. This push button, when depressed, holds the contacts of the contactor apart until the echo has been received. This second push button is especially necessary in measuring larger depths by the white light method. When this push button is used by the white light method, the depth is the reading of the Fathometer plus 600 times the number of complete revolutions of the indicating disc between the emission of the submarine signal and hearing the echo.

SPEED REGULATION.

The Fathometer Indicator is essentially a time measuring device, and consequently the speed of the revolutions of the disc must be accurate. The small motor, which is housed inside the Fathometer Indicator and produces the rotation of the disc, maintains a constant speed as long as the ship's voltage remains constant. Changes in speed of the motor can be made by means of the rheostat in the lower left-hand corner. A special vibratory tacheometer or speed indicator is provided to show the speed of the motor. This speed indicator can be seen at the upper right-hand corner of the face of the Fathometer Indicator.

When the motor is running at its correct speed there will be generated in this tacheometer circuit a current which will cause the reed above the arrow to vibrate at a maximum amplitude. The supplementary reeds are provided so that the observer can readily see whether the motor, and hence the disc bear-

ing the illuminated pointers, is running too fast or too slowly, and thus be enabled easily to adjust the potentiometer and bring the motor to the correct speed.

The scale is graduated for a mean velocity of sound, in sea water, equal to 1490 metres per second.

START AND STOP SWITCH.

Taps from the positive and negative wires of a 110 volt circuit are connected to the start-stop switch used to control the entire operation. It is similar to an electric light push button switch and can be seen at the upper left-hand corner of the face of the Fathometer Indicator.

REGULATION OF SENSITIVENESS OF HYDROPHONES.

The intensity of the reflected sounds depends greatly upon the depth of water, i. e. the distance the submarine signal has to travel, and upon the character of the bottom of the ocean at the point of reflection. It has been found that a certain variation in the strength of the current through the hydrophones best creates a useful and regular operation of the Neon tube. Likewise, the strength of current through the hydrophone which may be best suited for the red light method may be quite different when listening for the echo by the white light method.

A potentiometer is consequently provided by the use of which the current through the hydrophones can be controlled.

The handle of this potentiometer is placed at the lower right-hand corner of the face of the Fathometer Indicator.

ADJUSTMENT FOR DRAFT OF SHIP.

An adjustment is provided on the inside surface of the rotating dial graduated in fathoms in order that the depth reading may be made to indicate either depth from the surface or depth below the ship. This adjustment is graduated in fathoms so that, if for instance the ship is drawing 3 fathoms, the marker can be set on that figure on the dial, in order to have the indicator show depths from the surface. To make the instrument read correctly, this adjustment can be made whenever the draft is changed due to loading, although in many large ships the draft remains practically constant.

OSCILLATOR (*Fig.* 18).

Submarine signals are created by an electro-magnetic device which is attached to the bottom of the ship. It is a watertight iron case containing an electromagnet, the armature of which is attached to a thick iron diaphragm, the outer surface of which is in contact with the water. When an alternating current is passed through the windings of this electromagnet the diaphragm is made to vibrate to and fro and thus produce powerful sound waves in the water. The current used has a frequency of 525 cycles per second and when

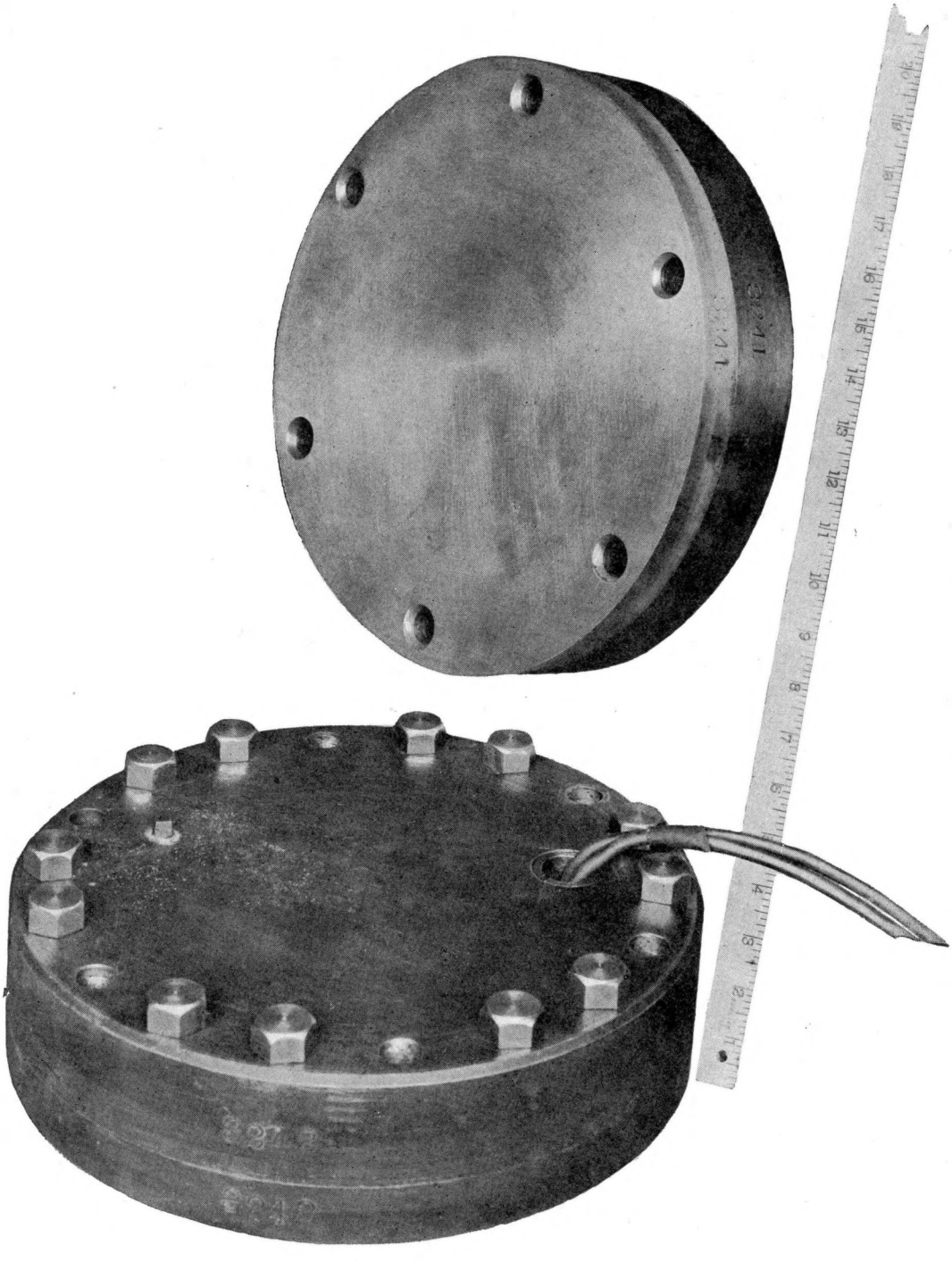


FIG. 18

impressed upon the electromagnet of the oscillator creates submarine sound waves having a frequency of 1050 cycles a second.

The submarine oscillator is a device which has been heard under water at a distance of 80 miles and which can emit enormous energy in a very small space of time.

The frequency of the alternating current is such that the magnetic pull pulsates with the natural frequency of the diaphragm, and a high pitched musical note results. As a consequence of the musical note, the echo is easily distinguished from water noises and accidental blows against the ship's hull.

The circuit of the oscillator is normally open, but is closed for a very small fraction of time by a cam in the Fathometer Indicator at the instant that the signal should be emitted.

The oscillator is a rugged device, has no parts in which friction occurs and requires no adjustment or care on the part of the operator.

HYDROPHONES.

A hydrophone is a multiple contact microphone contained in a watertight case and specially designed to be effective in responding to the submarine signals created by the oscillator and to their echoes.

It is customary to-day to furnish three hydrophones in a Fathometer installation; one of the three hydrophones is very highly tuned and especially responsive to submarine sound waves having a frequency of 1050 cycles and, consequently, is thought to be especially adapted for the reception of echoes in deeper water; the other two are alike and are less highly tuned and possibly more effective for receiving the echoes in shallower water.

These hydrophones are so connected that the user of the Fathometer can select that instrument which gives best indications of the depth of water under the ship. In order to aid in obtaining the best indications of depth a potentiometer is connected in the hydrophone circuit in such a way that the amount of direct current passing through the hydrophones can be controlled. Thus, in very shallow water where the echo is naturally loud and consequently agitates the hydrophone vigorously, it is best to reduce the current in the primary circuit. This change is effected by turning the handle of the potentiometer which is located in the lower right-hand corner of the face of the Fathometer Indicator.

Two tanks are placed within the ship in contact with its outer skin. These tanks have one side open so that when in place this open side is closed by the ship's skin. The tanks are so designed that when in place they can be filled with water which will not leak away.

The tuned hydrophone is suspended in one tank and the two untuned hydrophones in the other tank.

By the above arrangement the reflected submarine sound waves (or echo) pass through the plate or skin of the ship through the water in the tanks and to the hydrophones. This method of installation has been found to reduce the noises incident to the motion of the ship through the water and to remove the necessity of cutting the skin of the ship in any way.

