III. MARCONI MAGNETOSTRICTION SUPERSONIC ECHO SOUNDING EQUIPMENTS FOR DEEP SEA AND NAVIGATIONAL PURPOSES *

GENERAL.

Many magnetic materials exhibit the property of varying their lengths when subjected to a magnetic field.

Investigations have shown that different magnetic materials exhibit totally different effects.

For instance iron actually increases in length for low magnetisations and then completely reverses and decreases in length if the magnetisations are made more intense.

Cobalt decreases its length for low magnetisations and then increases for further intense fields.

Nickel on the other hand always contracts whatever the magnetic field strength.

The extent of these length alterations is very small and some idea can be given by stating that a rod one yard long of nickel will contract about two thousandths of an inch under a constant and intense magnetic field.

In 1928 G. W. Pierce of America utilised this phenomenon by applying instead of a constant or direct current field, an alternating current field of such a frequency as to strike the natural longitudinal period of the magnetostriction element or rod.

G. W. Pierce subjected rods to an alternating field of a frequency to match the natural longitudinal period of the rod with the result that the rods expanded and contracted by magnetostriction and built up movements far in excess of those produced by constant direct current fields.

By superimposing these alternating fields on a constant D. C. field to a nickel specimen then the D. C. field is first reinforced producing additional contraction by one half swing and the D. C. field is then reduced producing actual elongation by the other half swing with the net result that the movements of the nickel ends build up to large amplitudes by this striking of resonance.

This principle of magnetostriction applied to mechanical longitudinal vibrations was patented by G. W. Pierce as well as the fact that sound waves produced by these movements of the surfaces of the magnetostriction material could be transmitted through water to the ocean bed and received again as an echo on the same vibrator for the purpose of echo sounding.

Owing to the high frequencies obtainable by longitudinal vibrations of the order of thousands of cycles per second according to the lengths of specimens used, this comes under the category of supersonic frequencies or wireless frequencies.

High frequencies are used in Echo Sounding for two major reasons namely,

(*a*) To avoid the interfering noises of audible frequencies such as propeller noises, water noises produced by the sea on to the vessel and by the vessel through the sea, affecting the receiver.

(*b*) To obtain a comparatively sharp beam of transmitted energy to the sea bottom with reasonable dimensions of projector apparatus thus avoiding a distribution of energy over a wide area of sea bottom.

Directivity of beam depends upon the ratio of the diameter of equivalent piston vibrator relative to the wavelength in the medium which is water. In the same way directivity of beam in wireless depends upon the dimensions of the reflector scheme relative to the wavelength in the aether.

For these reasons supersonic echo sounders may work at frequencies between 60,000 cycles and 10,000 cycles per second.

The frequency having been decided upon settles the dimensions of the longitudinal vibrator or magnetostriction specimen and also the wireless electrical circuit which ultimately energises the specimen. Thus the frequency and wireless wavelength are determined.

The water wavelength of the transmitted sound energy in the water medium is however quite different. The frequency must remain the same but the velocity of the sound in water is much lower than that of electric waves in the aether and is of the order of 5000 feet per second against 186,000 miles per second.

A tabulation of figures therefore gives:

Frequency...	20,000 cycles/sec.
Wireless Wavelength................................	15,000 metres.
Water Wavelength	3 inches.

(*) From N. P. Hinton, B. Sc.

These figures are given for simple explanation purposes rather than for actual figures used in practice although these approach very closely.

The actual time intervals in sea water work out as 1/410 of a second per fathom.

Shallow depths with very short time intervals tend to produce difficulties due to these short time intervals compared with the short duration time of the transmitter impulse. Greater depths with long time intervals give greater accuracies but the energy returned in the echo is decidedly weaker.

CONICAL DISTRIBUTION.

With a semi-angular beam of transmission of 15 degrees it will be readily appreciated that as the depth increases, the area covered by this beam both at the ocean bed and at the water surface after reflection from the ocean bed, increases.

The result is that if the depth is doubled the initial energy (assuming no loss in the water itself) is distributed over four times the area and the resultant pressure per square inch of the

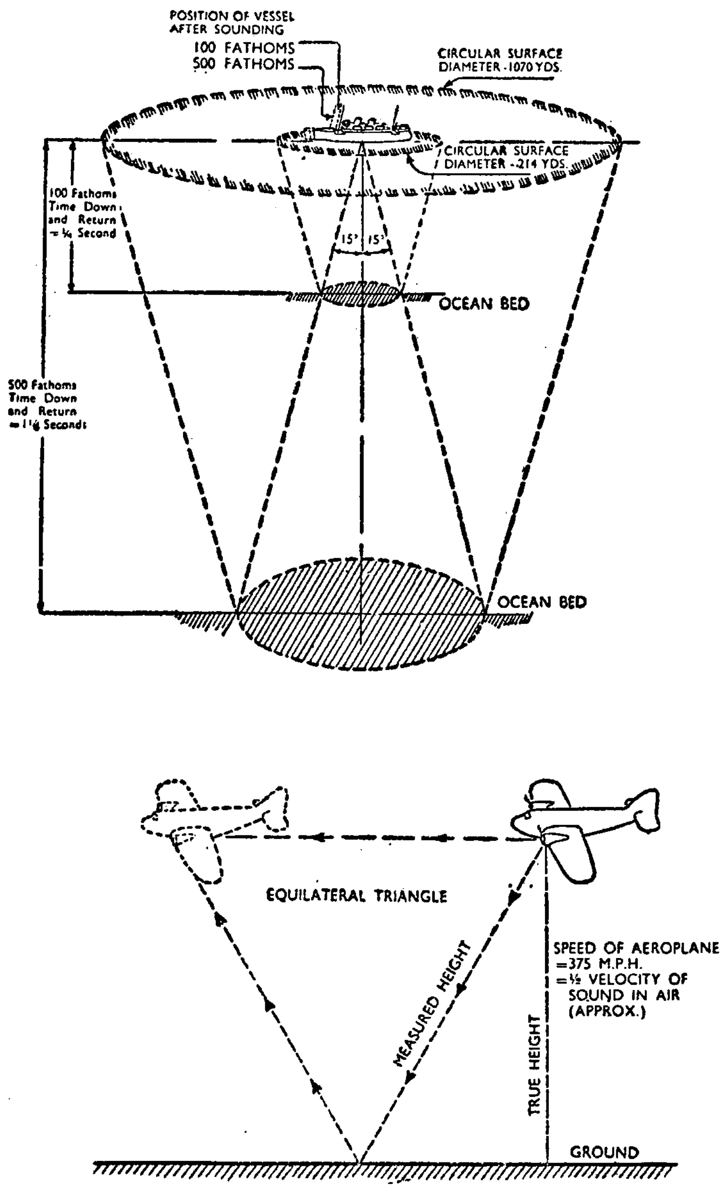

FIG. 18.

sound wave echo reaching the projector receiver is reduced to 1/4. This can be stated in general terms that the echo varies inversely as the square of the depth.

Some figures of the diameter of the circular area covered by the echo at the water surface after reflection from the bottom for various depths for a semi-beam angle of 15° may prove interesting.

After	sounding	10	fathoms	1/40 Sec :	Circular	surface	Dia :	21.4 yds.
"	"	100	"	1/4 Sec :	"	"	=	214 yds.
"	"	500	"	1 1/4 Sec :	"	"	=	1070 yds.
"	"	1000	"	2 1/2 Sec :	"	"	=	2140 yds.

If the speed of a vessel be taken as 30 miles per hour or 44 feet per second then for a sounding of 100 fathoms (1/4 sec. there and back), the vessel has only travelled 11 feet while the dia. of the circular area is 214 yds. There is therefore no possibility of the speed of even the fastest destroyer being so great as to move outside the area of the echo return, whatever the depth, owing to the wide differences in velocity of the vessel 44 feet/sec. and of sound in sea water 5000 feet per sec. unless the semi-beam angle were very small.

In passing it might be interesting to note that for similar transmissions through air instead of water, where the velocity of sound in air is 1100 feet/sec., the application of echo sounding to aircraft is apt to produce errors.

Modern aircraft are approaching speeds about one half the velocity of sound in air that is 550 feet/sec. or over 360 miles per hour. An echo sounder scheme applied to fast speed aircraft (if possible) would register not the true altitude but a higher angular figure produced by the lines joining the aircraft to the ground and to the new position moved to by the aircraft in the time taken by the echo to travel there and back.

Fig. 18 gives explanatory details of Echo Sounding in Water and Air.

PENETRATION THROUGH HULL PLATING BY SOUND WAVE.

In order to avoid the necessity for dry docking a vessel to install the echo sounding projectors, the frequency of the supersonic transmission is so chosen that the ratio of thickness of hull plating (normally 3/4 inch) to the wavelength in the steel of the hull plating is as small as possible, in order to transmit directly through the plate the greatest percentage of energy impinging on the plate from inside the vessel.

