B.R. 630

HANDBOOK

FOR

ECHO SOUNDING SET

TYPE 754

1943

Reprinted with amendments January 51.

NOTE.—The Instructions on Type 754 in BR. 313 are no longer considered adequate so that for the purpose of this set the book becomes obsolete.

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CHAPTER I—INTRODUCTION.

1. BASIC PRINCIPLES OF ECHO-SOUNDING.

In measuring the depth of water by echo methods a ship transmits an under-water sound impulse which travels outwards through the sea at uniform speed. On reaching the ocean bed part of the sound impulse is reflected and returns to the ship in the form of an echo where its arrival is automatically recorded graphically.

The velocity of sound in its passage to and from the ocean bed is known, and so by measuring the time interval between making the sound and noting the echo return an observer in the ship can determine the depth of water.

2. USE OF THE HANDBOOK.

Personnel maintaining the Echo-Sounding set should make themselves familiar with this book *as a whole*, it is not sufficient merely to read small sections.

The handbook contains the following information :—

(*a*) A description of the mechanical and electrical apparatus comprising the set.
(*b*) The method of operating the set.
(*c*) Care and Maintenance Details.
(*d*) Particulars of Periodical Routines.
(*e*) Instructions for Fault-Finding.

3. COMPONENTS OF THE SET.

The components of the Type 754 Echo-Sounding set are as follows :—

(*a*) The *Transmitter* which produces the Sound impulse.
(*b*) The *Hydrophone* which picks up the echo from the ocean bed.
(*c*) The Recorder which operates the transmitter by means of a timed transmission switch and automatically records the echo received by the hydrophone by means of a rotating stylus on a moving strip of sensitized paper.

4. STORES.

A list of the permanent and consumable stores which form the various parts of the set will be found in the Establishment List A/S 28, a copy of which is kept by the Officer-in-Charge of Stores. A list of Base Spares will be found in Establishment List A/S 61. These publications contain information regarding the pattern number, full name and quantity of each article fitted in the set, together with the spares. Instructions for Installing will be found in publication A/S 7306/R1 obtainable from Director of Underwater Weapons (Bath).

When demanding stores it is important that the correct Establishment List description is given as well as the Pattern Number.

CHAPTER II—TRANSMITTING EQUIPMENT.

5. GENERAL.

The Transmitter equipment consists of the following units :—

(i) Tank, Pattern No. 9966A.
(ii) Transmitter Junction Box, Pattern No. 9970A.
(iii) Transmitter, Pattern No. 9967.
(iv) Pressure and Filling Unit, Pattern No. 9969A.

6. TRANSMITTER TANK. (Figure 6.)

The transmitter tank, which is similar to the tank used for the hydrophone, is illustrated in Figure 6. It is oval in shape, open top and bottom, and has a circular flange on top provided with studs for securing the transmitter diaphragm. The lower face of the tank is shaped to conform to the curvature of the hull plating at the point of fitting and a water-tight joint between hull and tank is ensured by means of a channel section dermatine gasket, Pattern No. 9979.

The tank is kept in position by bolts passing through brackets, which are attached either to the ship's frames or to the hull plating, according to whether the frame spacing is small or large.

A tapped hole is provided in one side of the tank for the attachment of a filling and pressure pipe, and great care is to be taken that this *filling hole is on the lowest side of the tank when the latter is in position*, otherwise an airlock will be formed and transmissions will be weakened.

7. TRANSMITTER JUNCTION BOX. (Figure 1.)

This is fitted in the electrical lead from the recorder to the transmitter, and enables a common transmitter to be used in 110-volt and 220-volt ships. The junction box contains a resistance bank of five mats of total resistance 38·5 ohms

There are three terminals on the right-hand (inside the box) and the positive lead from the recorder is taken to the upper or middle terminal, depending upon whether the ship's voltage is 220 volts or 110 volts. The positive lead to the transmitter is connected to the lower terminal.

On the left-hand side of the box are two terminals connected by a short circuiting strip. This simply enables the negative lead from the transmitter to the recorder to be broken in order to insert a test resistance for use in adjusting the transmitter spring. This adjustment is described in paragraph 46.

8. TRANSMITTER A/S 2.

Sectional drawings of the transmitter A/S 2 are shown in Figure 3. The transmitter consists of a diaphragm to which is bolted an electro-magnet unit comprising a laminated core carrying two coils and guides for the hammer. The hammer itself moves in the guides on four ball races and is held against the anvil of the diaphragm by a spring The upper end of this spring is located in an adjusting sleeve. This is screwed into the casing of the transmitter which is bolted to the rim of the diaphragm. A locking ring is fitted to the adjusting sleeve to prevent the latter slacking back after the tension on the spring has been adjusted and the whole is protected by a watertight cap.

Two glands are fitted on the upper face of the diaphragm rim through which are taken the electric leads to the coils.