OTHER ESSENTIAL DEVICES.

The other essential devices in the operation of a Fathometer installation, apart from the necessary wires and wire connection boxes, are a Fathometer Amplifier and Filter, a motor generator to supply the alternating current necessary for the operation of the oscillators, and a small switchboard upon which are mounted the switches, fuses, and other devices required in the electrical power supply circuit.

Fathometer Amplifier and Filter.

The Fathometer Amplifier and Filter consists of a four-stage triod valve circuit for amplifying the received echo to a point where it is sufficiently strong to operate a relay known as the plate circuit relay, and a system of inductances and capacities which passes frequencies in the neighbourhood of the signal frequency but which eliminates or considerably reduces all other frequencies. As this circuit is placed between the hydrophone and the amplifier, water noises, etc., which are chiefly of low frequency, are cut out and the only currents which reach the amplifier with any magnitude are those of the signal. This tends to keep strays, water noises, and similar disturbances from operating the plate circuit relay.

The plate circuit relay is mounted within the Amplifier and Filter Box as is also a switch by the use of which the operator can select the hydrophone which is best suited for use at the time that depth measurements are to be made.

Motor Generator and Switchboard.

As at present issued, the motor generator is mounted with the switchboard upon a suitable frame.

The motor generator is designed to produce alternating current of approximately 150 volts at 525 cycles. The motor portion of the motor generator is wound in such a way as to make it suitable for operation on the voltage of the ship's current supply.

LOCATION OF APPARATUS.

The Fathometer Indicator, Filter and Amplifier as well as the current supply for hydrophones and amplifier are usually located in the chart room or pilot house of the ship.

The switch board and motor generator are usually placed in the engine room.

Two oscillators are to-day provided in a standard installation of this system. The location of these oscillators, designated by the engineers of the Submarine Signal Corporation, is on the skin of the ship forward and well below the water line.

Both Hydrophone Tanks are located within the ship on the opposite side of the ship from the Oscillators and as close to the keel plate as possible. The exact location is indicated by the engineers of the Submarine Signal Corporation. These tanks will usually be located about twenty-four feet from the oscillators.

FILTER AMPLIFIER CIRCUIT.

The Filter Amplifier, as its name implies, is designed to exercise two functions, a Filter to cut out as far as may be possible electrical waves of all frequencies other than that of 1050 cycles created by the oscillator and transformed by the hydrophones (this is accomplished by condensers, resistances and impedances); and an amplifier designed to amplify the changes in current produced by the action of the echo upon the hydrophone. The current thus created is sufficient to operate the plate circuit relay and open the Neon Tube circuit as above described.

In shallow depths the operation of the filter is as follows: each time the echo is received by a hydrophone the current in the hydrophone is changed at the same frequency as the oscillator note, about 1050 cycles per second, and a voltage of corresponding frequency is impressed on the grid of the first tube (after passing through the filter), where it is amplified and passed on to the second and third tubes. Before reaching the grid of the third tube the signal passes through a condenser and grid leak. In so doing it causes the grid of this tube to become more negative and hence decreases the plate current. This change in plate current gives rise to a pulsating voltage across the plate circuit resistance, which is passed on to the grid of the last tube through a condenser. A similar action takes place here in that the change in plate current causes a current to pass through the condenser and relay coil. This pulse of current causes the relay to open its contacts and therefore the spark coil circuit. The sudden change in the primary or low winding of the spark coil causes a rapid decrease in the magnetic flux through the secondary so that the voltage induced in the secondary of the spark coil is more than 1000 volts, which passing into the Neon Tube produces a momentary glow of red colour. Immediately after the cessation of the signal the circuit is again closed through the spark coil, allowing time for the current to build up to its normal value, which is of the order of 0.1 ampere. In general the knob of the potentiometer in the hydrophone circuit, located at the lower right of the Fathometer Indicator, should be turned as far to the left, counterclockwise, as will bring in the greatest number of echoes or red flashes with the least number of stray signals. This adjustment to the left gives the least possible current in the hydrophones.

When operated for deep depths, changing the gears from "shoal" to "deep" closes a rocker switch which lights the white light. The adjustment of the potentiometer in the hydrophone circuit now may be whatever best suits the condition of relative signal strength heard in the telephones, since the whole object now is to be able to distinguish when the echo returns and be able to read the position of the white light simultaneously. Practice is about the only guide in this case, for some people distinguish the echo more easily when it is faint and there is a small amount of water noise, while others hear more readily when it is loud even with a greater amount of water noise.

OSCILLATOR CIRCUITS.

A start and stop-switch is placed at the upper left-hand corner of the face of the Fathometer Indicator. This switch is similar to an electric light push-button switch and when the white button is depressed the entire Fathometer installation is set in operation, including the motor generator in the engine room. When the black button of the start and stop switch is depressed, the motor generator is stopped and the other devices returned to normal non-operating conditions.

When the white button of the start and stop switch is depressed, the magnetic starter, located near the motor generator, is actuated and current is thrown gradually from the ship's power or lighting circuit on to the motor of the motor generator.

A single throw double pole switch is located on or near the ship's switchboard which switch, when open, removes current from the entire Fathometer system.

A cam on the shaft of the Fathometer Indicator, upon which the revolving disc is mounted, closes the circuit of the alternating current generator and oscillator once in each revolution, thereby energizing the oscillator and causing it to emit a short train of submarine sound waves.

A resistance and capacity are connected in the circuit so as to obtain electrical conditions best suited to the production of the most powerful signals from the oscillator.

CONTROL OF OSCILLATOR SIGNALS.

The velocity of sound in water is taken to be under average water temperatures 4910 feet per second. The depth is clearly one-half the path travelled by the sound to and from the bottom. The Fathometer is designed to cause the oscillator to emit submarine sound waves four times each second. The result is that if the water is one hundred fathoms deep, the echo of a signal arrives at the instant that the next or succeeding signal is emitted, or if the water is more than 100 fathoms deep, the indication of depth is given on the second or succeding revolutions of the indicating disc. Thus, if the depth were 110 fathoms the observer might read the depth as 10 fathoms, thereby creating the possibility of a false reading of depth.

A difficulty of the same character is present with the white light method which indicates depth in a single revolution of the indicating disc to only 600 fathoms.

Both of these possible ambiguities are eliminated by the use of two devices which are incorporated in the Fathometer :—

a) *Automatic cut-out.*

Upon the shaft of the Fathometer which carries the cam which actuates the " Contactor " is a small commutator, designated "Automatic Cut-Out". Under normal conditions this "Automatic Cut-out" is short circuited and, therefore, inoperative. When it is desired to use the "Automatic Cut-out" the short circuit can be held open by depressing the key of the "Timing

Control Switch" located on top of the Fathometer Indicator. When the "Timing Control Switch" is depressed the "Automatic Cut-out" functions and, in so doing, reduces the number of submarine signals per second from four to two.

This arrangement removes thus the ambiguity which may occur towards the limits of either scale of the Indicator. Thus, for readings in the proximity of 100 fathoms on the red light method or of 600 fathoms on the white light method the "Timing Control Switch" should be employed.

b) *Contactor arrestor.*

This second device has been introduced for much the same purpose but is especially useful in operating the white light method in depths in the vicinity of 600 or 1200 fathoms.

The " Contactor Arrestor " is located on the right-hand door of the Fathometer Indicator. When the button on the door is depressed, one electrode of the contactor is drawn away so that there is no repetition of the oscillator signal until the button has been released. This permits the indicating dial to make as many revolutions as may be necessary to measure the time before the receipt of the echo.

HYDROPHONE CIRCUIT — RED LIGHT METHOD.

A potentiometer, the knob of which is located at the right-hand lower corner of the face of the Fathometer Indicator, is so connected to the leads to the hydrophone that the current in the hydrophone can be controlled by the observer. These leads terminate in the Filter Amplifier.

When an echo acts on the hydrophone a current is generated sufficient to energize the electromagnet of the plate circuit relay and thereby cause its armature to open a circuit in which is included a four-volt battery and the primary circuit of a transformer. This break in this primary circuit induces a current in the secondary circuit of the transformer, in which is included the Neon Tube, causing the tube to glow for an instant.

HYDROPHONE CIRCUIT — WHITE LIGHT METHOD.

This circuit is identical with the above except that when the knob is turned to change from the red light to the white light method the circuit is opened thus rendering the Neon Tube inoperative and allowing the echo transmitted by the hydrophones to be noted only by the use of telephone receivers.

METHOD OF OPERATING FATHOMETER INSTALLATION.

To find depth with a Fathometer the procedure is as follows :—

1. Put switch marked "Line" on motor generator switchboard to the "On" position.

Put either one of the switches marked "Oscillator 1", "Oscillator 2" on motor generator switchboard to the "On" position. The other should be in the "Off" position.

2. Turn knob of hydrophone circuit potentiometer (lower right-hand corner of Fathometer Indicator) counterclockwise as far as it will go.

3. Push white button of Start and Stop Switch (upper left-hand corner of Fathometer Indicator). This starts the motor in the Fathometer Indicator as well as the Motor Generator in the engine room, and results in submarine signals being emitted by the oscillator.