Velocities of sound have already been referred to and given for sea water, air and aether. Now another velocity of sound is met in steel. Steel has a velocity of sound of 5000 metres (16,400 ft.) per second so that the wavelength in steel for the same frequency already discussed namely 20,000 cycles/sec. is

$$\frac{5000}{20,000} \times 100 = 25 \text{ centimetres, (9.84 inches).}$$

The ratio, steel thickness : wavelength can therefore only be made small and the percentage of energy transmitted through the plate made high if the steel wavelength is large. Consequently the lower the frequency used the better the penetration of sound wave through the plate.

The effect is that a compromise must be struck in the choice of frequency otherwise a low frequency tends to give good penetration with lack of directivity and lack of selectivity from water and propeller noises.

A high frequency gives good directivity and selectivity from water and propeller noises but lacks good penetration.

Attenuations actually due to the water are very small compared with decreases of echo pressure per square inch due to conical distribution.

It should be realised that to operate an echo sounder through the hull plating requires considerably more power than would be required if the projector faces were directly operating on the sea water without the consequent loss in passing through the hull plating both in transmission and back again in reception.

Where projectors operate through a hole cut in the vessel's bottom greater ranges of depth can be obtained or alternatively the same depths can be obtained with less power.

Working through the hull is somewhat analogous to holding a conversation with the next door neighbour by shouting through the dividing wall instead of whispering over the garden fence.

This installation of the projectors without dry docking is a definite advantage and such requirements must be met in some cases in practice but the advantages of simplicity and low power required when a hole is cut, are not completely offset by the necessity for dry docking as the projector or projectors can be installed on a new vessel when normally dry docked after launch and on existing vessels during the period of overhaul at the very least once a year.

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a) *THE MARCONI MAGNETOSTRICTION SUPERSONIC ECHO SOUNDER NAVIGATIONAL EQUIPMENT — 0 TO 150 FATHOMS.* (Plates XVI to XXII)

Consists essentially of three distinct components located in different parts of the vessel and interwired to one another:

1. The projector assemblies located at the bottom or on the hull plating of the vessel.
2. The transmitter panel or power source located in any suitable position within 50-60 feet of the projectors.
3. The chart room equipment consisting of visual indicator, recorder and amplifier.

PROJECTOR ASSEMBLIES.

Each projector consists of a laminated core of nickel with the remainder of the magnetic circuit closed by non-magnetostrictive but high permeability material.

The nickel core is approximately 5" long and is supported at its centre to allow for free longitudinal movement without restriction in a small air gap formed between the core and the high permeability material.

In effect the projector is very similar to a transformer with a separate core and partially closed magnetic circuit, the faces of the core projecting and showing at each end. The core is surrounded by a winding of varying turns according to wavelength or power required.

These ends are the actual working surfaces and the sound waves in water are transmitted from these two faces, arranged in a horizontal plane, on to two separate conical reflectors, air spaced for perfect reflection, which deflect the sound waves vertically downwards.

Each projector is mounted in a rolled steel tank which is filled with water after the tank has been pressed down on a rubber pad by means of jacks on to the hull plating of the vessel.

The water in these tanks forms the starting medium for the sound wave which reverberates in the tank allowing a percentage of the original mechanical energy applied to the core to be transmitted through the hull plating into the sea water.

Each transmission is of quite short duration and after reflection from the ocean bed returns to the hull plating of the vessel again, to penetrate into the tank holding the receiving projector.

The receiving projector is similar in general design and formation to the transmitting projector but differs only in the number of turns in the windings.

The reverse process operates on reception due to magnetostriction, that is to say, the mechanical motion given to the nickel core by the echo sound wave produces electrical voltages or currents in the windings in the reverse way from that by which electrical currents produce mechanical motions in the transmitting projector.

The receiving projector is operated in a magnetised state by a small steady D. C. current which increases the sensitivity of the receiving projector.

Plate XVI clearly shows the top plate holding the projector element with its two reflectors each end and the elliptical tank into which the projector fits and in which water is maintained as the starting medium.

Plate XVIII shows the tank assembly, rubber mat and jacks completely installed in a section of a dry cofferdam or fuel tank in the double bottom of a modern vessel.

TRANSMITTER PANEL AND POWER SOURCE.

All batteries for operating the equipment are located close to the transmitter panel and are charged in this position to avoid the fitting of the charging apparatus with its resulting heat and fumes in the chart room.

The transmitter unit on this panel consists of a high tension machine, transmitting key or relay and a condenser bank of several microfarads for producing the short duration sound wave by the discharge of a charged condenser into the windings of the transmitting projector.

The H. T. machine is started up from the chart room by a remote control contactor while the filament battery for the valve amplifier in the chart room is also switched on simultaneously by a second contactor.

Plate XVII shows the complete transmitter panel consisting of fuses, charging resistances and transmitter unit.

Plate XXII shows the transmitter unit alone. This transmitter panel is located in a mast deck house, store room or in the engine room according to the position of the projectors on the vesse and according to atmospheric conditions for the battery and charging.

CHART ROOM EQUIPMENT.

This part of the equipment is the only part really obvious to the navigating staff.

The transmitter panel requires only occasional visits for charging and maintenance purposes, hence the chart room equipment forms the essential and only visible working parts of the echo sounder. One is apt therefore to see only this portion of the apparatus advertised and described.

Since this part of the equipment will be actuated and used by the Navigating Staff it is essential that to outward appearances the apparatus and controls should be as simple as possible.

VALVE AMPLIFIER.

The actual sound wave pressures per square centimetre dealt with both on transmission and reception amount to mere fractions of a gramme per square centimetre so that a high degree of magnification is necessary to augment the small voltages produced on reception by these minute pressures.

In order to deal with short duration or transient signals, the amplifier is of the resistance coupled type for the high frequency stages.

The mechanical vibrations are transformed back to wireless signals and finally rectified in the normal way. The output of this amplifier then feeds either the visual indicator or electrolytic recorder.

Plate XXI shows the amplifier with the main control switch for starting up the equipment on the right hand side.

VISUAL INDICATOR.

The visual indicator consists essentially of an oscillograph with a moving iron armature to which is coupled a deflecting mirror.

A spot of light plays on to this oscillograph mirror and the light is reflected on to another mirror rotating at a constant and predetermined speed which again reflects the light spot on to the fathom scale or dial.

The net effect on these arrangements is that a spot of light can be seen to move across the scale repeatedly, once every second, and whenever an echo is received the light spot jumps up in the form of a peak or hill.

One peak occurs or is made to occur at zero showing the transmission signal and a second peak occurs at the actual depth of the ocean below the keel as shown on the scale or dial. Since these echoes are being received at approximately one per second, no difficulty is experienced in noting the position of the point where the peak starts to move upwards.

The great advantage of the visual indicator lies in its simplicity of few moving parts and in its immediate action when switched on. Quick readings can be obtained of depths in two to three seconds as compared with the electrolytic recorder which takes several seconds to start up before the record on the graph can be observed and the depth ascertained.

Fig. 19 shows the peaks due to transmission and echo as viewed on the scale or dial of the Visual Indicator.

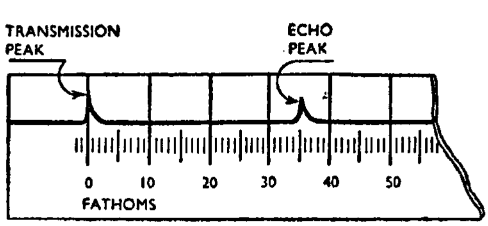

FIG. 19

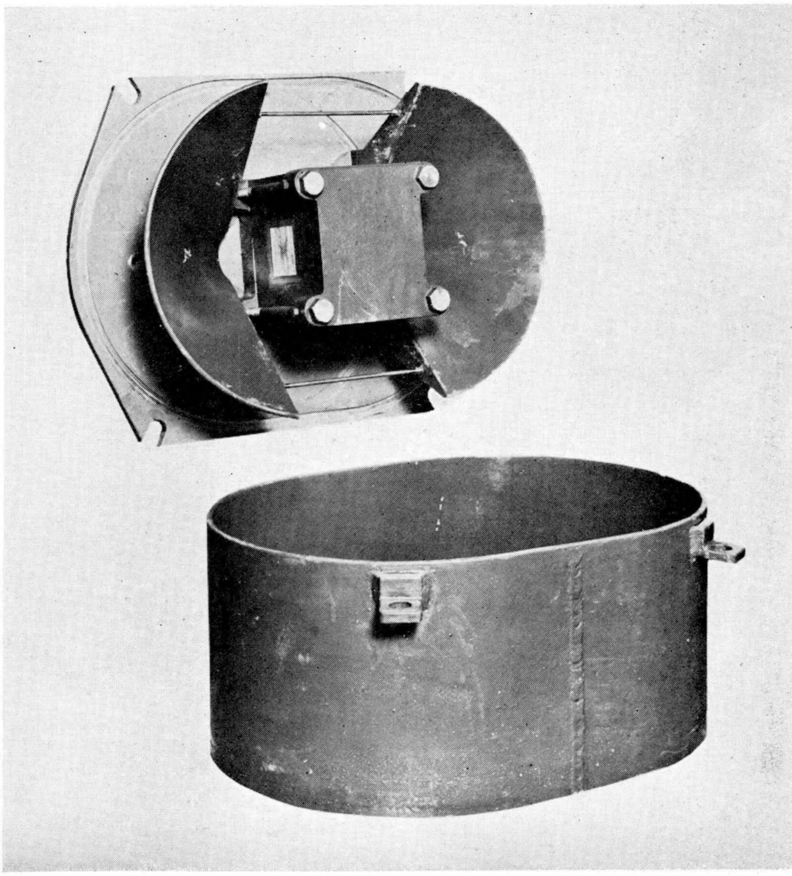

Planche XVI
Plate XVI.