A tapped hole is provided on the edge of the diaphragm rim for the attachment of the air release pipe. This hole leads through to the face of the diaphragm and forms an air escape when the tank is being filled with water.

The transmitter complete is bolted down to the top of the transmitter tank, the joint being made by means of a dermatine washer, Pattern 9978. Care must be taken that the air vent on the edge of the diaphragm is at the highest point when the transmitter is bolted in place (*i.e.*, diametrically opposite to the pressure pipe connection to the tank, *see* paragraph 6).

9. ACTION OF THE TRANSMITTER.

When the transmitter circuit is 'made" n the recorder, the electro-magnet is energised and the hammer pulled away from the anvil of the diaphragm causing the spring to become depressed. On the transmitter circuit being broken, the spring drives the hammer against the anvil, thus causing the diaphragm to vibrate and so transmit a sound impulse.

10. PRESSURE AND FILLING UNIT. (Figure 7.)

The filling and pressure unit consists of a brass container in which is a pump connected by a copper pipe through a stopcock to the filling connection on the side of the transmitter tank. Another copper pipe from the air release connection in the edge of the transmitter diaphragm leads through a stopcock to a connector in the bottom of the container. This pipe then continues inside the container and terminates in a turned down open end under the lid.

Between the stopcock and the transmitter a branch pipe leads from the filling pipe to an air vessel inside the container, and a pressure gauge is fitted to this air vessel for registering the pressure in the system. The air vessel acts as a compressed air container.

CHAPTER III—RECEIVING EQUIPMENT.

11. GENERAL.

The receiving equipment consists of the following units :—

(i) Tank, Pattern No. 9966A.
(ii) Hydrophone Junction Box, Pattern No. 9971A.
(iii) Hydrophone Tank Filling Unit, Pattern No. 9972A.
(iv) Hydrophone, Pattern No. 9968. This item consists of a diaphragm, Pattern No. 9974, and a microphone set, Pattern No. A. 947.

Note.—A microphone set, Pattern No. A. 947, for echo-sounding installations, consists of a microphone button, Pattern No. 2540, mounted on a special adaptor for securing it to the boss of the hydrophone diaphragm.

12. HYDROPHONE TANK. (Figure 6.)

This is similar in all respects to the transmitter tank described in paragraph 6.

13. HYDROPHONE JUNCTION BOX.

This is similar to the transmitter junction box, except that the resistance mats are replaced by four Pattern No. 58 inert cells. The right-hand terminal block has only two terminals, the upper of which is connected to the positive of the battery and to the recorder, and the lower to the negative of the battery and hydrophone. The left-hand terminals are short-circuited and connected upper to recorder and lower to hydrophone. In effect, therefore, the hydrophone junction box connects the hydrophone and battery in series with the recorder.

14. HYDROPHONE TANK FILLING UNIT.

This consists of a small gravity tank fitted in any convenient position above the hydrophone. It is connected by a ¼-inch copper pipe to the filling connection on the side of the hydrophone tank. A similar copper pipe, forming a vent or air release, is fitted to the connection on the edge of the hydrophone.

It is led to a position just below the filling unit where a stopcock is fitted and the end of the pipe turned down.

(80 2516)

15. **HYDROPHONE.**

Drawings of the hydrophone are shown in Figure 5. The hydrophone consists of a diaphragm with a raised boss in the centre on which is screwed a microphone unit, the latter comprising a microphone and bakelite adaptor. Electrical leads from the microphone are connected to two terminals on an insulated bridge and from the underside of these two terminals leads go to two glands where junction is made with the two leads from the hydrophone junction box. In connecting the external circuit to the hydrophone there is no necessity for removing the cover.

The hydrophone diaphragm is bolted down on to the top of the hydrophone tank, the joint being made with a dermatine washer, Pattern No. 9978.

A domed cover is bolted to the top of the diaphragm, also with a dermatine joint Pattern No. 9975, and the microphone is thus protected from damp and damage.

16. **MICROPHONE.** (Figure 5.)

The microphone fitted in the echo-sounding hydrophone consists of two carbon electrodes, one of which is cemented to a brass backing plate which, in its turn, is secured by means of a screwed stalk to a bakelite adaptor rigidly attached to the centre of the hydrophone diaphragm. The second carbon electrode is secured to the inside of the brass case of the microphone and the space between the electrodes is about three-quarters filled with small, highly-glazed carbon granules.

A mica diaphragm is behind the brass backing plate and is clamped in position by a nut screwed on the microphone stalk. The brass case of the microphone is then secured to the mica diaphragm by a brass ring behind the mica being turned over the rim of the case. This general arrangement ensures that the electrical connection between the electrodes is through the carbon granules, whilst the diaphragm itself, being elastic, provides a non-rigid mechanical connection between the electrodes.