4. If depths less than 100 fathoms are to be measured, turn knob on left-hand side of Indicator so that the designation "*Shallow*" as engraved on its shaft faces you.

5. Regulate speed of revolution of Indicator Disc by turning knob of speed control rheostat (at left-hand lower corner) until the middle reed in speed indicator is vibrating. (If the speed is too slow a reed to the left of the centre will be vibrating; if too high, a reed to the right of the centre will be vibrating).

6. Turn knob of hydrophone potentiometer to the right only as far as will create clear indications of depth.

7. Select hydrophone which produces most uniform and frequent indications of depth. (The switch for selection of hydrophones is located within the Filter Amplifier Box at lower right hand. Experience seems to show that the tuned hydrophone is most serviceable in deeper water and one or the other of the rubber hydrophones is best in shallow water.)

8. When using red light method and indications are in the vicinity of 100 fathoms, press down button on top of Fathometer Indicator so as to use Automatic Cut-out.

9. To use white light method turn knob on left-hand side of Indicator, so that the designation "Deep" as engraved on its shaft faces you, and the white light is moving opposite the larger scale. (The zero of this scale is at the bottom of the Indicator.)

10. Place the telephone receivers at the ears. (Two signals will now be heard in the telephones, one at the instant of emitting the submarine signal — this is the direct or outgoing signal — and another a moment later, which is the echo.)

11. Observe the position of the white light at the instant that the echo is heard — and note the reading on the larger scale of the Indicator.

12. In depths in the vicinity of 600 fathoms or greater, press button on right-hand side of Fathometer Indicator immediately after hearing the direct or outgoing signal, and observe the position of the white light as before as well as the number of complete revolutions of the white light which have occurred. The depth in fathoms is the reading plus 600 times the number of revolutions.

ADVANTAGES OF SOUNDING WITH THE FATHOMETER.

1. Soundings are known at a glance.

2. One person only is required in the taking of the sounding. That person is the one who uses the sounding to guide him in the operation of the vessel.

3. Soundings are indicated continuously until the actuating current is shut off.

4. The Fathometer can be left in operation for hours or for a day at a time, the device being so substantially built that no harm will result.

5. Soundings are taken so rapidly and easily that navigators will thereby be induced to make more frequent use of soundings and thus add greatly to the safety of their vessel.

6. The Fathometer has received the unqualified endorsement of the United States Coast and Geodetic Survey.

Tests of the Fathometer have been carried out under service conditions in all kinds of weather and in depths from a few fathoms up to 1000 fathoms.

The machine gave readings of the depth 20 to 30 times a minute during the whole run. Such continuous indications are especially important when it is desired to ascertain the instant when some well-known point is reached as, for example, the crossing of the 100 fathom line on the Atlantic shelf. It is possible to proceed at full speed with confidence that the shelf will reveal itself by an abrupt change in the position of the moving white finger when the echo returns, or in a sudden appearance of the red flash.

III. AKUSTICHE LOTANLAGE OF THE ATLAS-WERKE — Bremen (Germany).

ATLAS-LOT.

The Atlas-Werke of Bremen informs the Bureau that for over 25 years it has been working in collaboration with the Submarine Signal Corporation of Boston and that, consequently, it manufactures, under the name of the "Atlas Lot" (Atlas Sounder), an apparatus almost identical with the "Fathometer".

A few years ago the surveying vessel "Meteor" was equipped with one of these appliances which was used for drawing up the well-known profiles executed by this vessel in the Atlantic Ocean.

Since then, this type of sounder has been put into extensive use in practice and numerous vessels are now equipped with it.

The Atlas-Werke also points out that its management is now associated with that of the Signal Gesellschaft of Kiel which constructs certain appliances mentioned in the International Hydrographic Bureau Special Publication N° 4 (March 1925).

The description of the Atlas-Lot being on all points analogous to that of the Fathometer, we ask the reader kindly to refer to the details concerning the latter already given in this article. To supplement these details, we give simply the following designs and information of German origin, which have been forwarded to the Bureau either by the Atlas-Werke or by the Nautische Abteilung der Marineamt, Berlin.

Figure 19 shows the general arrangement of the Atlas-Lot, fitted on board (with double transmitter and double receiver); from Fig. 19 also an idea may be obtained of the principle of its operation.

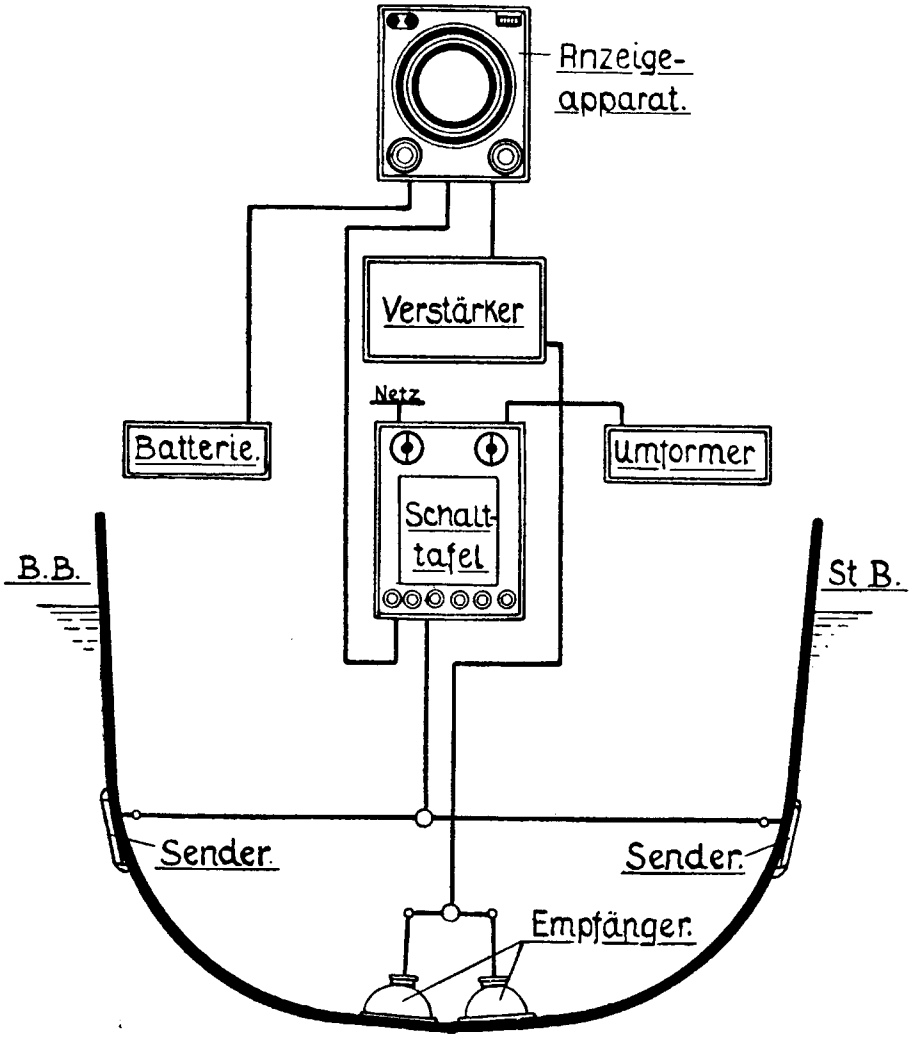


FIG. 19

B. B.	Port.	Bâbord.
St. B.	Starboard.	Tribord.
Sender.	Transmitter.	Emetteur.
Empfänger.	Receiver.	Récepteur.
Umformer.	Transformer.	Transformateur.
Anzeige-Apparat.	Indicator.	Indicateur.
Schalt-tafel.	Switch-board.	Tableau des commutateurs.
Verstärker.	Amplificator.	Amplificateur.

Figure 20 is a sectional drawing of the oscillator-transmitter.