Elément de projecteur avec ses reflecteurs attachés au couvercle, caisson en dessous

Marconi navigational equipment 0 to 150 fathoms.
Projector Element on top plate with reflectors and tank below.

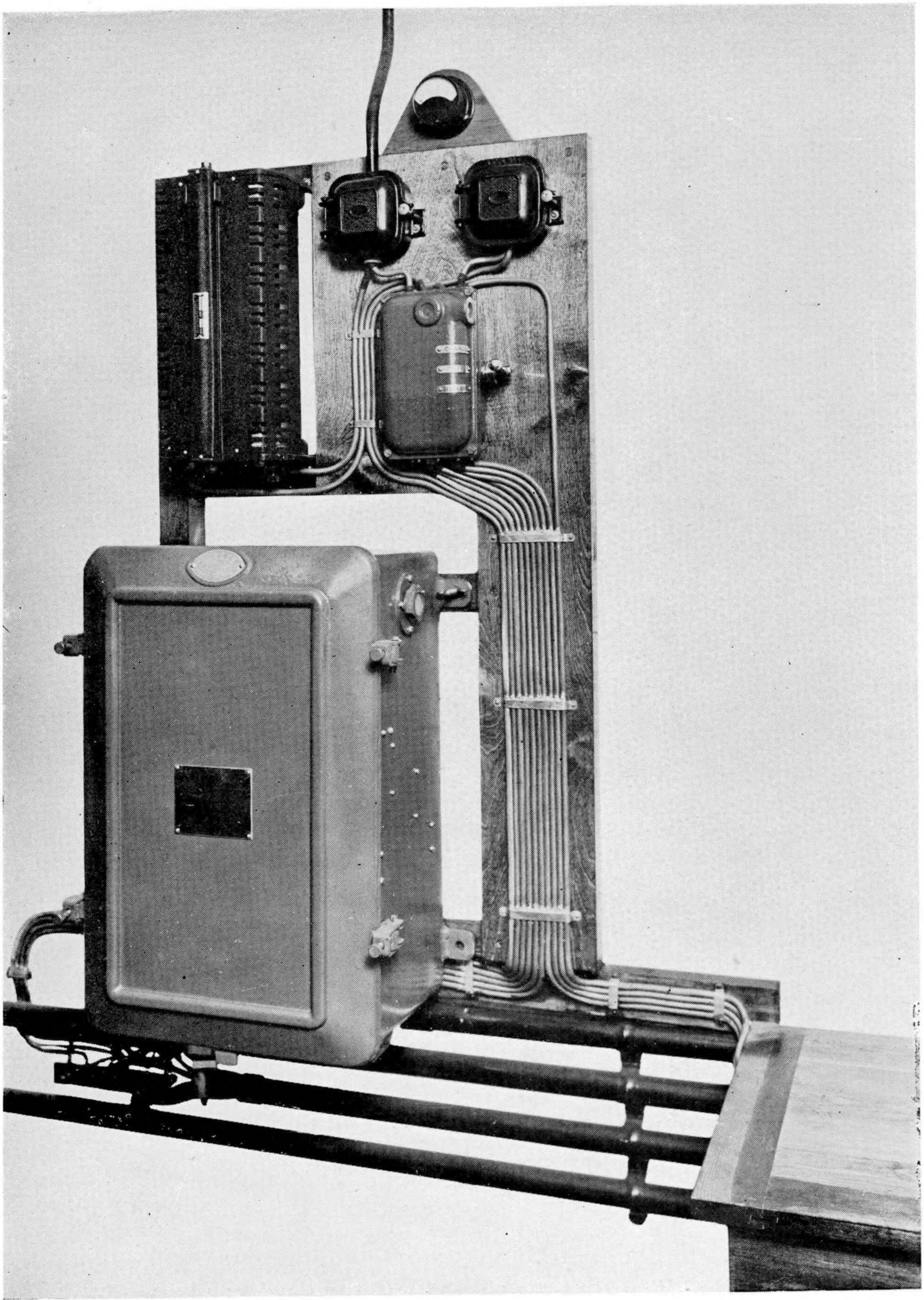

Planche XVII
Plate XVII.

Tableau d'émission. — Emetteur et dispositif de charge

Marconi navigational equipment 0 to 150 fathoms.
Transmitter panel showing transmitter unit and charging arrangements.

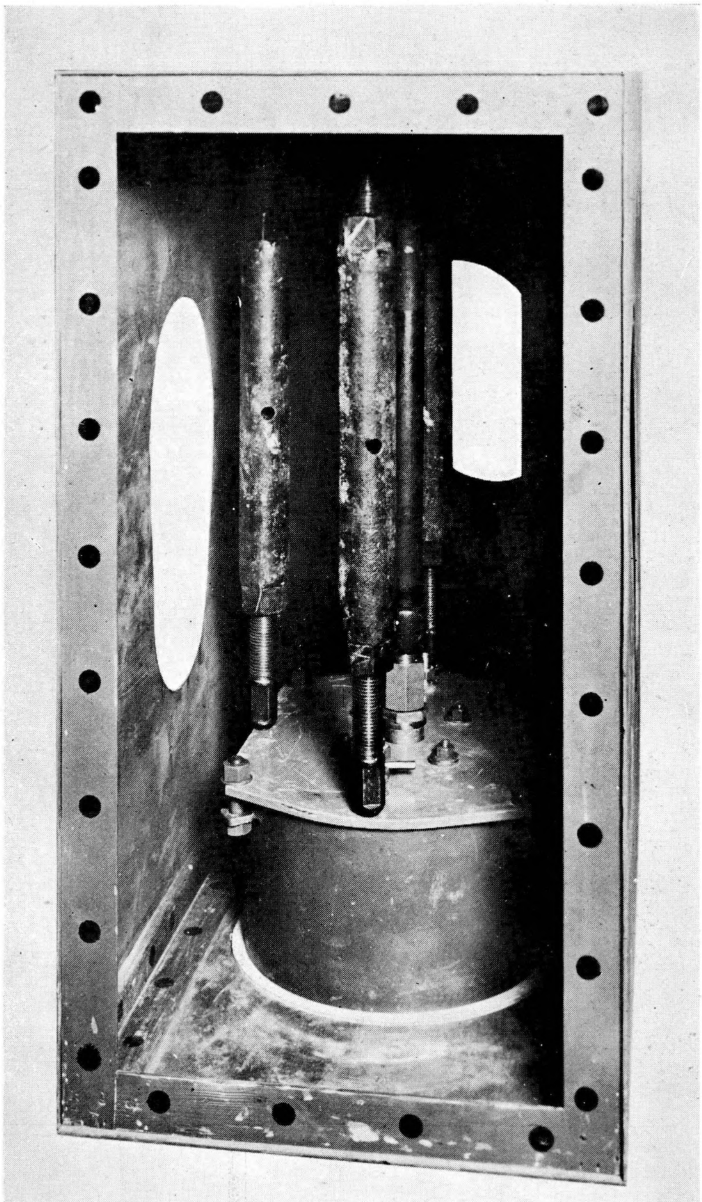

PLANCHE XVIII
PLATE XVIII.

Equipement MARCONI, *Modèle Navigation de* 0 *à* 150 *brasses. — Ensemble des Projecteurs à magnétostriction, dans leur cofferdam avec épontilles pour pression sur le joint en caoutchouc*

MARCONI Navigational Equipment 0 to 150 fathoms. Complete Magnetostriction Projection Assembly in Cofferdam tank and jack for pressing down on to rubber pad.