The microphone forms part of an electrical circuit, the connections being made to the electrodes and the carbon granules making a conducting path through the microphone.

17. **ACTION OF THE MICROPHONE.**

A sound impulse reaching the hydrophone diaphragm causes it to vibrate. This vibration is transmitted via the bakelite adaptor and screwed stalk to the microphone electrode attached to the hydrophone diaphragm. As the mechanical connection between this vibrating electrode and the other electrode is through an elastic mica diaphragm, the second electrode does not vibrate in phase with the first. Therefore, when the hydrophone diaphragm vibrates, one electrode of the microphone moves relatively to the other. As a result, there is a variation of the pressure exerted on the carbon granules between the electrodes and this causes a variation in the electrical resistance of the microphone. The current flowing in the microphone circuit therefore varies, and the variation in current after amplification causes a mark to be made on the recorder paper.

CHAPTER IV—RECORDER. (Figures, 9, 10 and 11.)

18. **GENERAL.**

A shaft, driven from a motor through suitable gearing and at a speed depending on the range of depths it is desired to record, carries a cam which operates the transmitting contacts once every revolution of the shaft.

A rotating arm is fixed to this shaft and at the extremity of the arm is a spring controlled stylus. As the arm rotates this stylus traverses a metal track during part of every revolution. Interposed between the stylus and the track is a strip of chemically prepared and moistened paper which is caused to travel slowly downwards past the track by an independent geared drive from the motor.

The pulse received in the hydrophone is injected into an amplifier (incorporated in the recorder) and the amplified pulse, after rectification into direct current, passes from the stylus through the paper to the metal track. In doing so iodine is liberated on the surface of the prepared paper and a brown stain or record is produced. The intensity of the record depends upon the speed of the stylus across the paper, and also the strength of the current, the latter being proportional to the intensity of the received signal.

The stylus point commences its travel across the track near the left-hand edge of the paper, at the instant the transmitter contacts break. Consequently, if a returning echo pulse arrives at the hydrophone during the traverse of the stylus across the paper a mark will be made thereon.

It will be seen that the position of this mark relative to that of " break " represents the " time-path " of the signal, and if the distance between them is measured against a suitably divided scale, corrected for lag and separation (*see* following paragraphs), a direct measurement of the depth of water beneath the ship will be obtained. Subsequent traverse of the stylus across the slowly moving paper will therefore trace out a contour of the sea bottom.

When it is desired to extend the range of a recorder without contracting the divisions on the scale and slowing up the movement of the stylus arm, the timing of the transmission relative to the position of the stylus can be advanced by a known interval corresponding to a known depth. This is known as *phasing* and the " depth " by which the transmission has been advanced is added to the depth shown against the scale to obtain the true sounding.

In addition to the glass divided scale, which is attached to the recorder, a depth scale is automatically marked on the paper by injecting into the stylus circuit an interrupted flow of current from

a dry battery. This scale is marked on the paper at definite time intervals, and so becomes a " depth-time mark " by means of which the depth at any past instant may be obtained.

By means of a change speed control a shallow and deep range can be incorporated in one recorder, and this is done in Type 754 (Recorder A/S 50). At slow speed of stylus, a range of 300 fathoms is covered in one traverse of the stylus over the paper, and it will be obvious that by speeding up the stylus arm to ten times the speed, one traverse of the paper will cover a depth of 300/10 (*i.e.*, 30 fathoms).

19. **TRANSMITTER LAG.**

The transmitting contacts are operated so that the transmitting circuit is " made " for a fraction of a second and then " broken." When the circuit is " made " the powerful magnetic field created by the transmitter coils draws the hammer away from the diaphragm against a powerful spring. On the circuit being " broken," the magnetic field collapses and the spring drives the hammer against the diaphragm.

There is a short time lag between the breaking of the transmitter circuit and the striking of the diaphragm. This time interval—which for convenience is measured in " echo " feet—is called the transmitter " lag," and an allowance has to be made for it when graduating the recorder scale.

20. **SEPARATION.**

In order to screen the hydrophone from sound travelling *direct* from the transmitter (either through the water or ship's hull) these instruments are placed at some distance apart and on opposite sides of the keel. The distance between them is known as the " separation."

It will be seen that the distance travelled by the sound from the transmitter to the receiver via the sea bottom is more than if the instruments were close together. Allowance has to be made for this in graduating the recorder scale.

21. **RECORDER CASE.**

The recorder mechanism and amplifier are housed in an " alpax " case in three portions—the base, the middle portion and the outer door. The middle portion hinges and closes on to the base, and the outer door hinges and closes on to the middle portion, so that when the instrument is closed up all moving parts and electrical connections are protected from external damage. The instrument is NOT watertight. Photographs of the recorder are shown in Figures 9, 10 and 11.