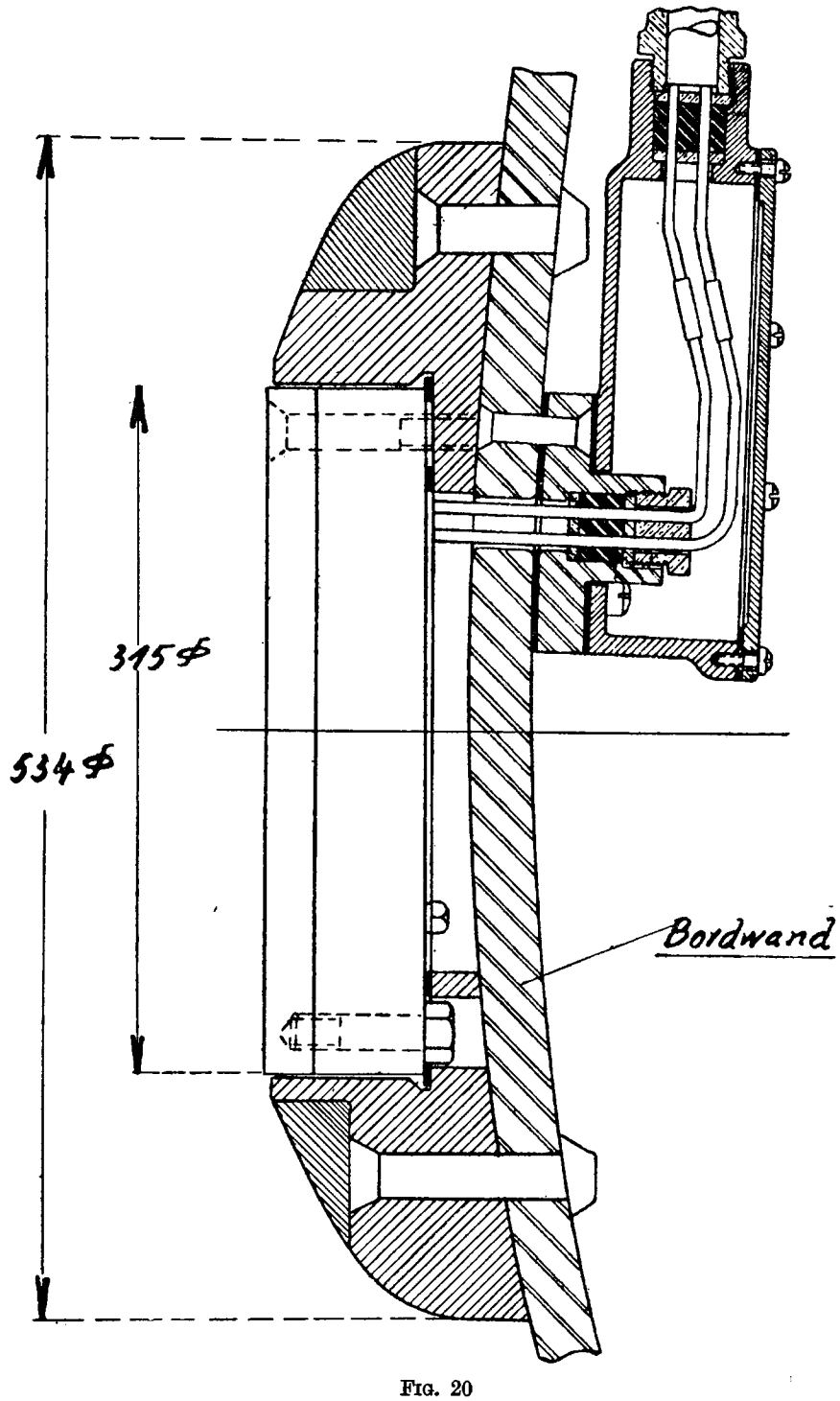


FIG. 20

Bordwand. Ship's shell. Bordé.

a) *TRANSMITTERS.*

Sound emissions, to be used for taking soundings, must be very powerful and of very short duration for, if they are too feeble, they cannot produce

a perceptible echo at great depths and, if they are of too lengthy duration, the echo will have returned before the cessation of the emission, above all in the case of shallow water. This fact has led to the construction of a special transmitter (oscillator) for the case in question The exterior surface of the membrane is in contact with the water. Its diameter is 315 $\frac{m}{m}$ (1 ft). The dimensions of the plates of the transmitters are so chosen that the natural period of vibration under water is approximately 1050. The transmitter is non-polarised and is actuated by means of an alternating current of 525 periods, so as to make use of the mechanical regulator of the transmitter. In addition, there is a condenser in the circuit of the transmitter, so that an electirc resonance is set up.

Each apparatus possesses two transmitters of this kind, one of which is fixed to port and the other to starboard of the vessel, several feet above the keel. A strong flange riveted to the outside plating of the ship serves to consolidate the transmitter. The cable conductor is introduced through the lower plate of the transmitter by way of a special lead in the shell of the ship. A special cable box is fixed in a suitable position inside the plating.

Figure 21 shows the scheme of the installation of the microphone receiver on board.

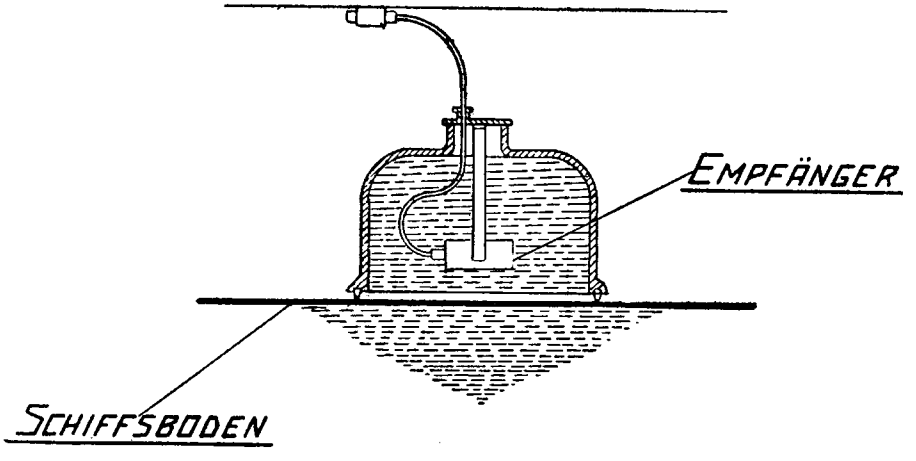


FIG. 21

Empfänger.	Receiver.	Récepteur.
Schiffsboden.	Ship's shell.	Bordé.

RECEIVER.

For picking up the echoes, special microphone receivers, placed in a special tank fitted in the ship's interior, are used. These tanks are bolted to the framing of the ship or, as the case may be, in the hold, and are rendered watertight by means of a rubber covering. The receivers are suspended in these tanks, which are filled with fresh water. A cable line connects the receivers with the indicator. Each apparatus has three receivers of this kind which are placed in different parts of the ship and which may be used indifferently.

Figure 22 shows the general aspect of the indicator and of the switch-board of the interruptors, such as they are within easy reach, on the bridge.

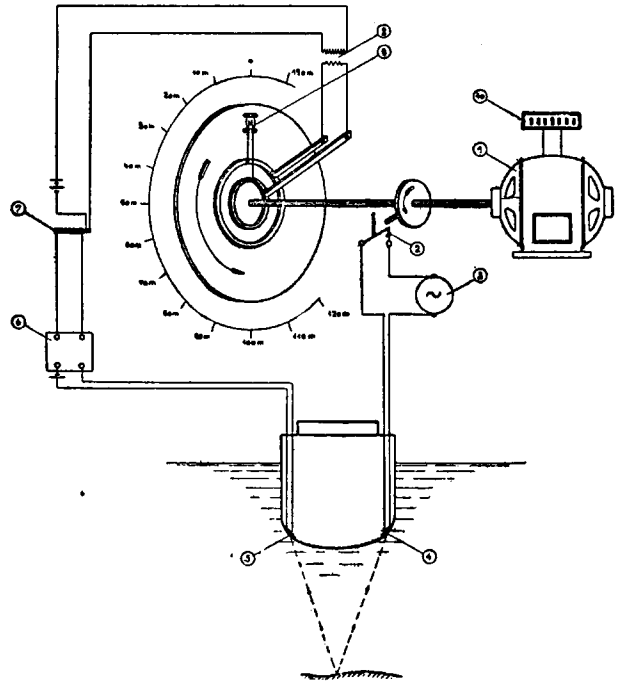


FIG. 23
ATLAS-LOT
Diagram. Schéma.

SWITCHBOARD WITH STARTER.

An automatic starter is found on the switch-board for starting the transformer and for using the transmitters. The latter contains the necessary commutators and fuses. S1 is the principal commutator of the network; S2 is the commutator which puts in contact, as the operator may wish, the port or starboard transmitter.

Figure 25 shows the general arrangement of the electric circuits for an apparatus with double receiver.

AMPLIFIER (FILTER).

In the circuit of the current, between the receivers and the indicator properly so-called, an amplifier, possessing 4 lamps, is inserted. The synthony is sufficiently acute to dominate all foreign noises, but at the same time the damping is great enough to avoid the natural vibrations of the tubes and the tinkle of the sound emissions. It is very important that the sound emissions should be most carefully limited for otherwise, in the intervals of short duration now under consideration, it would be impossible to obtain great exactitude.