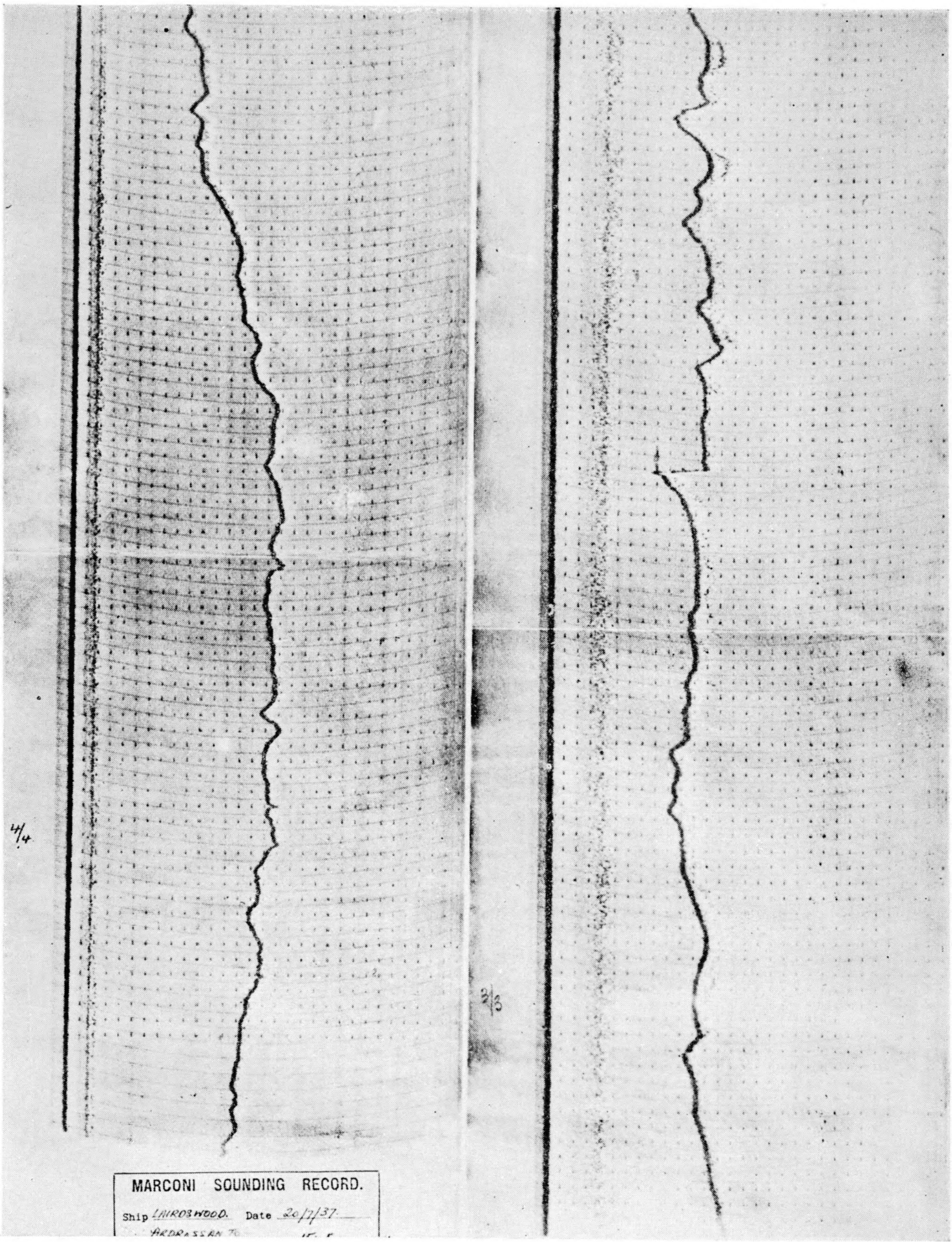

Planche XIX

Plate XIX.

D'Ardrossan à Belfast. - 30 *sondages par minute. Chaque division représente* 5 *brasses. Em tteur dans fourcat avant*

Marconi Navigational Equipment 0 to 150 fathoms. - S.S. *Lairdswood* - *Ardrossan to Belfast.* 30 Soundings per minute. Graduation lines 5 fathoms each. Projectors fitted in fore peak.

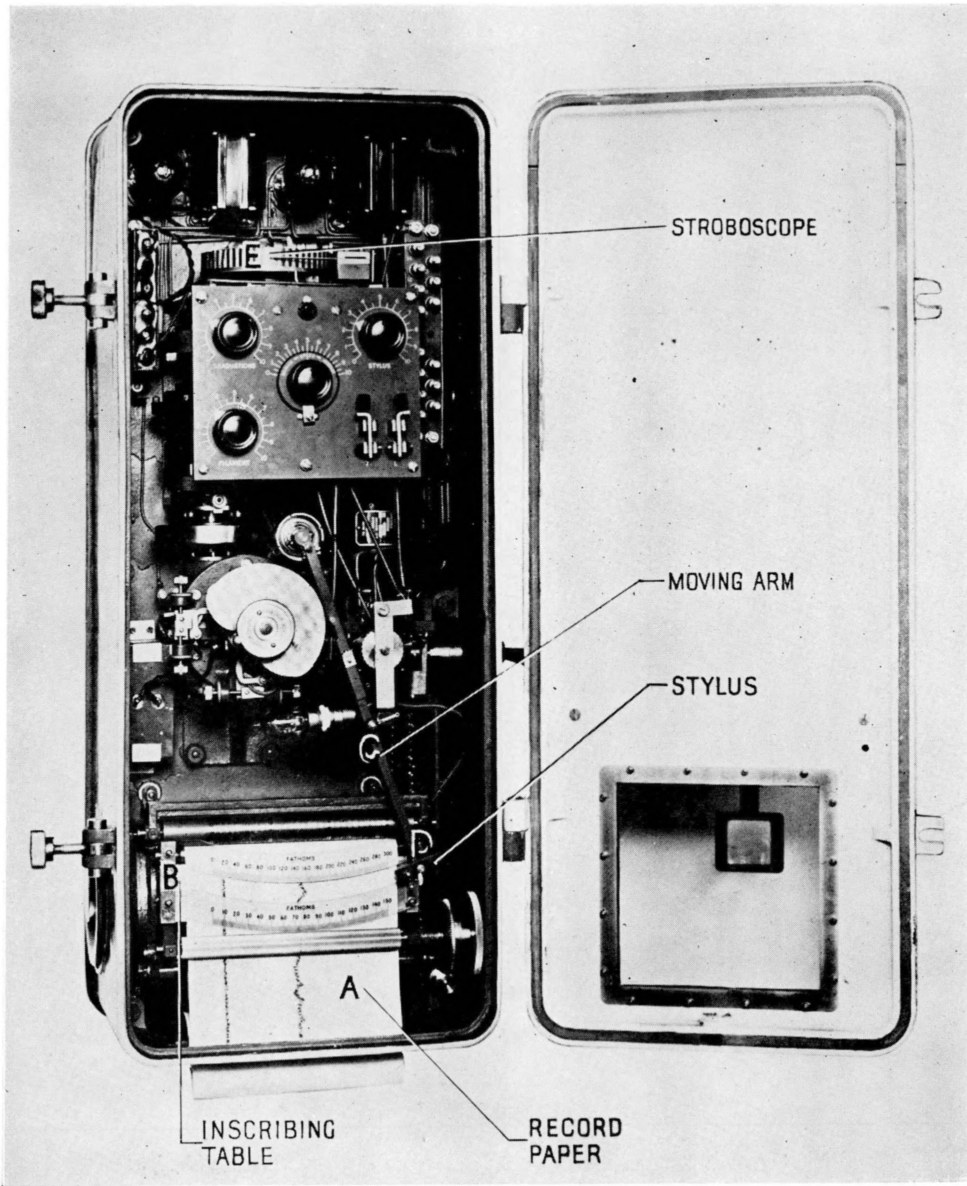

PLANCHE XX

PLATE XX.

Equipement MARCONI *pour Navigation de 0 à 150 brasses. - Enregistreur électrolytique. - Stroboscope pour réglage de la vitesse. - Bras mobile et son style, enregistrement en cours*

MARCONI Navigational Equipment 0 to 150 fathoms. Electrolytic recorder showing. Stroboscope for correct speed adjustment. Moving arm fitted with stylus and record being produced.

