ECHO SOUNDING

ECHO SOUNDING (XV).

NEW BRITISH ADMIRALTY RECORDER ECHO SOUNDERS.

The constructors of British Admiralty Echo Sounding Machines, Messrs Henry HUGHES & Son, Ltd., 59, Fenchurch Street, London, E.C. 3, have sent to the International Hydrographic Bureau several documents containing descriptions of the most recent models of Echo Sounding Machines adopted by the British Admiralty. Extracts from these pamphlets, consisting of the most recent details concerning those instruments, are given below; they form a supplement to the information already published in different volumes of the Hydrographic Review: (1)

The following are complementary details of the M.S. III and M.S. IV models of Echo Sounding Machine (for previous mention see Hydrographic Review, Vol. XI No. 2, November 1934, page 38).

The recording echo sounders types M.S. III and M.S. IV are supersonic with magneto striction transmission and straight scale recorders.

Photograph 1 gives a general idea of the exterior of the receiving apparatus ; the window by which the recording is effected may be seen: photograph No. 2 shows a portion of a record with its straight scale system of analysis.

(See also photograph facing page 164 of *Hydrographic Review* Vol. X, No. 2, November 1933).

In these models the stylus moves across the paper in a straight line ; thus the record is only "compressed" it is not "distorted".

Figure II is a diagrammatic representation of the Recorder mechanism. The essential features are the motor *A* driving through a gear box *B* and shaft *C*, the switch cam *D*, and the scroll *E*. The revolving of the scroll *E* drives the stylus *F* backwards and forwards across the recording paper *G*.

Once each revolution the cam *D* causes a sound to be sent out from the bottom of the ship. At approximately the same instant the stylus passes the zero of the scale, as will be explained in detail later, the stylus marks the paper to show the interval between transmission and the echo being received. This being directly proportional to depth, the scale can be graduated in fathoms or any other depth unit.

The recording paper is chemically treated so that a current passing through the paper from a point such as the stylus *F* to a plate such as the tank *H* will cause a brown mark on it. Hence if a steady current is passed through the paper while the stylus is moving across it, the brown mark will record the track of the stylus point, but if a short pulse of current is passed through the paper at a definite position of the passage of the stylus, the brown mark will occur only at that position.

It is readily seen that such an arrangement may be used as a depth recorder by causing the returning echo to supply a short pulse of current to the moving stylus at the moment of its arrival. If the paper is made to move a short distance, at right angles to the movement of the stylus, for each passage of stylus, the successive echoes will form a contour record of the sea bed.

The considerations governing the calibration of the scale are simple. The velocity of sound in sea water may be taken as 800 fathoms per second, so that sound requires 1 sec. to go and return in a depth of 400 fathoms. Hence, if we divide the scale into say 400 divisions, and make the stylus move through these 400 divisions in 1 second, then for every fathom of depth the stylus will move through 1 division. If the switch

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(1) *See Hydrographic Review - Vol. V. No.* 1 *- May* 1928, *p.* 131.
See Hydrographic Review - Vol. VII. No. 1 *- May* 1930, *p.* 99.
See Hydrographic Review - Vol. VII. No. 2 *- Nov.* 1930, *p.* 105.
See Hydrographic Review - Vol. IX. No. 2 *- Nov.* 1932, *p.* 135.
See Hydrographic Review - Vol. X. No. 2 *- Nov.* 1933, *p.* 160.
See Hydrographic Review - Vol. XI. No. 2 *- Nov.* 1934, *p.* 36 *&* 38.
See Hydrographic Review - Vol. XII. No. 2 *- Nov.* 1935, *p.* 50.