It should be remembered that at depths exceeding 250 metres (140 fathoms) the registration of the depth is effected by means of an acoustic telephone;

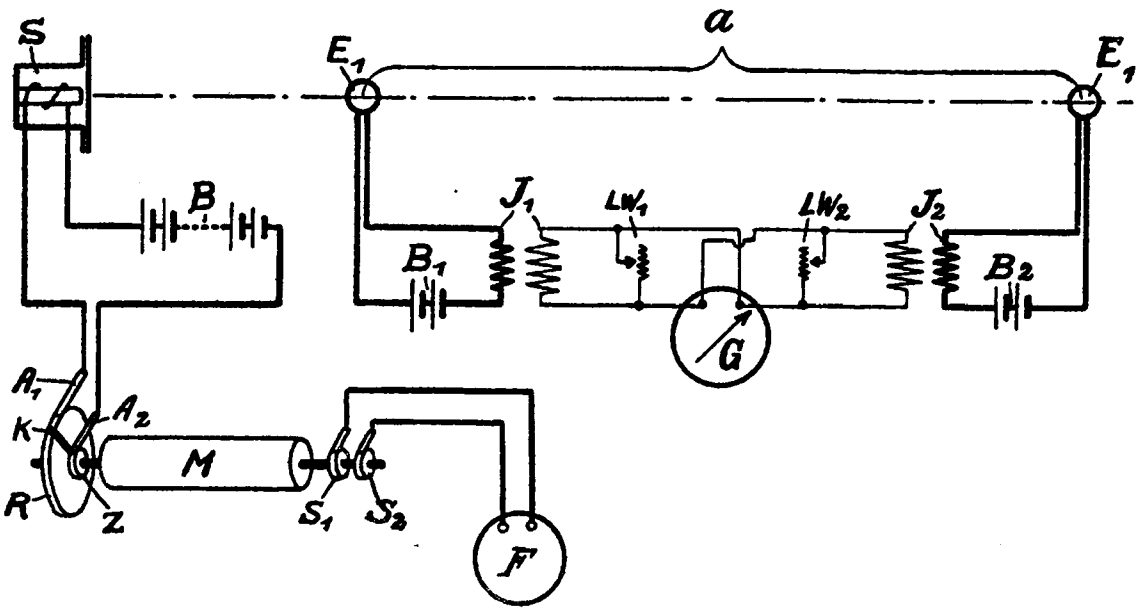


FIG. 25

Normally, the amplifier is used only in conjunction with the automatic indicator — hence for depths up to 250 metres (140 fathoms); if necessary, however, it may also be left in contact when greater depths are measured. In the amplifier case is installed the relay for putting in action the luminous signal upon the arrival of the echo impulsions. This relay is an extremely sensitive device which, each time that the echo impulsion coming from the amplifier passes through its winding, throws an impulsion of the current through the inductor of the red lamp belonging to the indicator, thus provoking an optical signal.

The amplifier lamps work with a heating tension of 5 volts and an anodic tension of 72 volts. The tension of the anode must be evenly maintained, for the current of the anode passes through the winding of the relay and the relay is regulated accordingly.

FOR THE RED LAMP METHOD.

As the depth does not change to any noticeable degree within a second, the time inferior to one second which the sound requires to complete its passage remains unaltered and, consequently, each time upon the arrival of the sound impulsion, the luminous ray travels the same distance from zero. In fact, therefore, the illumination is produced at the same place on the scale, thus giving the impression that a red pencil of light is continuously seen at the place in question. Should the echo, however, be too feeble to put the relay in action, the light fails and the scale rests in obscurity for an instant.

FIG. 22

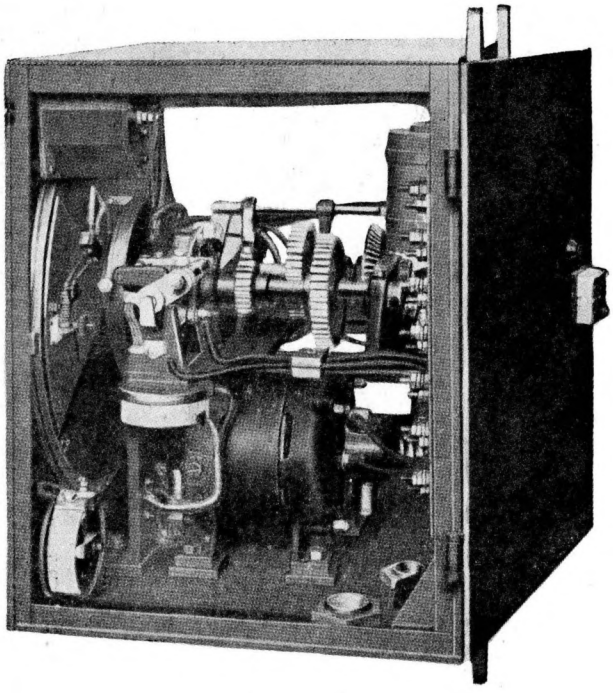


FIG. 24

ATLAS-LOT

Internal view. Vue intérieure.

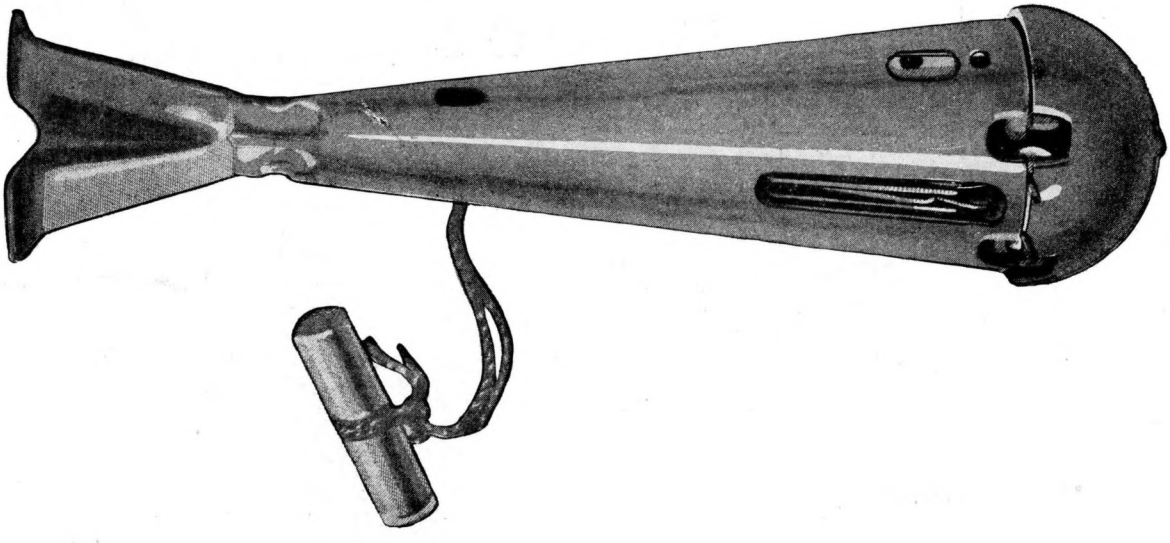
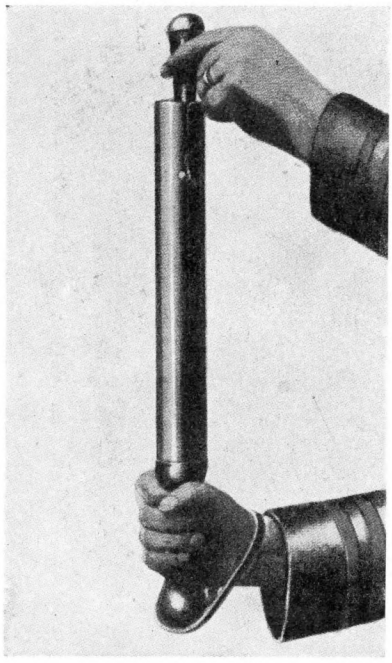