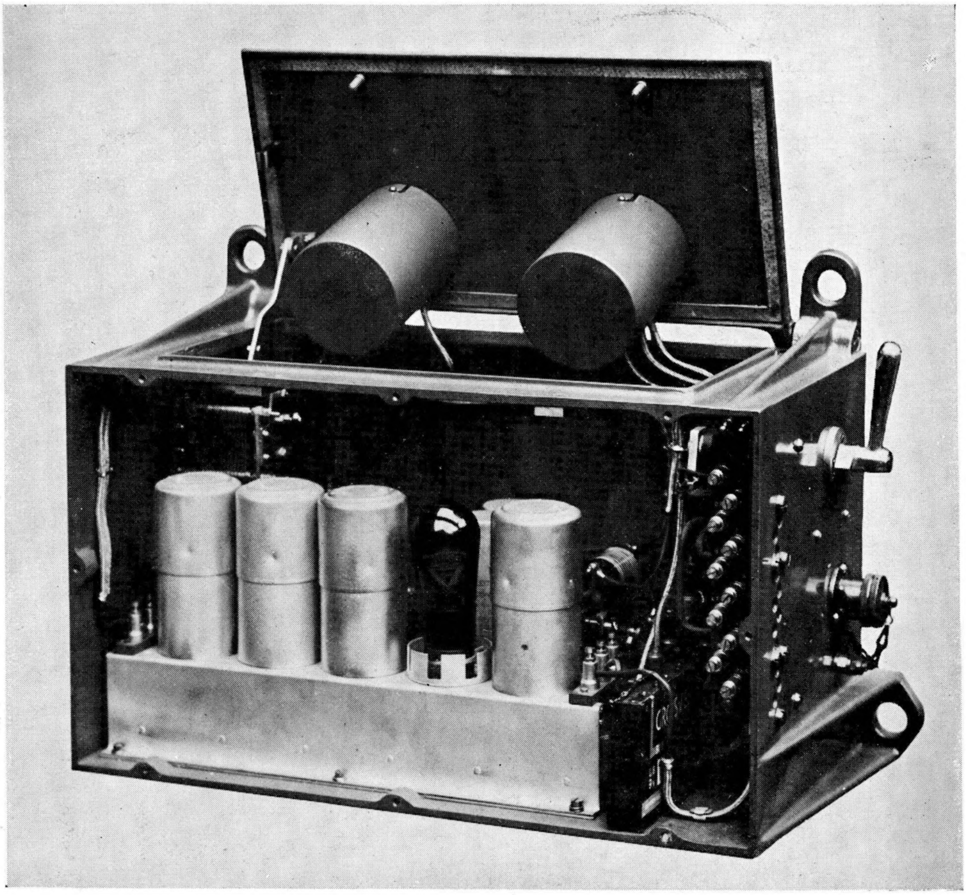

Planche XXI

Plate XXI.

Amplificateur à lampes. — Support des lampes et commutateur principal

Marconi Navigational Equipment 0 to 150 fathoms. Valve amplifier. Showing valve chassis and main control switch.

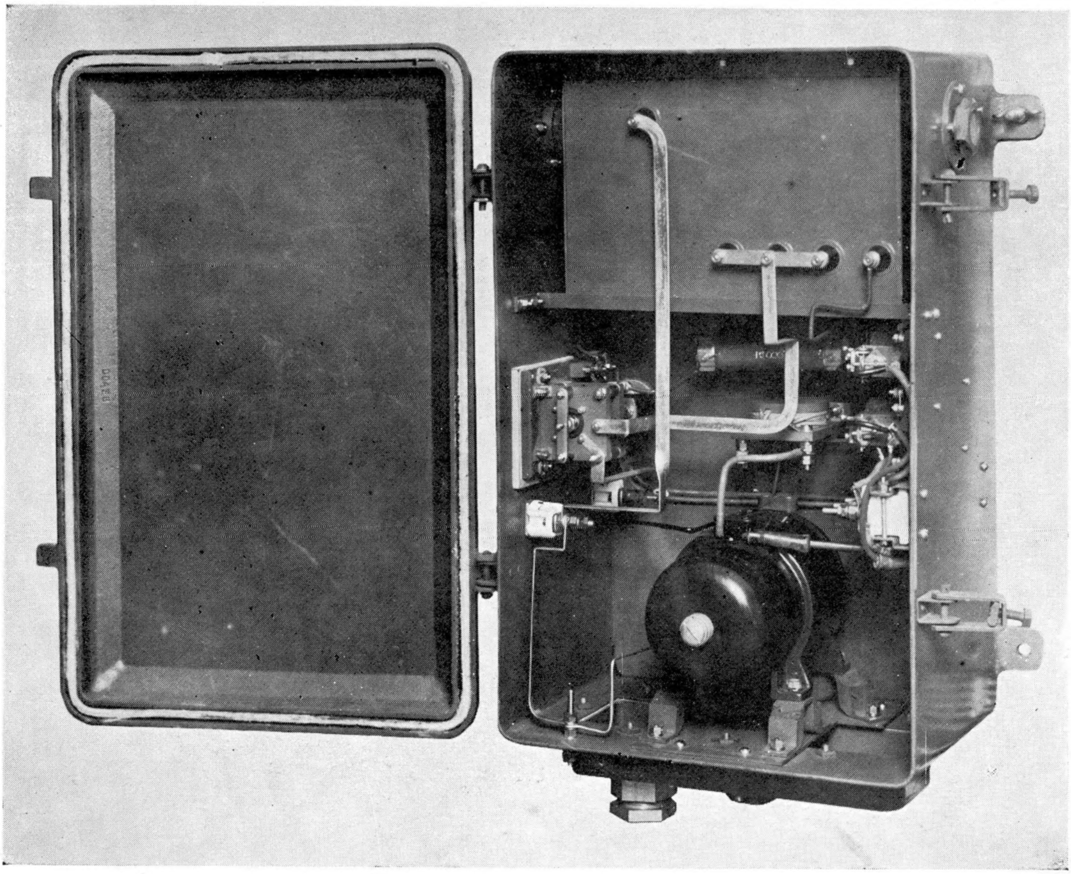

Planche XXII
Plate XXII.

Ensemble émetteur. — Générateur H. T., condensateur et relais de charge et décharge

Marconi Navigational Equipment 0 to 150 fathoms. Transmitter unit. Showing high tension Generator. Condenser bank and charge and discharge transmitting relay.

THE ELECTROLYTIC RECORDER.

This instrument is utilised for obtaining automatically a series of soundings plotted on a graph over several minutes or hours in order to observe the depth of the ocean and any tendencies for this depth to become shallower or deeper or even to observe the first signs of a reasonable depth of 100 fathoms under the vessel when approaching land from a deep ocean.

This recorder is shown on Plate XX. All recording devices are naturally mechanical to incorporate firstly the governor controlled motive power on which the accuracy of the instrument depends, secondly the stylus which moves across the recording paper to make the marks forming the graph and lastly the paper feed mechanism which moves the paper forward at a slow speed.

The electrolytic recorder is therefore nothing more than a platinum pointed pencil or stylus which is made to move at a predetermined and constant speed across a specially prepared paper in a moist condition, after impregnation in a solution of iodine and starch.

The electrical voltages produced by the short duration transmission and the echo from the ocean bed produce currents in the circuit formed by the stylus and moist paper with the result that the iodine is released from the impregnating solution and iodine marks are produced at the zero position on the scale and at the reading corresponding to the depth of the ocean respectively.

As the paper is fed through the instrument the transmission marks will remain constant at zero while the echo marks will form a graph or contour of the ocean bed. These marks are reduced in actual length for proper differentiation in reading shallow depths by a system of two rectifiers and transformers in the recorder itself.

Some typical graphs are shown from various vessels on Plate XIX.

A close study of these photographs will show a series of graduation lines across the paper to assist in reading off the true depth after the record has been removed from the machine.

Also it will be noted that the paper is lightly scribed by arc lines which denote half minute durations to assist the navigating staff in determining the distance travelled by the vessel between characteristic points on the graph.

The combination of the visual indicator and recorder in an echo sounding equipment satisfies therefore the condition for immediate readings for depth checking and for plotted readings to watch for characteristic contours to assist in checking position.

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b) *THE MARCONI MAGNETOSTRICTION. — SUPERSONIC ECHO SOUNDER DEEP SEA EQUIPMENT — 0 TO 3000 FATHOMS.* (Plates XXIII to XXVIII)

A natural sequence in development has been carried out by increasing input powers of a normal MARCONI Magnetostriction Equipment operating through a thin stainless steel plate in the bottom of a Cable Ship to produce a Deep Sea Sounder for cable survey work.

Electrolytic paper charts of the sea bottom have been obtained up to 2750 fathoms by this apparatus, the maximum depth passed over during a survey in the Bay of Biscay.

The principle used in both equipments, deep sea and navigational, is the same and the apparatus is similar in design.

Both systems are supplied with many hundred times the power of a normal MARCONI quartz steel echo sounding equipment and this increase of power over the quartz steel equipment is utilised in the navigational equipment for transmitting and receiving the sound waves through the hull plating of the vessel without the necessity of cutting holes in the hull plating itself.

In the case of the deep sea equipment however, where the much greater depths are required, it is essential that all losses in the sound wave transmission and reception should be reduced to a minimum and therefore the projector elements are arranged to be in direct contact with the water by cutting two holes in the hull plating and assembling the projector elements in special hull castings the orifice being sealed off by a light plate to prevent water "turbulence" inside the casting. It will therefore be appreciated that the development of a deep sea 0 - 3000 fathoms equipment follows naturally from the standard navigational equipment by an increase in power supplied to the special deep sea transmitter and the freedom from losses in the hull plating by arranging for the projectors to be in direct contact with the sea water.