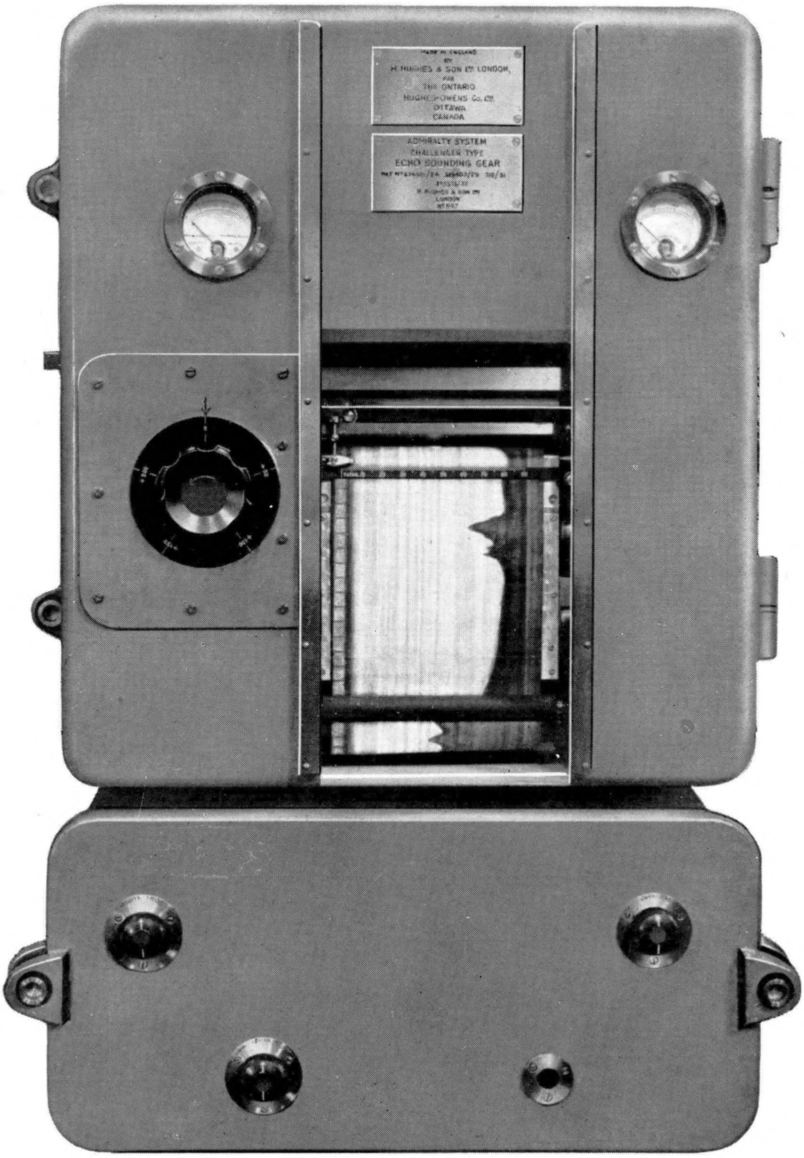


Fig. I

Modèle super sonore de l'Amiranté avec émission par Contraction magnétique
Types MS. III & IV.

Admiralty Super-Sonic Pattern with Magneto-Striction Transmission
Types M.S. III & IV.

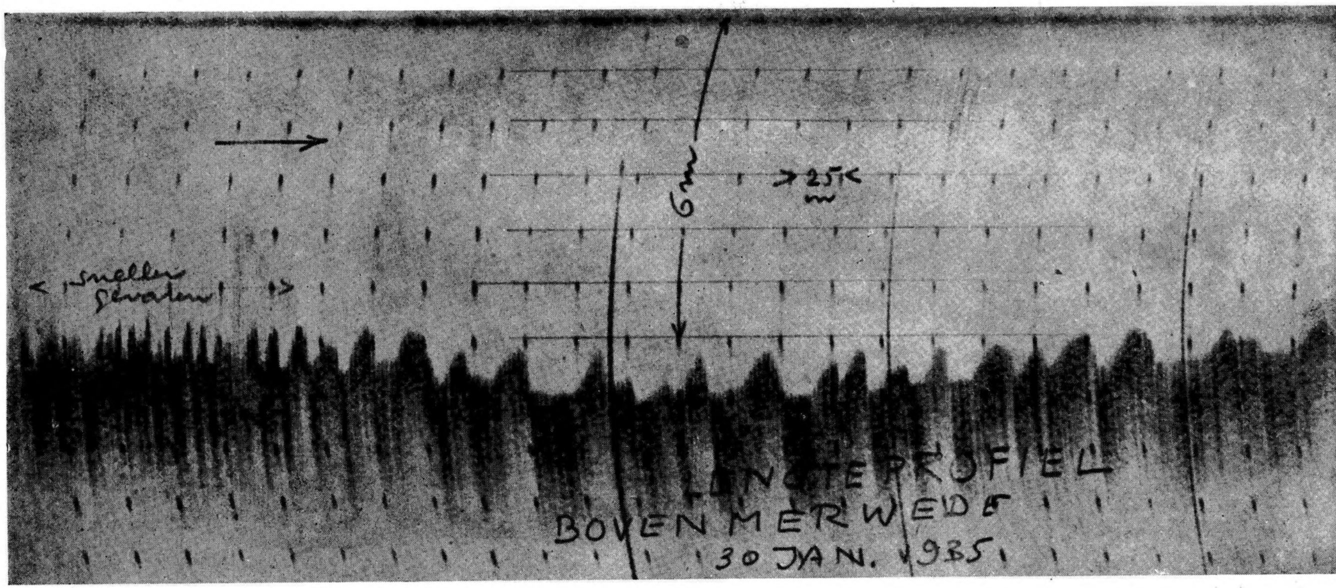


Diagramme mettant en évidence des ridins de sable du lit de la mer du Nord, pris avec l'enregistreur à bras tournants
Chart showing Sand Ripples taken in the North Sea with Rotating Arm Gear