FIG. 26



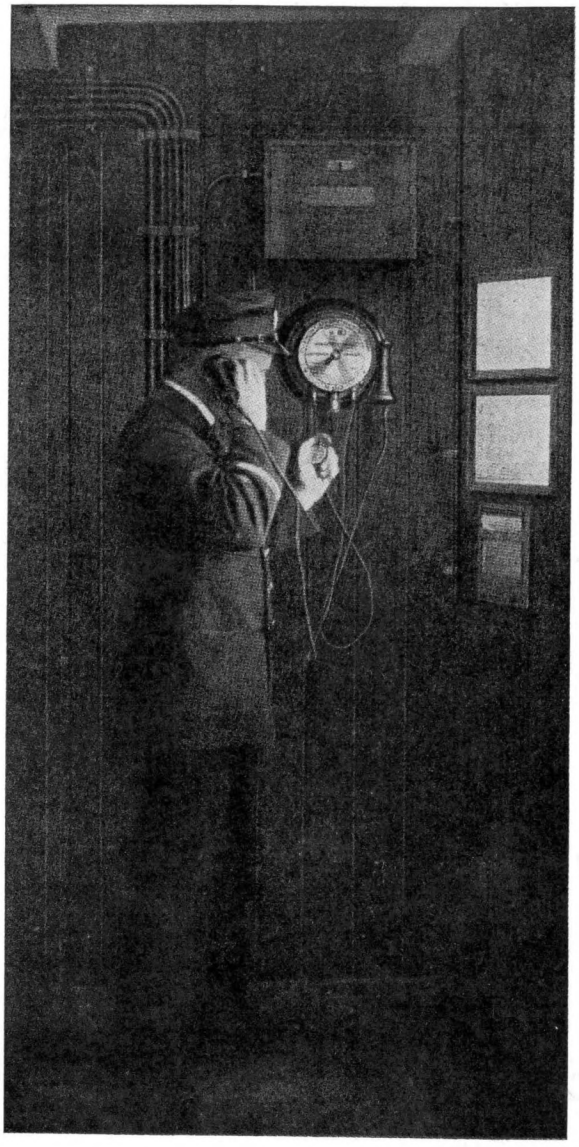


FIG. 28

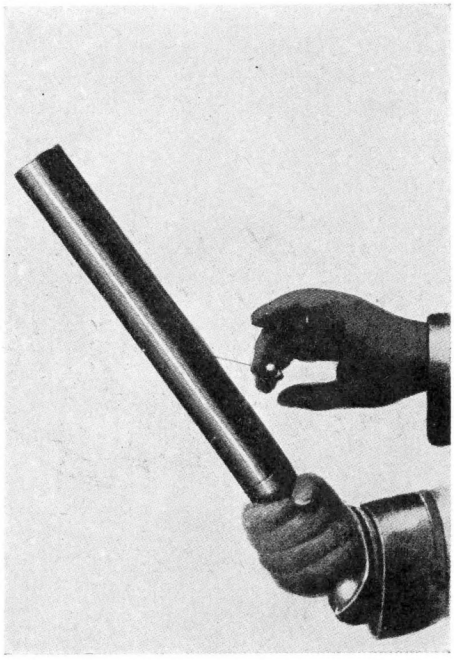


FIG. 27

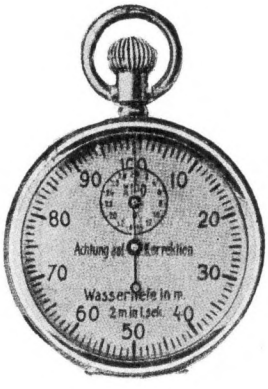


FIG. 29

Erroneous measurements due to disturbances, noises, etc., are signalled by the fact that the red light appears irregularly, now here, now there, at different places on the scale, thus showing that the indications themselves have nothing in common with the measurements. No measurement must be accepted as an indication of true depth for which the red light signal has not acted regularly and smoothly.

FOR THE WHITE LAMP METHOD.

The circuit of the white light is put in contact so as to act uninterruptedly and a ray of white light slowly makes the round of the edge of the outer scale.

It completes one revolution in exactly 1.5 seconds. At the moment when this white light signal passes zero on the outer scale the emission of a rather longer impulsion is produced.

In this case the observation is made by means of an auricular helmet. The measurement consists of the determination of the point on the outer scale at which the luminous signal stands each time an echo is heard in the receiver. After a certain amount of practice it is easy to succeed, upon hearing the echo, in fixing the position of the white light signal on the outer scale with an exactitude of from 10 to 20 metres ($5\frac{1}{2}$ to $11\frac{1}{2}$ fathoms). One complete revolution here corresponds to a depth of 1200 metres (about 650 fathoms).

If depths greater than 1200 metres (650 fathoms) are under consideration, a sound signal is emitted by means of a contact device when the pencil of white light passes over zero, then the button is pressed; in this way the production of other sound emissions when the white ray again passes over zero, is prevented. With the button still pressed down, the number of revolutions made by the luminous signal is counted — the position at which it rests at the moment when the echo is heard being thence deduced. To obtain the true depth, all that is necessary is to multiply the number of complete revolutions by 1200 and add the figure indicated on the scale. The echo having been picked up, the button is released in order that a sound signal may be emitted the next time that the pencil of light passes over zero, and the measurement is repeated in the same way.

"ATLAS FREILOT" ("ATLAS DROPPING LEAD".)

As complementary information to that already given in Special Publication N° 3, page 51, on a device for taking soundings in which an explosive is used, the following description of the "*Atlas Freilot*" (Atlas Dropping Lead) is given. This description has been communicated by the "*Atlas Werke Aktiengesellschaft*" of Bremen, the constructors, and deals more particularly with the safety assured in the manipulation of the instrument.

The "*Atlas Dropping Lead*" made on this principle (fig. 26) consists of a drop-shaped body of 6 inches length and weighing not quite 4 ounces. The velocity of fall is exactly 2 metres per second. At the upper end the body is provided with two tailshaped fins which ensure a uniform speed of

fall in the water, and in the manufacture serve for accurately adjusting the velocity of fall.

At the lower end is attached a movable, semispherical cap which, on touching the sea bottom, releases a mechanism similar to the trigger of a gun, which in turn releases a pin and explodes a cartridge. In the design of the "*Atlas Dropping Lead*" particular importance has been attached to protection against premature explosion, by the arrangement of a number of safety devices. As main security against explosion during transport, a locking pin is fitted which is only removed when preparing the lead for use. Two safety fuses of blotting paper still give full security after the removal of the above pin, and they allow the striker to pass only when under the influence of water. Finally, the Dropping Lead is cast into the water with the help of a sheet-steel throwing tube (fig. 27), and the main locking device is not withdrawn until the lead has been inserted in the tube. Everything has therefore been done to prevent any possibility of danger while handling the apparatus.

MANIPULATION OF THE ATLAS DROPPING LEAD.

The lead is extracted from the moisture-proof packing, is inserted in the throwing tube (fig. 27) and the locking pin withdrawn. The lead is now ready for casting. It is cast into the water from the bridge, on the lee side, and the stop watch is started the moment the lead plunges into the water. As said before, the lead sinks to the bottom with a uniform velocity of 2 metres per second. In the interval, the operator goes to the submarine signal receiving apparatus (fig. 28) holds the receiver to his ear, and awaits the detonation which indicates that the lead has struck against the sea bottom. The watch is stopped immediately the explosion is heard and the depth is ascertained by multiplying the number of seconds shown by the watch, by 2. If desired, the *Atlas Werke* can supply stop watches gauged direct in depth metres, or in fathoms (fig. 29). In the dark and in misty weather, when it is impossible to see the lead drop into the water, the watch can be started when casting off. In this case the measurements taken must be corrected, as the time of fall for the space between the bridge and the level of the sea must be added. Correction tables are included in the directions for use.

Height of projection....	4	6	8	10	12	14	16	18	20m.
Correction	−1.8	−2.2	−2.5	−2.9	−3.1	−3.4	−3.6	−3.8	−4m.

This device is used in the German Navy and on board numerous merchant ships.

IV. "ECHOLOT" OF THE SIGNAL GESELLSCHAFT KIEL (Germany)

The Nautische Abteilung of the Marineamt, Berlin, has forwarded to the Bureau a booklet issued by the Signalgesellschaft concerning the "*Echolot*" (Echo Sounder) constructed by this firm. A few extracts accompanied by drawings are given below which will permit the method of operation of this apparatus to be understood.

GENERALITIES.

In this apparatus, the time required by the sound to traverse the distance from the ship to the bottom of the sea, to be reflected there, and to return back in the form of an echo, is measured by comparison with the duration of rotation of a disc actuated by a uniform rotary movement.

The device is regulated for a velocity of sound in sea water of 1470 metres (800 fathoms) per second. One revolution of the disc is graduated for 1000 metres (550 fathoms); therefore, with the figure adopted above, it is effected in 1.36 seconds. The speed is regulated by an electric motor with centrifugal governor which is verified by means of a test tacheometer. As the rotation is very rapid there is a telephonic arrangement with which one listens for the reception of the echo by the microphone receiver. This telephone is connected up at the departure of the signal and the arrival of the echo. This connection, at the arrival of the echo, is produced for 0.0136 of a second and is reproduced with each revolution of the disc by the action of a milled wheel which moves a pointer on the scale. 0.0136 of a second corresponds to 10 divisions of the scale.

The regulation of the milled wheel gives the variation of depth — an approximation of 1 % is easily obtained on the measurement.

Up to depths of 50 metres (about 28 fathoms) the duration of the passage of sound does not exceed 0.068 of a second; in such a short interval of time, the receiver would not yet have acted because of its damping and the departure of the sound and the arrival of the echo would be heard simultaneously, it being thus impossible to notice their difference of intensity.

Similarly, if the disc makes more than one revolution, the apparatus would give identical indications for 125 m., 1,125 m., 2,125 m., etc. (about 70, 550, 1000 fathoms, etc.).

Delays due to the personal equation of the observer have been measured at the Signalgesellschaft Laboratories. With a watch showing thirds of a second a mean value of from 0.25 sec. to 0.05 sec. has been found, corresponding to a depth of 37 m. (20 fathoms).

To take soundings in depths over 1000 m. (550 fathoms), the duration of the period of emission for each revolution of 1000 m. is multiplied by 9, and a small auxiliary scale permits the revolutions to be read each 1000 m. This change for the great depths is effected by means of a press-button.

DESCRIPTION OF THE APPARATUS. (*See plate annexed — Fig.* 30)

The transmitter *Sd* is periodically excited by the controlling relays *R K*1 *K*2 for a duration of about 0.0136s.

As has already been stated, there are two periods :

the small period (for each revolution of 1000 m.) corresponds to 1.36054s.

the large period (9 times greater) corresponds to 12.248s. (for 9000 m.) (4950 fathoms), taking 1470 m. as the velocity of sound in sea water.