(1) *MAGNETOSTRICTION PROJECTOR, TRANSMITTING.*

For the absorption of increased input energy the transmitting projector for the deep sea equipment is wound with fewer turns of heavier gauge conductor giving a smaller resultant inductance.

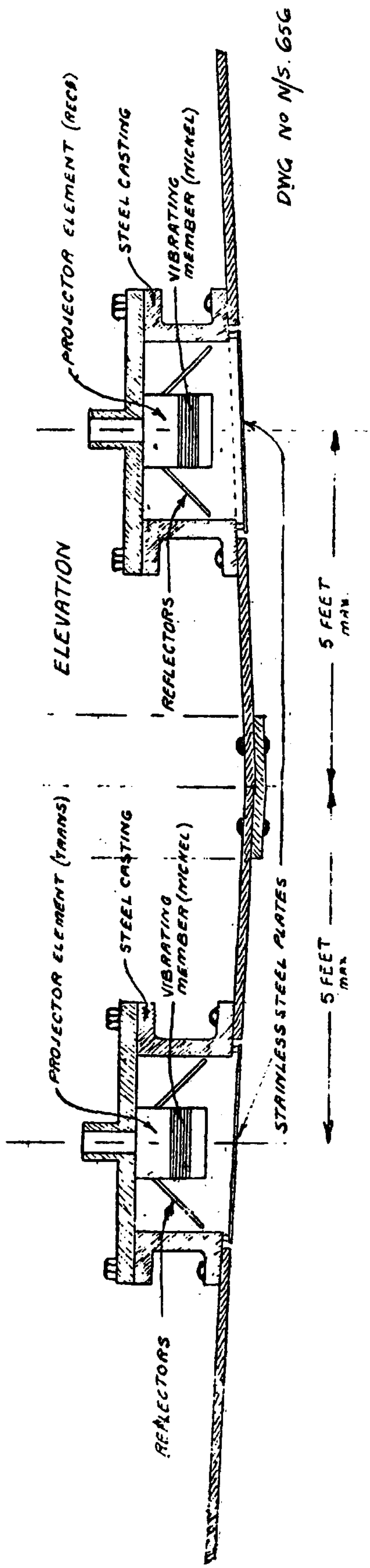
DWG No N/S. 65G
PROJECTOR ELEMENT (RECS)
STEEL CASTING
VIBRATING MEMBER (NICKEL)
ELEVATION
REFLECTORS
5 FEET max.
PROJECTOR ELEMENT (TRANS)
STEEL CASTING
VIBRATING MEMBER (NICKEL)
STAINLESS STEEL PLATES
5 FEET max.
REFLECTORS

FIG. 20.

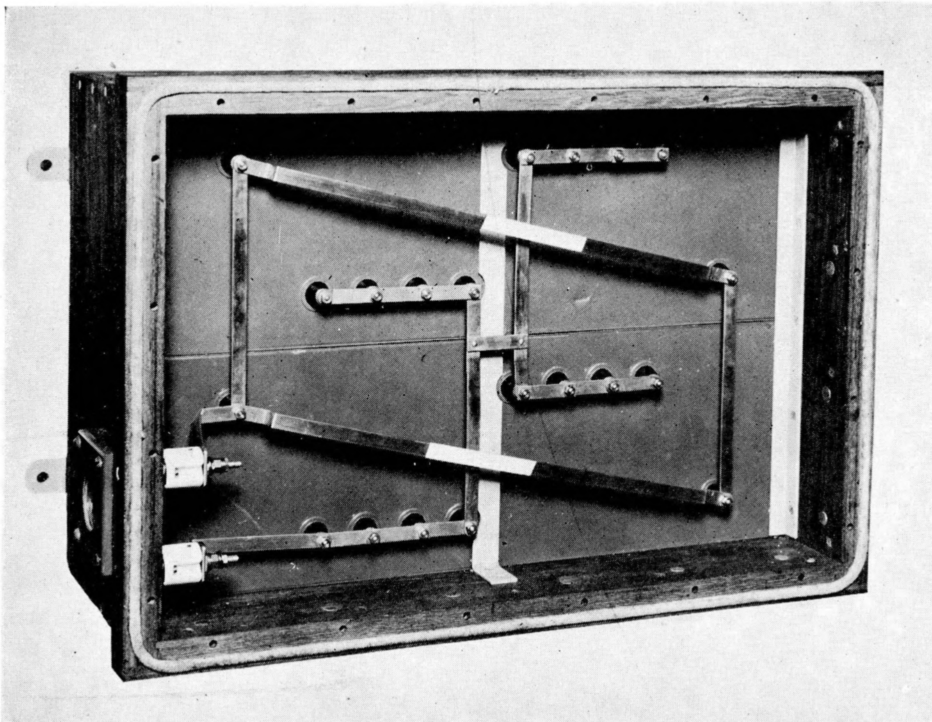

PLANCHE XXIII
PLATE XXIII.

Condensateur d'émission, couvercle du coffre enlevé. — Capacité 36 microfarads

MARCONI deep sea equipment. Transmitting condenser in case with cover removed.
Capacity 36 Micro-farads.

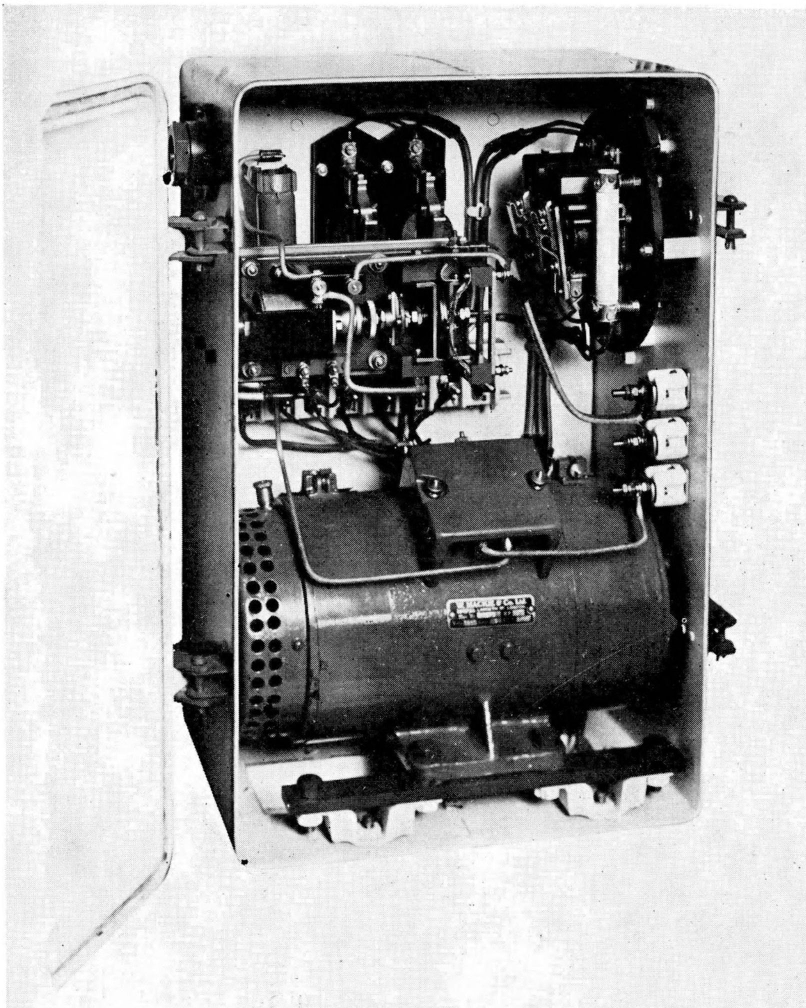

PLANCHE XXIV

PLATE XXIV.

Ensemble émetteur. — Générateur H. T. 2.000 volts. — Auto démarreur à 2 temps et contacteurs relais de charge et décharge

MARCONI deep sea equipment. Transmitting unit. Showing high tension generator 2000 volts. 2 step auto starter and contactors, charge and discharge transmitting relay.