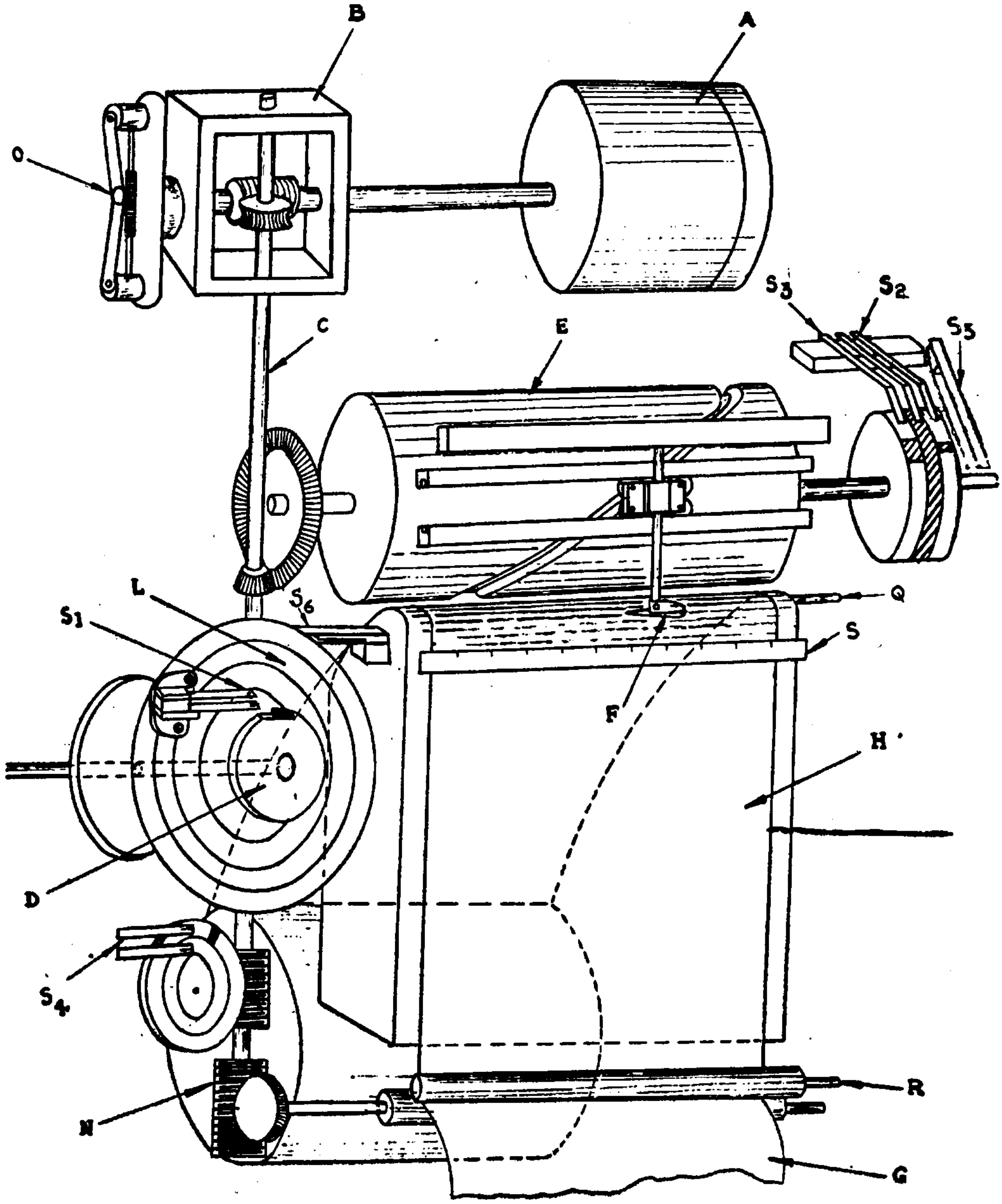


FIG. II

cam D is adjusted so that transmission occurs at the instant the stylus passes the zero division, then an echo from a 100 fathom depth will return as the stylus is passing the 100th division, and the record will be made on the paper at the 100th division. Such a scale may be marked directly in fathoms. It is clear that recorders possessing different scales may be produced by simply varying the rate of travel of the stylus. It is also clear that, for any given recorder it is essential to keep the speed constant at the rated value. An automatic governor is fitted so that the speed varies very little with ordinary variations in voltage.

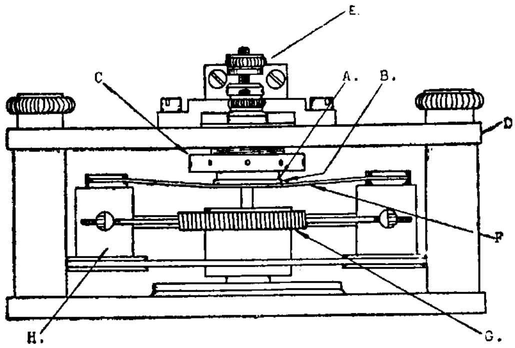


FIG. IV.
Motor Governor Gear.

Phasing :

It is clear that if there is an interval between transmission and the instant the stylus passes the zero of the scale, then the recorded depth will not be true, but if the interval is known then the echo depth corresponding to the interval, can be added to the recorded depths, to give the true depth. Advantage is taken of this fact to increase the range of the recorder beyond the depth shown on the scale without the necessity of contracting the divisions of the scale. Referring again to Fig. II, transmission is caused by the break of the contacts of S_1, and these are mounted on a dial L, which can be turned by hand about the cam D. Hence since the cam D is rotating at a definite known speed, the displacement of S_1 through a known angle, results in a definite interval between transmission and the instant the stylus passes the zero. This interval can be readily expressed in fathoms and can be engraved on the dial to show the amount to be added to the scale reading. (Knob Z, photograph 1). A spring plunger engages in slots, cut in the periphery of the dial to determine this definite angular displacement.

On the diagram, the indication of the zero is represented by a band of a certain width. The width of this zero band is determined by the sound reaching the receiver either by diffraction or by transmission through the hull. The band is of appreciable width but less intense than the echo band in very shallow water; in order to record very shallow depths it is therefore sufficient to reduce the sensitivity of the amplifier.

Transmitter :

It has been sought to realise as transmitter an oscillator having a frequency lying between that of the piezo-quartz (30 to 40,000 cycles per second) and the hammer. This has been achieved by the Admiralty scientists in making use of the magnetic properties of certain metals — principally alloys of iron-nickel-cobalt. If a rod thus constituted is subjected to the action of an alternating magnetic field parallel to its length, changes in its linear dimensions are produced (the JOULE effect) and mechanical oscillations at the frequency of this alternating field are set up; when this frequency coincides with the natural frequency of the rod in longitudinal vibration, resonance occurs and a large increase in the amplitude of vibration results. Conversely, some ferromagnetic materials possess the properties of changing their magnetic condition when mechanically strained (the VILLARI effect). However, the phenomenon in this simple form is practically useless for the generation and reception of sound at high frequencies. In the first place the eddy currents in the rod prevent the penetration of high-frequency