The various parts are as follows :

*M*1 *M*2	Microphone Receivers
SP	Telephonic Transformers
BT	Battery
W	Variable Resistance
J	Ammeter of the microphone
H_6 H_4 H_5	Sound interruptors mounted, in parallel, to the terminals of the telephone.
M	Segment worked by the milled wheel, the position of which may be read on the scale *Sk* 1.
A	Disc with nose turning independently of *M* in the direction of the arrow.
Z	Needle forming part of *A* serving as index connected with the mechanism.
B and *C*	Demultiplicator discs (in the ratio of 1 to 9) — *B* and *C* make one revolution for each 9 revolutions made by *A*.
B	is fitted with 9 small teeth which act on the interruptor H_1.
B	is also fitted with 1 large tooth.
	For each revolution of *B*, the interruptor H_1 makes 9 contacts, each small tooth corresponds to 1 revolution of *A*.
	The disc *C*, mounted similarly to *A*, serves for depths greater than 1000 m. for which the period of emission is 9 times greater.
	The cam of *C* occupies 1/9th of the circumference and, through the interruptor H_4, it suppresses any short circuit in the telephone transformer *PS*.
*Sk*1	is the principal scale (*See also Fig.* 31)
*D*1	is its manipulation wheel
*Sk*11	is the secondary scale, manipulated by wheel *D* 11.
PO	is an ohmic resistance, branched in parallel, to reduce parasitical noises.
F	Telephone plugs.
*E*1	Commutator of the small motor.
*E*2	Commutator of the Microphone battery.
R (Fig. 31)	Rheostat for regulation of the intensity of current of the microphone.
*E*3	Interruptor of the current of emission.
*E*4	Interruptor disconnecting H_6 H_4 H_5.

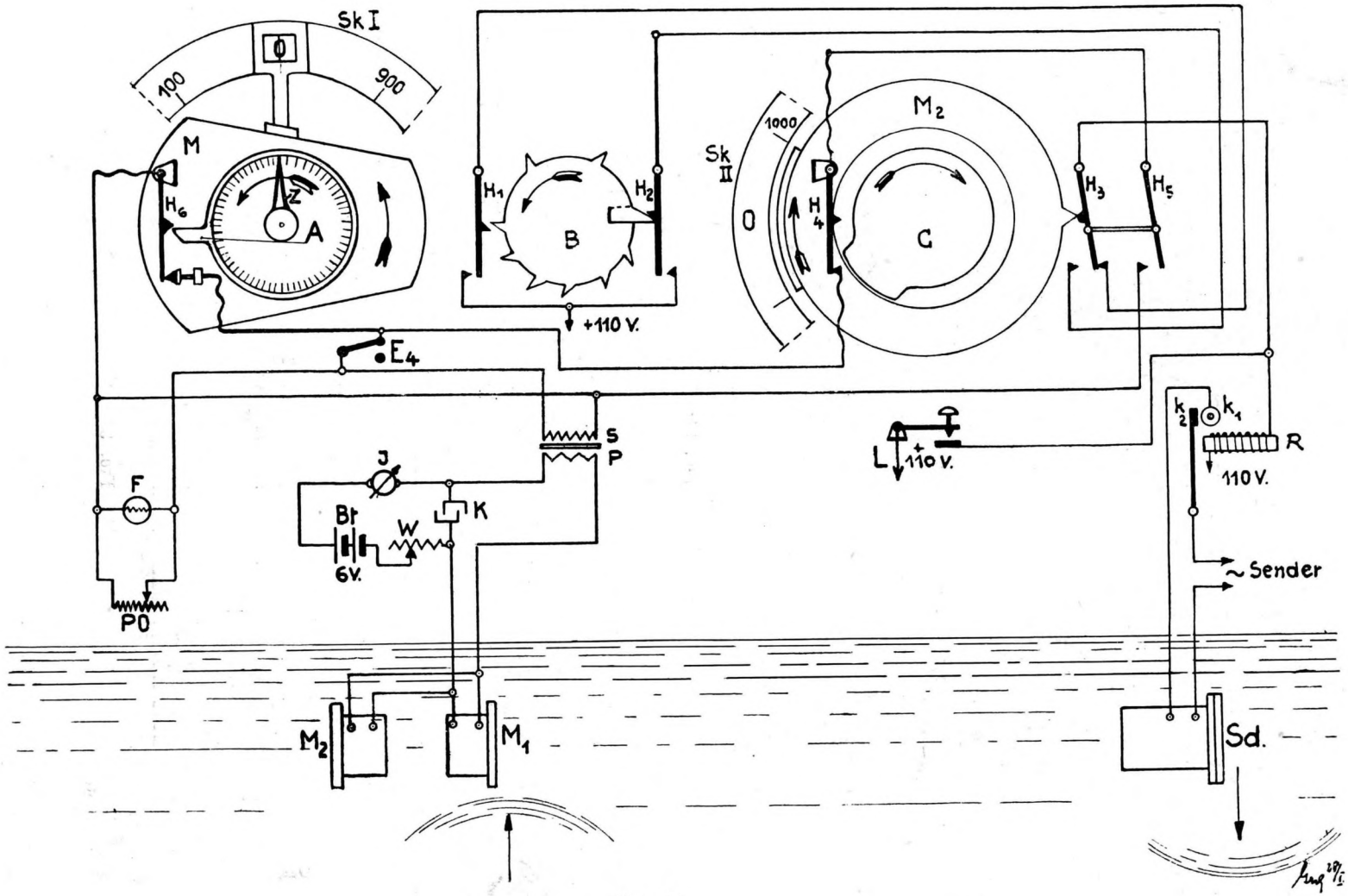

Sk I
0
100
900
M
H6
Z
A
H1
H2
B
+110 V.
Sk II
1000
0
H4
M2
C
H3
H5
E4
S
P
J
F
Br
6V.
W
K
P0
L
+110 V.
k2
k1
R
110 V.
~ Sender
M2
M1
Sd.

FIG. 30

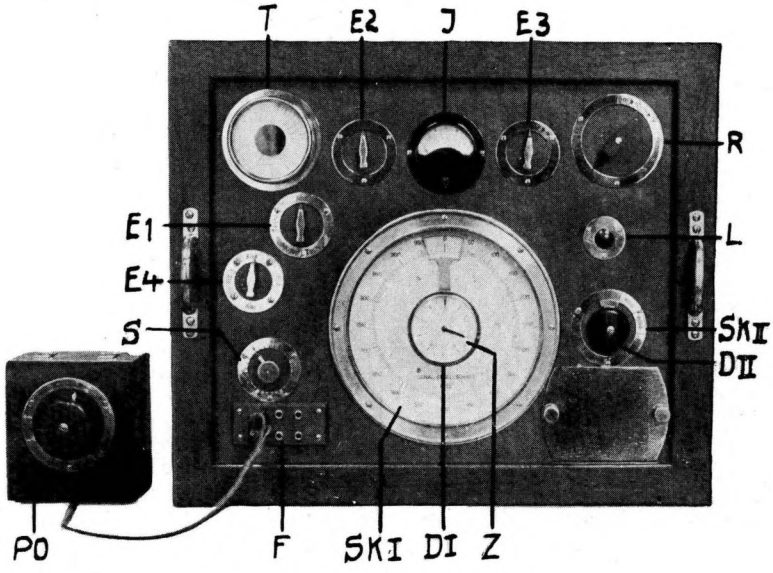


Fig. 31

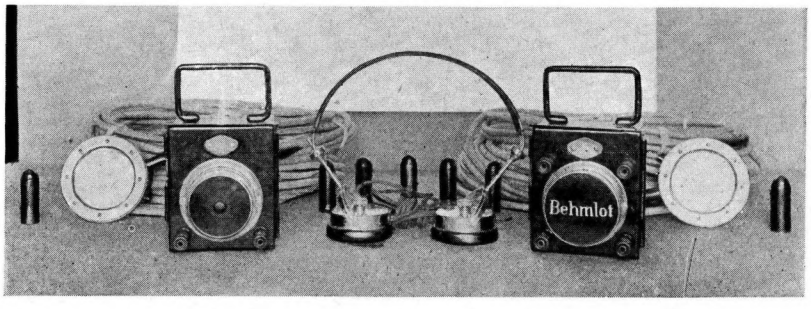


Fig. 32

S	Hand-lever for regulating the speed of the mechanism.
T	Tacheometer
L	Key of relays.

METHOD OF OPERATION.

To measure depths less than 1000 m., *E*1 which puts in motion the motor which turns the disc, is closed.

The number of revolutions is regulated by means of *S*.

*E*2 *E*3 are closed and the current of the microphone is regulated to 0.100 amp.

*E*3 is closed, the transmitter begins to emit regular impulsions.

Fix the telephone helmet; then turn the wheel *D*1 slowly in the direction of the arrow until the return of the echo is heard by means of the telephone.

To arrive at the best position for the hand-lever, it seems of advantage to work it by "swinging" on this side and that of this position.

To measure depths greater than 1000 m., after having started the apparatus as described above, *Sk* II is moved from its inoperative position and *E*4 is opened — the cover is taken from the large scale so that the latter may be seen.

From this moment the emission is heard each time that the small index passes to zero, then, shortly afterwards, according to the depth, the echo itself is heard.

To operate with greater precision, *E*4 should be again closed and *Sk* II placed on the number of the 1000nds which corresponds to the depth of the water. Then *D* 1 is adjusted so that the echo may be perceived in the telephone; the depth is equal to *Sk* I + *Sk* II.

The preceding appliances (Atlas-Lot or Fathometer) have, in particular, been fitted up on the American surveying ships, "*Surveyor*", "*Discoverer*", "*Guide*", *Pioneer*"", "*Fathomer*", "*Marinduque*", "*Pathfinder*", and on the German surveying ship "*Meteor*".