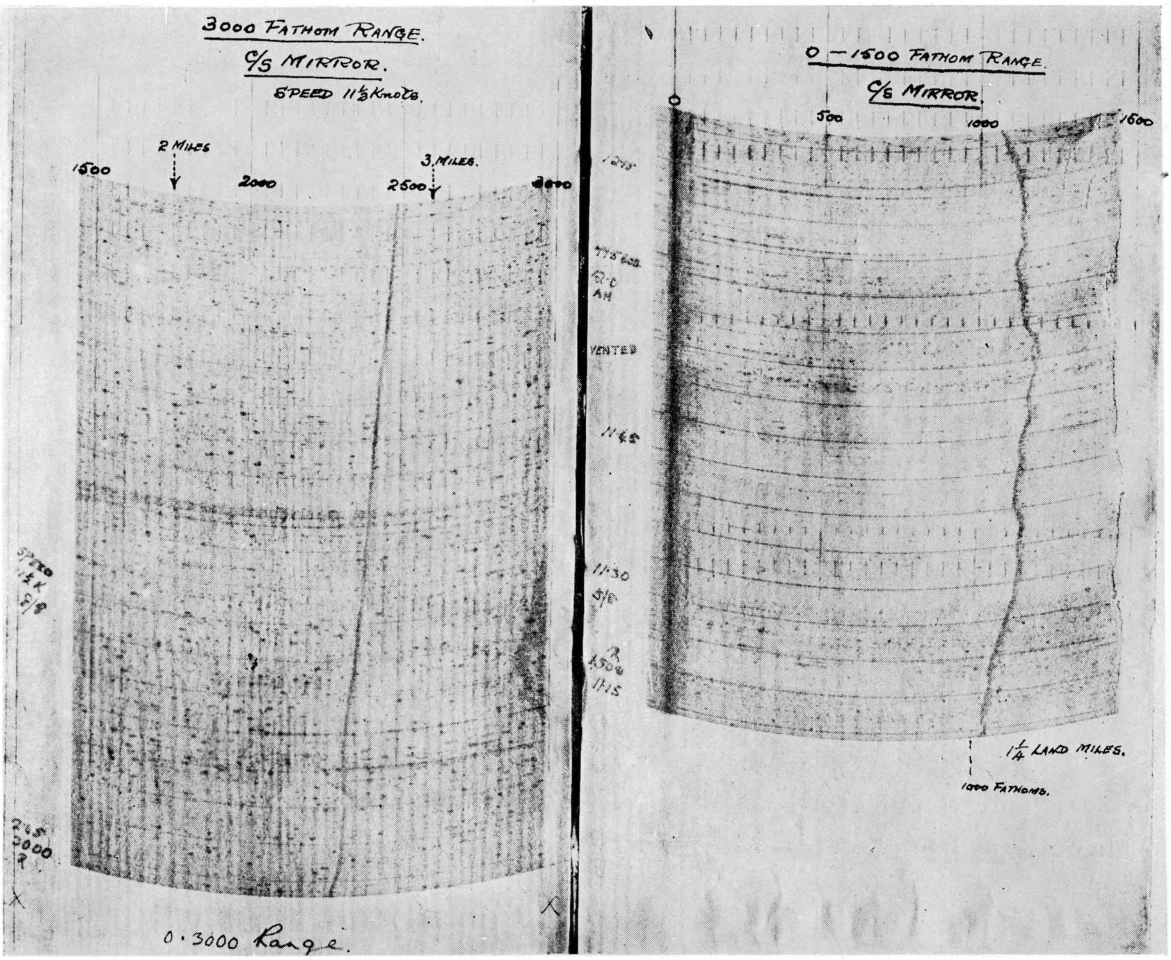

PLANCHE XXV

PLATE XXV.

Equipement MARCONI *pour grands fonds de 0 à 3.000 brasses. — Enregistrement à 3.000 brasses de fond dans le Golfe de Gascogne*

MARCONI deep sea equipment 0 to 3000 fathoms. Record on 3000 fathom range. Sea bed in Bay of Biscay.

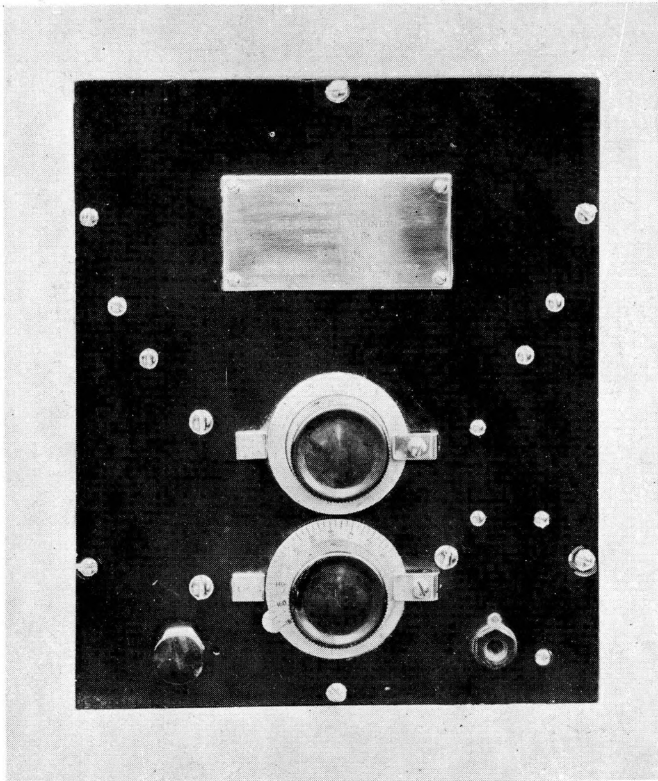

PLANCHE XXVI
PLATE XXVI.

Oscillateur hétérodyne

MARCONI deep sea equipment 0 to 3000 fathoms. — Heterodyne Oscillator.

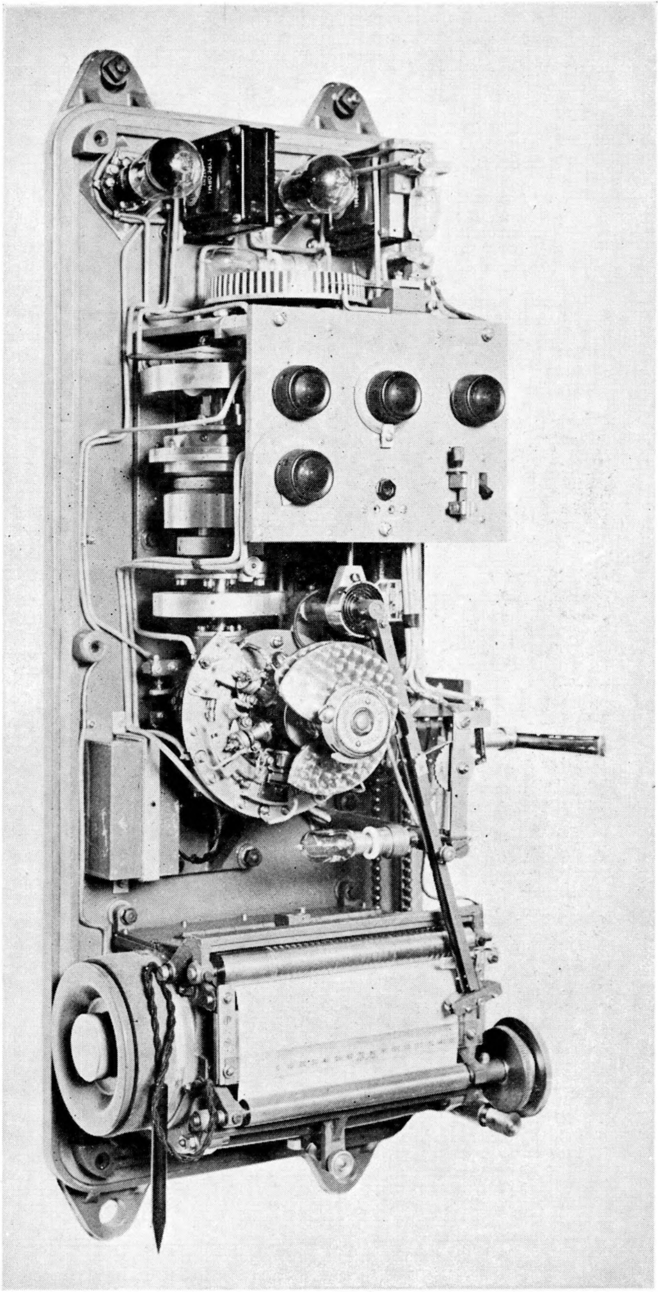

PLANCHE XXVII
PLATE XXVII.

Vue intérieure. — 7,6 sondages à la minute

MARCONI deep sea equipment 0 to 3000 fathoms. MARCONI electrolytic recorder-inside view
0 to 150 fathoms.
0 to 1500 fathoms.
0 to 150 fathoms.
0 to 1500 fathoms.
0 to 3000 fathoms.
7.6 soundings per minute.