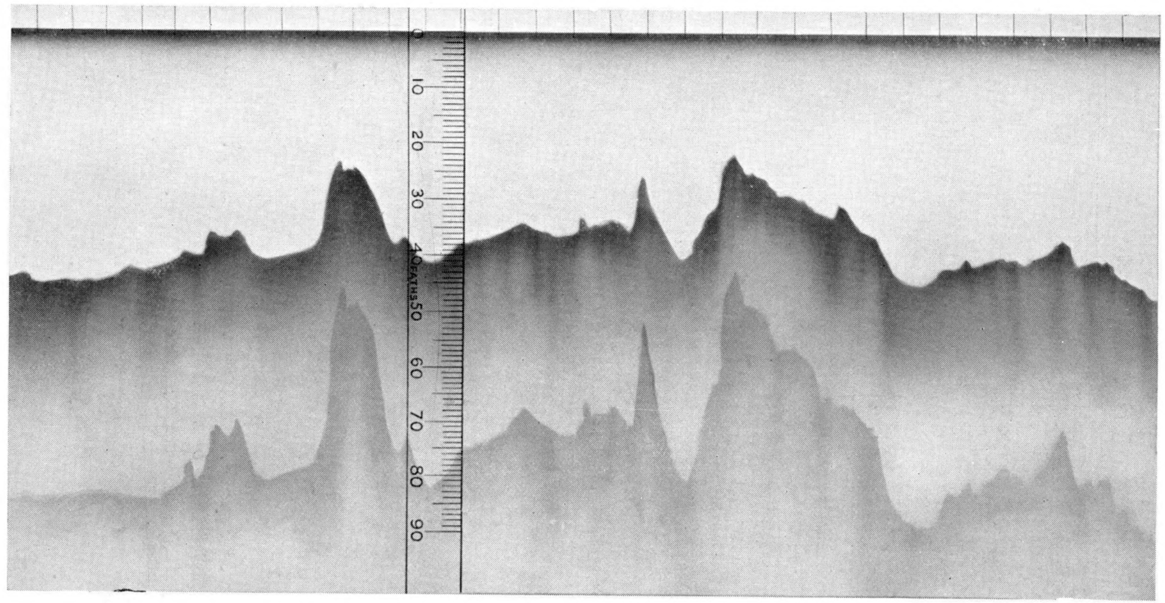


FIG. 3

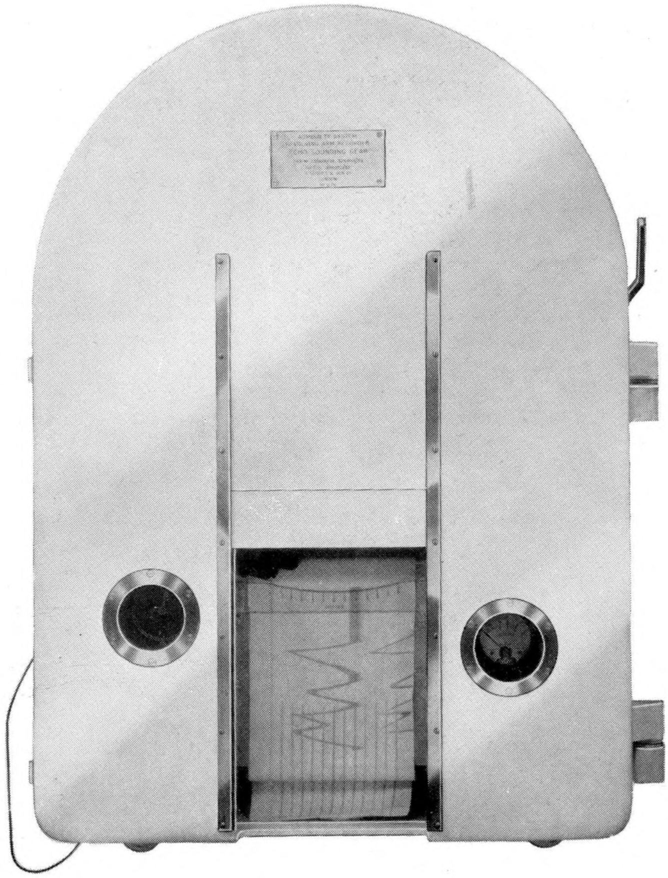
Photographie d'un enregistrement effectué par l'enregistreur Type M.S. III monté à bord du S.S. "Clan Mackinlay".

Portion du Firth of Clyde au large de Holy Island, Août 1935.

Nota. — L'échelle que l'on voit le long de la partie supérieure de l'enregistrement est une échelle des temps en minutes.

Photograph of Record made by Type M. S. III Recorder, fitted in s.s. "Clan Mackinlay". Portion of Firth of Clyde, off Holy Island. August, 1935.

Note. — Scale along top of record is a time scale in minutes.



Modèle "Universal" Type M.S. XII avec enregistreur à échelle courbe et bras tournant.
Dimensions du coffret : 28 × 41 × 28 c/m.

Rotating arm curved scale recorder "Universal" Pattern Type M.S. XII
Size of case 11" × 16" × 11".

alternating magnetic fluxes, and only a thin layer of material on the outside of the rod is effective in producing vibrations. Again, the demagnetizing effect of the ends of short bars prevents the magnetic induction from attaining sufficiently high values. Consequently it is desirable that the magnetostrictive material should be constructed (*a*) of thin sheet or laminations, and (*b*) in the form of a closed magnetic circuit. These laminae, however, must not be excessively thin; thin laminae are not usually regarded as capable of good resonance. Measurements in water show that the internal mechanical damping of the laminae is small compared with the radiation damping; the efficiency of conversion of electrical into mechanical energy is thus very good.

Various forms of these high-frequency oscillators have been constructed in accordance with the above principle — some of them making use of longitudinal vibrations and others (ring oscillators) making use of radial vibrations.