The last-mentioned, during its Atlantic cruise, was equipped with sounding machines of the following models:—

1° The Freilot (or Dropping Lead) of the Signalgesellschaft of Kiel, for shallow water to depths of 200 m. (110 fathoms).

2° The Sounder "Behm Type II" of the Behm Echolot Gesellschaft of Kiel for depths ranging from 14 to 750 m. approximately (8 to 420 fathoms).

3° The Signal-lot of the Signalgesellschaft of Kiel taking soundings from 50 m. (25 fathoms) up to the greatest depths encountered which were 8060 m. (4400 fathoms) with a precision of 10 m. (5 ½ fathoms).

4° The Atlas-Lot of the Atlas Werke of Bremen, giving soundings from 10 m. up to the greatest depths. Its precision by the needle indicator is from ½ to 10 m. for from 10 to 185 m. depths, and 10 m. for the greatest depths measured by the arrival of the echo through the telephone.

On the occasion of the 14th Conference of the Navigational Companies (Berlin, 15th March, 1927). Dr W. Kunze gave a lecture on the recent development and the importance of echo-sounding appliances in the Merchant Service. Through the intermediary of the Atlas Werke of Bremen, an illustrated booklet containing this lecture was published in the German language.

On the other hand, various documentary articles appeared in the "Annalen der Hydrographie u. Mar. Met." at the time of the cruise of the "Meteor". A separate publication of these articles appears in a work entitled: "Die deutsche atlantische Expedition auf dem Vermessungs-und-Forschungschiff "Meteor"; they contain detailed commentaries and descriptions of the above-mentioned appliances — particularly one article:— "Die akustischen Tiefseelote" (Annalen der Hydrog. 1926, Heft III) by Lieutenant FREIHERR VON RECUM.

A photograph of the aerial Echo Sounder of the Behm Echolot Gesellschaft of Kiel (Fig. 32) accompanies the present article; this sounder was used by the aeronautic polar expedition. Its total weight with 100 cartridges is 12 kg.500.

V. — REDUCTION OF SOUNDINGS.

REDUCTION OF SOUNDINGS.

In special Publication N° 4 (March 1925) the I. H. B. has already given (page 25, page 55, etc.) a few elements of the method of reduction of soundings and their correction for the velocity of sound (page 55 and following) as well as in the *Hydrographic Review*, Vol. III. N° 1, November 1925, pp. 69 to 100 and Vol. IV. N° 1, May 1927, page 229.

Since the last date, the Hydrographic Department of the British Admiralty has published Tables entitled:— "Tables of Velocity of Sound in Pure Water and Sea Water for use in Echo-Sounding and Sound Ranging — 1927 — Price 1s. net".

In the Annalen der Hydrog. u. Mar. Met. of September and October 1926 Dr H. Maurer published an article entitled:— "Echolotung bei geneigtem und stark bewegtem Bodenprofil" which gives a Table of Corrections for Echo-Soundings taken when the bottom of the ocean slopes or is of very irregular conformation.

After three years of experiment in echo-sounding, the United States Coast and Geodetic Survey has drawn up a diagram for slope corrections, based on the hypothesis of a uniform slope and for various slope values up to 20°.

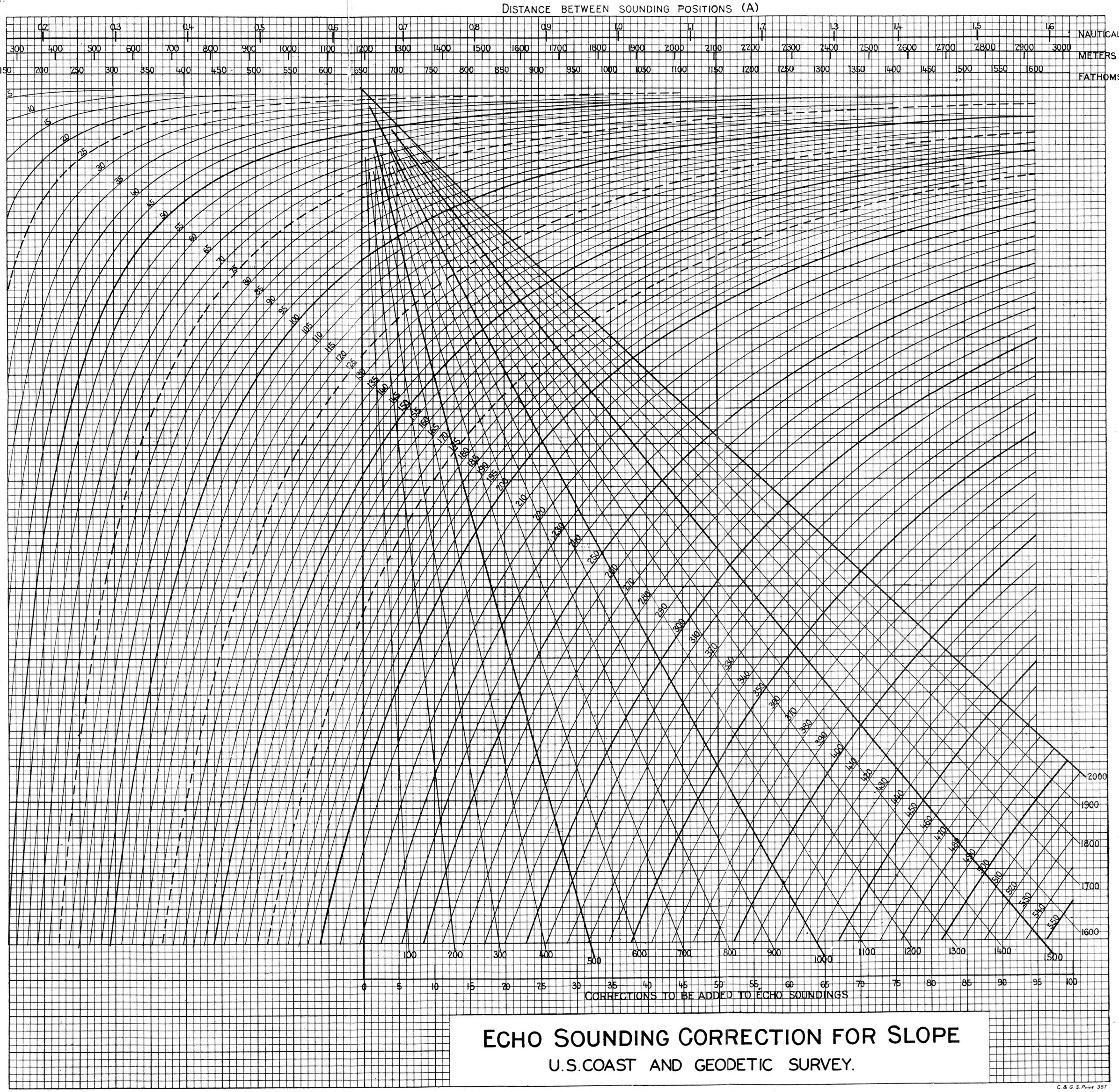

DISTANCE BETWEEN SOUNDING POSITIONS (A)
NAUTICAL MILES
METERS
FATHOMS
CORRECTIONS TO BE ADDED TO ECHO SOUNDINGS
ECHO SOUNDING CORRECTION FOR SLOPE
U.S.COAST AND GEODETIC SURVEY.
C. & G. S. Print 357

Fig. 33

This diagram is here reproduced (Fig. 33) with the following explanation and directions for use.

Distances between sounding positions are given at top of diagram in tenths of nautical mile, in metres and in fathoms (A of Fig. 34).

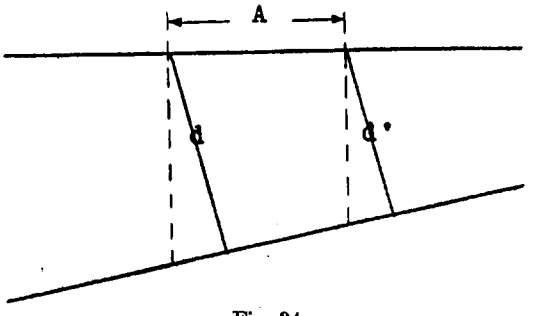


Fig. 34

Curved lines numbered from 5 to 550 are differences of adjacent echo soundings or apparent depths (*d* and *d'* of Fig. 34).

Diagonal nearly straight lines, numbered 100 to 2000, are apparent depths (*d* and *d'* of Fig. 34). Scale at bottom of diagram numbered 0 to 100 gives corrections, in same units as soundings, to be added to apparent depths.

To get slope correction — Enter diagram at top with distance between adjacent echo soundings. Drop down vertically to curve of difference of soundings and then step horizontally to the curve of the first apparent depth (echo sounding), interpolating between 100 fathom lines. The depth correction will be given by the number of squares between the intersection of the horizontal line with the apparent depth curve and the vertical line, numbered *0* on the bottom scale. Correction to the second echo sounding is obtained in the same way by continuing along horizontal line to the curve of that apparent depth.

In order to satisfy a wish the expression of which has been forwarded to it, the Directing Committee of the I. H. B. would be glad to receive from Hydrographic Offices complementary information on the methods employed by them for reduction of echo-soundings.