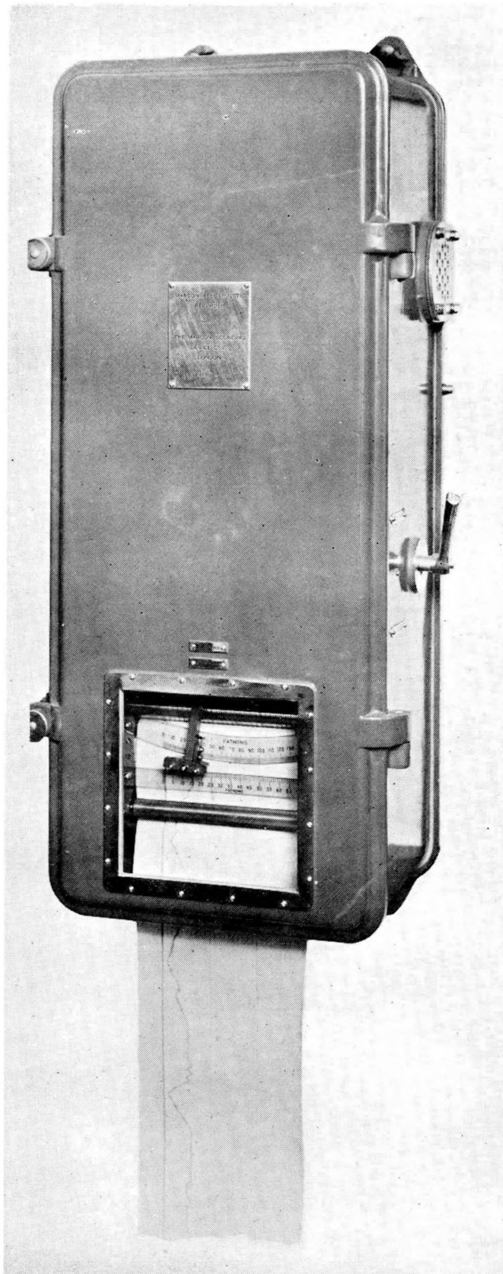

Planche XXVIII.
Plate XXVIII.

Enregistreur électrolytique Marconi. — *Vue extérieure*

Marconi deep sea equipment 0 to 3000 fathoms. Marconi Electrolytic recorder. Outside view.

The projector element itself is mounted in a heavy oval steel casting which closes the hole cut in the shell plating and in front of this hull casting is placed a thin stainless steel plate through which the sound waves are transmitted and received. This stainless steel plate is used to prevent any turbulence that might occur in the cavity formed by the hull casting when the vessel is proceeding at speed. (See fig. 20).

(2) *MAGNETOSTRICTION PROJECTOR, RECEIVING.*

This is exactly similar to the standard receiver as used on the navigational equipment and is erected in a hull casting with a stainless steel plate across its aperture in the same way as the transmitting projector described above.

(3) *TRANSMITTER UNIT.*

The deep sea transmitter unit is similar to the navigational transmitter unit and is mounted in the same container. The motor generator however has an output voltage of 2000 as compared with 1500 of the navigational type. The machine is operated direct from the ship's supply by means of a two step auto starter.

Increased power has been obtained by the use of a much larger condenser bank and this condenser bank is placed outside the transmitter unit in a separate container. Compare Plate XXII with Plates XXIII to XXIV showing respectively the transmitter unit and condenser bank of the deep sea equipment.

(4) *VALVE AMPLIFIER.*

This is identical in outward appearance to the navigational type, see Plate XXI. The sensitivity however, has been improved.

(5) *HETERODYNE OSCILLATOR.*

This heterodyne oscillator is supplied for use with the deep sea equipment under exceptional and bad conditions of sea bottom. Under normal conditions of sea bottom, up to 3000 fathoms, this heterodyne oscillator need not be brought into action, but where the ocean bed is decidedly soft and lacking in good reflecting properties it will be found that the heterodyne oscillator considerably improves the resulting echo obtained.

(6) *VISUAL INDICATOR.*

This instrument is only arranged for use on the navigational range of the deep sea equipment 0-150 fathoms and no provision has been made on this deep sea equipment for a visual indicator for the greater depths. It has been found on these deep ranges with visual indicator that the reading of the spot of light when travelling so slowly across the dial becomes laborious, tiring and difficult. On lower ranges where the light spot is moving rapidly and the number of soundings per minute is high the reading of the visual indicator is simple and most effective.

The visual indicator may be used also with deep sea equipment for navigational purposes.

(7) *ELECTROLYTIC RECORDER.*

The time taken for an impulse to reach the bottom of the ocean at 3000 fathoms and return to the vessel is approximately 8 seconds and for this reason the number of soundings possible per minute with a deep sea equipment is therefore limited. Consequently, it is most essential on a deep sea equipment for the echoes to be received on a recording device and all deep sea equipments are supplied with an electrolytic recorder for actually plotting out the ocean bed in the form of a graph.

The electrolytic recorder used for deep sea equipments is outwardly identical with the navigational type, but very decided changes of design internally have been made to cover the wide range required on this instrument.

There are in all five ranges:

0 - 150 fathoms, purely for navigational purposes on the Cable Ship or survey vessel.

0 - 750	fathoms	Deep sea ranges.
750 - 1500	"	
1500 - 2250	"	
2250 - 3000	"	

The soundings per minute on this instrument are brought up to a high figure of 16.4 in spite of the large depths in order to obtain as many echoes per minute as possible. Plates XXVII & XXVIII show the inside and outside of a typical 0 - 3000 fathoms electrolytic recorder for deep sea soundings. The particular instrument shown in the figure however has only three ranges 0 - 150, 0 - 1500, and 1500 - 3000 fathoms. The soundings on this instrument were only 7.6 per minute. It will be appreciated therefore that the new design giving five ranges and increased sounding per minute up to 16.4 is a definite improvement over the model shown in the figures. Typical reports on the 3000 fathoms deep sea ranges are shown on Pl. XXV, and it will be observed from these records that a very decided contour of the ocean bed is obtainable even at full speed on a Cable Ship at ranges of 1000 to 2500 fathoms.

IV. THE ATLAS ECHOLOT

High Frequency Type.

MANUFACTURED BY THE ATLAS-WERKE AKTIENGESELLSCHAFT, BREMEN.

The ATLAS echo sounder of the high frequency type manufactured by the Atlas-Werke of Bremen makes use of the principle of the ultra-sonic waves for the measurement of the depth, produced by sounding apparatus based on the principle of magnetic contraction (magnetostriction). The sound waves are radiated in the shape of a cone and are directed towards the bottom, whence they return to the vessel after reflection in the form of an echo. The depths are determined entirely automatically, and the depth indications in metres and fathoms are shown by means of a luminous red point at the corresponding position on the circular depth scale of the apparatus.

Normally, the indicating apparatus is provided with two scales; the standard model of the Echolot for high frequency for navigational purposes is equipped with an inner scale running from 0 to 100 metres and an outer scale from 0 to 1000 metres.

The depth indications succeed each other at an extremely rapid rate; on the 100 metres scale there are 7.5 soundings per second. The observer cannot separate out the individual depth indications; he sees only a permanent line which follows the slightest variations in depth somewhat like an indicating pointer. On the outer scale the depth indications succeed each other at a proportionately slower pace. It is possible also to read off on the inner scale depths which exceed the range of the scale divisions, provided one assures oneself of the actual sounding by switching on, for a short time, the other circuit to obtain temporary readings on the outer scale. For instance, if one has found depths on the outer scale of, say 385 metres, after switching to the inner scale of 0 to 100 metres a reading of 85 metres will be obtained.

The accuracy with which the depths can be obtained depends naturally upon the range of the measurements. It is evident that on the scale of 0 to 1000 metres the accuracy cannot be as great as on the scale up to 100 metres since the divisions of the former scale are much closer. Generally speaking, the accuracy of reading on the scale of 0 to 100 metres is plus/minus 25 cm.

Since the transmitter and receiver are placed at a short distance from each other, it is possible to measure also very small depths beneath the keel. Generally speaking, one can measure depths under the keel from one metre upwards.

Owing to the large periphery of the scale, the readings may be effected at a distance from the apparatus, so that the observer is not under the necessity of approaching the apparatus closely each time a reading is desired.

PRINCIPLE OF THE ECHOLOT:

This is explained with the aid of Figure 21. The straight neon tube (*h*) is inserted radially in the disk which is turned by the motor (*a*) at a constant speed behind the fixed scale (*g*) showing metres and fathoms. The centrifugal governor (*b*) either cuts in or out the series resistance of the induction circuit, thus assuring an exact number of turns with the necessary regularity, independent of the voltage fluctuation in the supply mains. On the gear axis (*c*) is also inserted a sliding contact (*d*) which, each time the neon tube passes the zero on the scale, discharges a condenser (*l*) into the windings of the magnetostriction oscillator (*f*), from which is sent out an impulse of short duration into the water. This short wave impulse reaches the ocean bottom, is reflected, and arrives at the vessel where it impinges upon the magnetostriction tuned oscillator (*k*). This, acting as a receiver, transforms the sound waves into electrical oscil-