In order to obtain sufficient "directionality" in the magnetostriction transmitter and receiver, the oscillators must be mounted in some form of reflector in order to confine the sound-energy to a relatively narrow cone. Pure nickel has been chosen as metal as it has a high resistance to corrosion and may remain for long periods in water without sign of deterioration.

The frequency can be adjusted by the dimensions of the oscillator. If a ring or annulus of the metal be considered, then the natural period is directly proportional to the diameter of the ring; in the magnetostriction type of oscillator a frequency of 16,000 cycles per second has been found to give results covering every ordinary requirement; in fact, it has great penetrative power and is capable of sounding to depths of over 1,000 fathoms. The half-angle of the reflected beam being about 21° round a vertical axis, pitching and rolling of the vessel up to angles of 20° are practically negligible.

Frequency is sufficiently high for the machine to be inaudible.

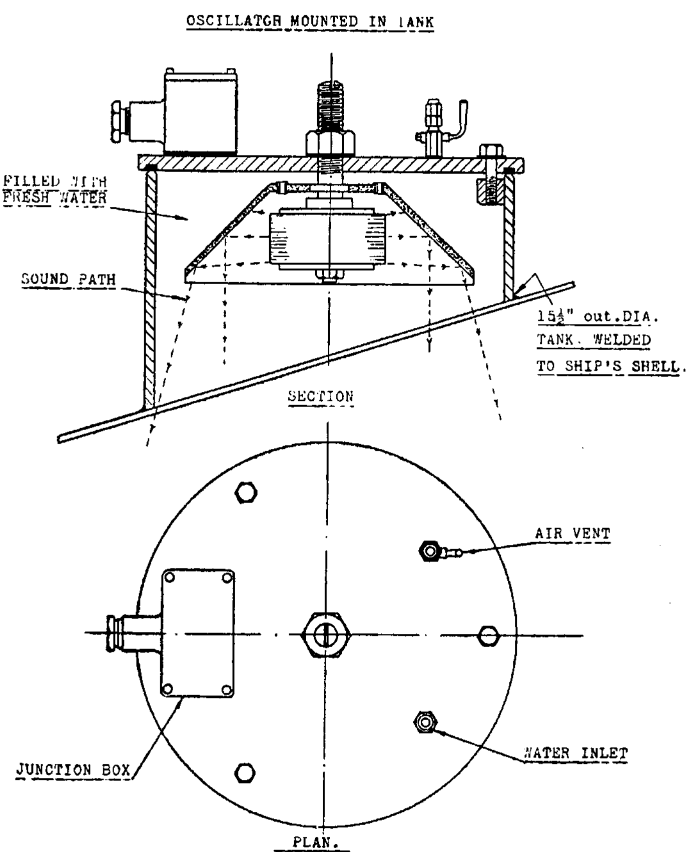


FIG. III

The transmitter is simply a pile of nickel stampings with a toroidal winding, so that the oscillatory discharge sets up an oscillatory magnetic field in the nickel stampings. The oscillatory magnetic field causes the mean diameter of the stampings to undergo periodic changes, or in other words to vibrate radially.

As has been said, the frequency of the discharge is adjusted so that the pile of stampings resonates at its fundamental mechanical frequency.

The radial vibrations are transmitted to the water horizontally and reflected downwards through the bottom of the ship by a conical reflector.

The Receiver :

The Receiver is similar in construction to the transmitter and is arranged in the same type of conical reflector. The process which occurs as transmission is reversible, so that when the incident sound energy sets the receiver into vibration, the magnetisation of the nickel is altered periodically and sets up an oscillatory electrical current in the windings. This current requires amplification in order to operate the recorder.

In most respects the amplifier resembles standard wireless amplifiers. (See Fig. V. bottom of diagram).

The input transformer is of the dust-core type tuned by means of a .0005 M.F. variable condenser. The 2-volt battery valves are MULLARD S.P. 2 Pentodes.

The first stage of amplification. is choke-capacity coupled to the second and yields a voltage amplification of about 100 times.

The second stage is coupled to the recorder stylus by a Ferranti output transformer employing a 10 : 1 step down ratio. A WESTON metal rectifier is used to rectify the output from the transformer before applying it to the stylus. The voltage amplification of this stage is about 30 times.

The V.A.F. of the input transformer is about 350 so that the V.A.F. of the whole amplifier is about one million. These figures are for maximum sensitivity of course.

The lower sensitivity required in shallow water to prevent the reception of cross-noise is obtained by applying a bias to the grid of the first valve. This bias is applied in a rather unusual manner. Instead of regulating the grid bias by means of a manual control, as is usually done in wireless amplifiers, the grid bias of the first valve is dependent on the charge on the condenser C_1 shown between the input transformer secondary and the L.T. negative lead.

The condenser C_1 is charged immediately prior to the moment of transmission by means of a switch S_1 which is coupled to the recorder mechanism and is located beside the zero and minute marking switches. This switch is called the suppressor switch.

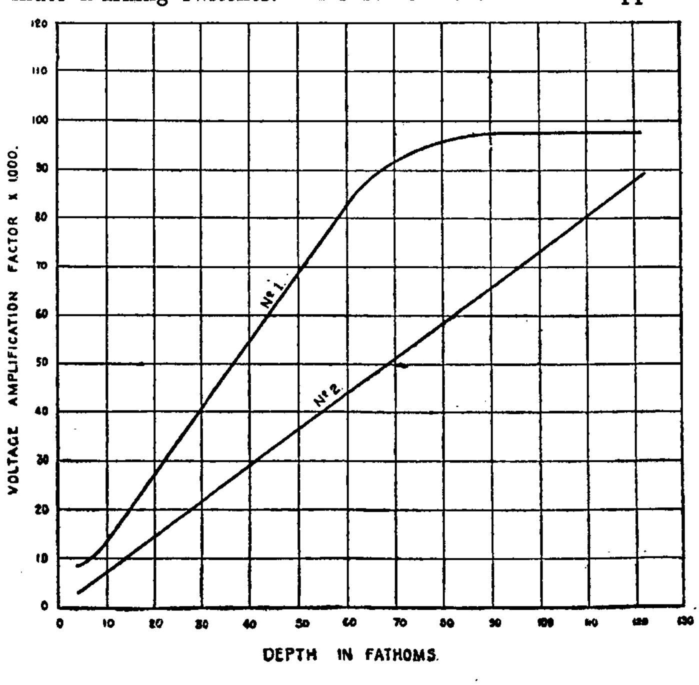


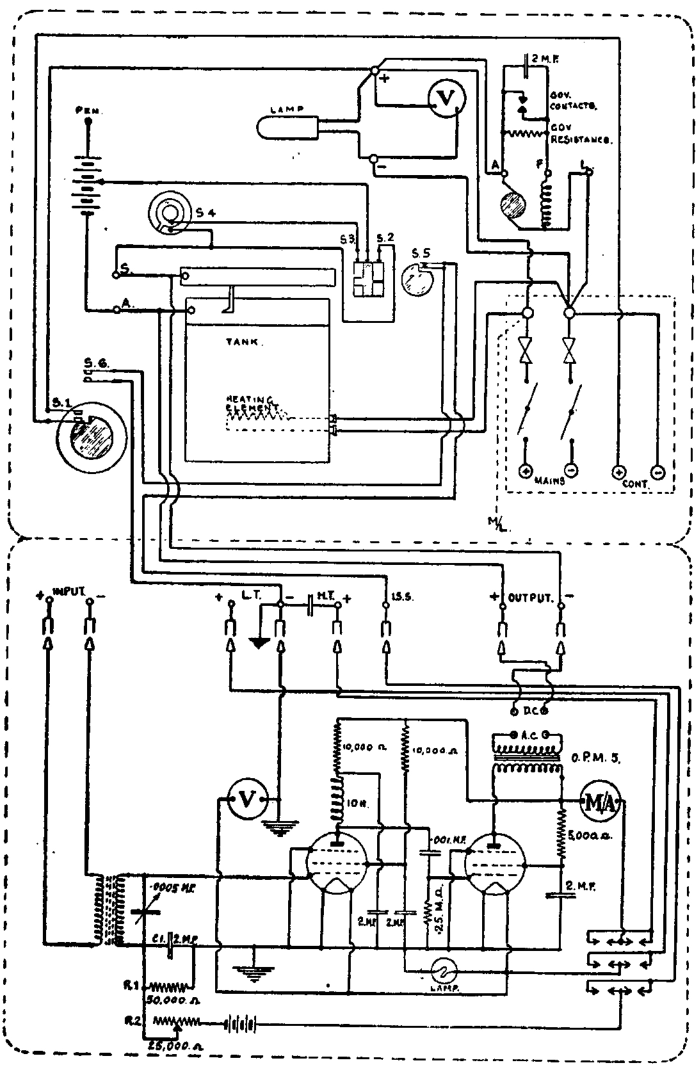
FIG. VA.

The charge then leaks off the condenser through the resistance R_1, and the grid bias consequently diminishes and the sensivitity rises. The rate at which the sensitivity rises is shown in Fig. VA - Curve 1., which is based on measurements on a 125 fathom machine. In this figure the fathom may be treated as a unit of time, each fathom being 1/400 sec. Hence, Curve 1 shows that 40 fathoms (1/10th sec.) after the moment of transmission, the amplification factor is nearly 55,000 ohms.

Curve 2, shows the lowest amplification that may be used in any given depth. It is clear that the amplifier actually provides an amplification about double that required, which is desirable in order to receive echoes from a soft mud bottom.

The charge applied to the condenser may be regulated by varying the voltage tapping on the grid bias battery, or by adjusting the 25,000 ohm resistance R_1 shown at the left hand side of Fig. V. in series with the grid bias battery and the condenser. This is the control at the left hand side of the amplifier.

In the case of a recorder employing a system of phasing it is clearly not desirable that the suppressor switch should operate on any phase above zero phase, as it would provide a sensitivity appropriate to say 10 fms. when in a depth of 110 fathoms if phased up by 100 fms. Hence a switch S_6 (Fig. 5) is placed in series with the suppressor switch, this switch being closed by the phasing dial when in the zero phase position, and allowed to open with the phasing dial in any other position, thus automatically throwing the phasing switch out of action when not wanted.



VALVES:-

FIG. V

The Recorder Mechanism :

The motor is a nominal 1/8 H.P. which actually requires only about 70 watts input to drive the recorder. Its speed is controlled by a *centrifugal governor*, the wiring diagram of which is shown in the upper right hand corner of Fig. V. When the correct speed is reached the governor brings two contacts together. This short circuits a resistance in series with the field windings of the motor, increases the field current, and prevents the speed rising further.

The two contacts which short circuit the field resistance are *A* and *B*. *A* is an annular ring of carbon mounted in an adjustable holder *C* which is threaded into the insulating plate *D* and locked by the nut *E*. The contact *B* is of copper mounted on a steel spring *F*. Spiral springs *G* serve to oppose the centrifugal force on the weights *H* The tension of these springs may be adjusted by means of the 6 *B.A.* nuts on each end. A box spanner is supplied for this purpose. The tension should be the same on both springs and adjustments should be made on all four nuts at the same time in order to preserve the balance of the assembly.

The speed at which the governor comes into action depends on two factors, the setting of the contact *A* and the tension on the springs *G*.

If it is desired to make a small adjustment of speed it is best to alter the tension on the springs. A sixth of a turn on each of all four screws produces a change of speed of one to three per cent. An accuracy of setting of one per cent or better can be made in two or three trials. Increasing the tension increases the speed, while a decrease of tension reduces the speed.

Checking speed :

This is most easily done by counting the number of transmissions per minute. Counting the "clicks" of the transmitter switch is one method.

Alternatively, telephones on the output from the amplifier enables a count of each transmission to be made. The number of transmissions which should be produced by any particular machine may be found by dividing the motor speed (either 2880 or 1800 r.p.m.) by the gearing down ratio between the motor shaft and the contractor switch.

The roll of Recorder paper *N* (See Fig. II) is located behind the liquid tank *H*. The paper is drawn over the wick *Q* by rollers *R*, being dried by an electrical heating element before passing through the rollers.

The zero line appearing on the left hand side of the chart is produced by arranging that the switch S_1 applies a few volts from a small battery to the stylus at the instant that it passes behind the zero mark on the scale. Another switch S_4, in series with the wider segment of S_1, is arranged to close once every minute, this producing an enlargement of the zero line at one minute intervals.

The starting handle on the right turns on the main switch supplying power to the motor and the contractor box, and raises the wick so that it touches the paper. Turning off the switch lowers the wick thus preventing the over-saturation of the paper which would result if the stationary paper were left in contact with the wick.

The rolls of paper last 60 hours, and the machine may be run continuously for any convenient length of time.

Phase setting :

The minute marks and zero line which lie to the left of the chart are caused by a switch which bears a constant relationship to the stylus, and so are independent of phase settings.

On zero phase the transmission line, produced by a combination of the cross-noise and the electrical interference accompanying transmission, is superimposed on the zero line if the machine is set to read the depth under the keel and lies to the right of the zero line by a distance on the depth scale corresponding to the draft of the ship if set to read the depth from the water line. The echo line lies to the right of the transmission line.

On going into depths of water greater than the scale range (say 90 fms) the echo is received after the pen leaves the paper and so is not recorded. By causing the transmission to occur earlier (phasing) by a time corresponding to say 50 fms, the echo is brought back to the record, and the depth is obtained by adding 50 fms. to the scale reading. At this setting the transmission occurs before the stylus comes on the paper. The chart thus shows only the minute, and zero marks, and the echo.

The second and third phases produce a similar chart, and 100 fms and 150 fms respectively must be added to the scale reading.

On phase 4 the transmission occurs before the pen leaves the paper. This produces a marking on the chart at about 50 fms, giving an uninterrupted range of 200 fms plus 50 fms. This is the nominal range of the machine, and the appearance of the mark at 50 fms on the scale does not in any way interfere with the echo-reading up to this depth.

However, on going into depths greater than 250 fms, the echo disappears into the transmission line and reappears to the right of it. Here the echo from each transmission is received *after* the subsequent transmission has taken place. If the echo goes off the scale at 200 + 90 fms, it may be picked up again on phase zero, the depth now being 250 fms plus the scale reading.

In this way the echo may be followed from phase to phase up to a depth of several times the nominal range of the machine.

It may be thought that the appearance of an echo at 30 fms on the scale at zero phase for depths of both 30 fms and 280 fms would lead to confusion. This is not the case, however, as the depth is generally known to sufficient accuracy to distinguish between the two cases. Further, the intensity of the echo at 30 fms is so much greater than that at 280 that very little experience is required to distinguish between the two cases.

The Elimination of Inductive Interference :

Under certain conditions the ship's wireless may suffer from inductive interference caused by the echo-sounder, especially when they are close together. It has been found that such interference as does occur is almost entirely through the ship's mains, and may be eliminated by the arrangement of inductance and capacity shown in Fig. below.

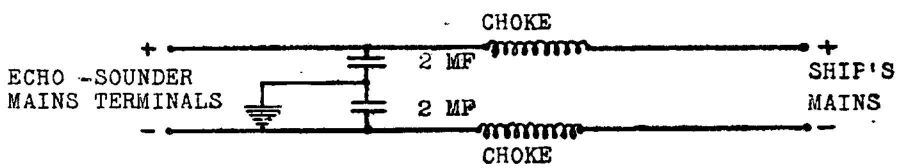


Figure.

The 2 MF. condensers should have a working voltage equal to or greater than the mains voltage, and must be earthed at their centre points. The chokes may be made by winding 50 turns of D.W.S. 16 S.W.G. copper wire on a 2" diam. cylindrical former air core.

A unit can be supplied consisting of a box containing the above components, complete with terminals, ready for convenient mounting near the echo sounder mechanism, if any trouble should be experienced due to interference.

NEW ROTATING ARM CURVED SCALE RECORDER.

The possibilities of the recorder echo sounding machine gave rise to a demand, in connection with certain work and particularly with shallow water sounding, for more and more open scales; the higher speeds demanded by the pen rendered the reciprocating movement unsuitable, and the problem of a recording instrument using a rotating arm to carry the stylus in lieu of the reciprocating mechanism became urgent.

In the sounders types *M.S. X* and *M.S. XII* the stylus describes an arc of a circle instead of a straight line as in the preceding models. This enables a simpler form of "drive" to be used, admitting of much higher pen-speeds and also allows the use of change gears, so that two or more scales can be given if required.

The main principle of operation is the same and the same system of recording is used, the only difference is that the form of the profile is based on a curved track instead of a straight track.

The accompanying figure shows recorder type *M.S. X* and portion of a curved line record.

Using high speed of drive, a scale of 0 to 40 ft. can be given; this allows a space of 1/8 inch to one foot.

The same machine geared down 6 to 1 would on its slow speed have a scale of 0 - 40 fathoms with 1/8 inch = one fathom.

By means of phasing both scales can, of course, be further extended.

Type M.S. X Rotating Arm Double Range Scale Recorder was particularly designed for accurate surveys. In this instrument an arm of 9-inch radius was used in order to give a high pen speed in traversing the paper, without running the instrument at an unduly large number of revolutions. With this comparatively long radius for the arm, the distortion or compression of the scale was reduced to an unimportant percentage. This type has, however, the disadvantage of being cumbersome where space is a consideration.

The figure is an interior view of the *M.S. X* recorder.

The instrument may be used on surveying boats with the oscillators hung outboard; mounted in a streamline form, they offer very little additional resistance. Soundings may be taken by this method to an accuracy of 3 inches (1/10,000 sec.).

Echo Sounder M.S. XII - Rotating Arm Curved Scale Recorder "Universal" Pattern:

In this instrument the radius of the rotating arm has been reduced so as to render the whole less cumbersome and more compact. Type *M.S. XII* is thus better adapted to the encumbered space on the bridge of war-vessels and to the restricted space of vessels of any other category. In view of its wide application it has received the name of "Universal".

This little recorder is only 16 inches high, 11 inches wide and 11 inches deep; the radius of the rotating arm has been reduced to slightly under 4 inches. It has a two-speed gear with a 6 : 1 ratio so that in open water it takes soundings in fathoms (0 to 130) and, when it has passed the 10-fathom line and enters pilotage waters, it can take soundings in feet (0 to 130). In these conditions the 10-fathom (60 ft.) line falls in the middle of the chart record and the 5-fathom (30 ft.) line to the left at one-quarter of the width of the record, scale 1/4 inch per fathom approximately.

The same system of electro-chemical recording is employed as in the preceding model, but in this case the paper is supplied already moistened and is contained in a sealed tank inside the instrument. The paper is 6 inches in width and the sounding scale occupies 5 inches of this space. A window of some 8 inches in depth, in the front of the case, gives a clear view of the record.

The scale can either be engraved on the glass of the window or can be applied by a curved scale bar situated close under the track of the pen.

The ordinary remote control for marking a "fix" by a momentary short circuit is fitted.

The governor prevents variations of motor speed of more than a fraction of 1 %, even though the voltage varies by 20 to 30 %.

The application of this machine is very wide. The makers can deliver it with different scales for the two speeds, usually of the ratio 4 : 1, 6 : 1, 10 : 1. For British surveys the 6 : 1 ratio is generally preferred, representing fathoms and feet; a simple lever changes from one to the other as necessary. The scale now adopted in hydrography is one giving 0 to 150 feet/fathoms, that is to say, representing one foot by 1/30 inch.

In addition, when desired, phasing switches admitting of increases in depth by steps of about 75 % can be fitted; hence, in an instrument having a scale of 0 to 150 feet/fathoms, with a 75 % phase, soundings up to 450 feet/fathoms can be assured.

The instrument has a still wider application. Although originally produced for ships or boats requiring a shallow open scale, it is equally suitable for deep-water scales up to 1,000 fathoms, and when fitted to a deep-water recording set, can be used up to 6,000 fathoms.

For use in surveying boats a scale of 0 to 90 feet/fathoms has been adopted, though for special purposes the large scale of 0 to 40 feet is also supplied.

The accompanying photograph illustrates the "Universal" recorder. The glass window and the end of the rotating arm carrying the stylus are clearly visible, as also the actuating switch in the top right-hand corner for changing the scale from fathoms to fact.

Different patterns of recorder *M.S. XII* may be delivered; present prices of the various makes are as follows:

M.S. XII.

One scale only, *no* phasing £300 0 0

M.S. XIIB.

One scale only, *with* phasing.......... £320 0 0

M.S. XIIC.

Two speed gear (ratio to be decided by customer) *no* phasing.......... £330 0 0

M.S. XIID.

Two scales (ratio to be decided by customer) *with* phasing.......... £360 0 0

M.S. XIIE.

Extra powerful oscillators, suitable for greater depths or greater speeds of ships £400 0 0

A MAGNETOSTRICTION ECHO DEPTH-RECORDER

(BRITISH PATENT N° 375375)

by

A. B. WOOD, D. Sc., F. D. SMITH, D. Sc., ASSOCIATE MEMBER,
and J. A. McGEACHY, B. Sc.

(Reproduced from *The Journal of the Institution of Electrical Engineers* - Vol. 76, No. 461. London, May 1935).

I. — INTRODUCTION.

At the present time there are in existence several types of marine echo-sounding devices in regular use. Some of these may be described more particularly as depth *indicators*, whilst one or two not only give isolated indications of the depth of the sea but also provide a more or less continuous record of the sea-bed.

Echo-sounding devices may conveniently be divided into two main classes:

a) Low-frequency (sonic) systems, and

b) High-frequency (supersonic) systems.

Of these, the British Admiralty system is of the low-frequency type. Recently this system was fitted with an electrochemical recorder, (1) similar in principle to that described in the present paper but differing in mechanical features. The only high-frequency system which has hitherto attained commercial importance uses the supersonic vibrations of a quartz piezo-electric oscillator. This system, devised by Prof. LANGEVIN and M. CHILOWSKY, has been developed commercially in this country by the MARCONI Sounding Device Company. These two echo depth-sounding systems are now sufficiently well-known to render further detailed reference to them unnecessary.