The main components are disposed as follows :—

In the Base (bolted to the bulkhead).—A mains operated amplifier, comprising a single valve and necessary resistances for anode, filament and grid bias supply ; input and output transformers ; rectifier ; a potentiometer for sensitivity control, a three-pole single way control switch and a terminal block for taking the external connections and distributing to the necessary points in the recorder. Leads are taken from the base to the hinged middle portion through a special cable hinge.

In the Middle Portion.—A governed motor which drives through a two-speed gear box the rotating shaft carrying the transmitting cam and stylus arm ; the time marking switch and depth marking commutator ; and a shaft drive for drawing the paper past the stylus track ; a nine-volt dry battery for supplying the auxiliary (*i.e.*, depth and time marking, fix and electric pencil) circuits ; two condensers, one for absorbing the inductive kick at the break of the transmitting circuit and one between the negative main and earth as a precaution against interference in the amplifier ; a closed container or tank for housing the roll of moistened recorder paper in use ; a chamber incorporating a heating element and automatic winding device for drying and rolling up the used paper. The change speed handle is situated externally on the left-hand side of the middle portion.

The Outer Door.—The outer door contains a glass window behind which an engraved glass scale is secured by two spring suspension strips. A small additional window displays an automatic indicator showing the scale range in use. The phasing control disc is situated externally on the outer lid and an indicator showing the amount phased is provided under the glass window.

22. **PHASING DETAILS.**

The Navigational Recorder, A/S 50, for Type 754, is a two-speed machine with ranges of 0–30 fathoms on high speed and 0–300 fathoms on slow speed.

At both speeds phasing can be effected in six steps of 20 fathoms (high speed) or 200 fathoms (slow speed) each.

The scale readings at each speed and on each phase are as follows :—

Phase.	Scale Range at High Speed.	Scale Range at Slow Speed.
Zero	0–30 fathoms	0–300 fathoms.
+ 20 or 200	20–50 fathoms	200–500 fathoms.
+ 40 or 400	40–70 fathoms	400–700 fathoms.
+ 60 or 600	60–90 fathoms	600–900 fathoms.
+ 80 or 800	80–110 fathoms	800–1,100 fathoms.
+ 100 or 1,000	100–130 fathoms	1,000–1,300 fathoms.

With this type of gear it is, of course, unlikely that more than one phasing step on the slow speed setting will ever be required

23. **SCALE.** (Figure 14)

A glass engraved scale is suspended inside the window of outer door of the Recorder by means of two suspension springs. The scale is attached to the suspension springs by means of countersunk screws and nuts and locknuts. A leather washer between the scale and the spring prevents damage to the scale. A rubber buffer Pattern A 978 is pushed over each of the locking nuts and this prevents damage to the glass scale through shock gunfire, etc. A thin transparent cellular skin known as "Duravista" is applied to the underside of the window in the outer door of the recorder. This prevents "misting up" of the window.

Details regarding time marking, and stylus and paper speeds, are as follows :—

Scale Range.	*Positions of Paper Change Speed Knob.*	*Paper Speed.*	*Time Marking Interval.*	*Stylus Disc Speed.*
Fathoms	IN	·4 inches/min.	1 min	206–2/3 r.p.m.
	OUT	·2 inches/min.	2 mins.	
Fathoms × 10 ..	IN	·04 inches/min.	10 mins.	20–2/3 r.p.m.
	OUT	·2 inches/min.	2 mins.	

In recorders for Type 754 (two-speed recorders) two scales are employed for the following reasons :—

(*a*) The separation correction incorporated in the scale, which necessitates "closing up" the divisions at shallower depths, is only applicable to the first phase of the high-speed range; as this correction ceases to have any appreciable effect when the second and subsequent phases are in use, an evenly divided scale is then employed.

(*b*) The corrected scale mentioned above is obviously not suitable for the first phase of the slow speed range, and, theoretically, an additional corrected scale is required. In practice, however, to avoid the complexity of having to provide three scales, it is intended that the high speed range should *always* be employed for depths under 30 fathoms, thereby obviating the necessity of an additional corrected scale for the slow speed range. The evenly divided scale referred to in sub-paragraph (*a*) above can be used as common to both speed ranges for the second and subsequent phases. At slow speed all readings are multiplied by ten (giving FATHOMS × 10).

(*c*) For convenience the glass scale is divided to incorporate the corrections and the evenly divided scale is engraved on the front face of the ebonite flap situated above the stylus track.

24. **MOTOR AND GOVERNORS.** (Figure 12.)

The motor (Pattern 6119 or 6138), which is driven from the ship's 110 volt or 220 volt supply, is shunt wound, with governing on the field winding by means of a resistance, in series with the field, which is cut in and out by the governor.

The governor consists of a flat leaf spring mounted between the arms of the back spring, and carrying a nickel contact disc at its centr The back spring is mounted on the motor shaft in the recessed face of the motor flywheel and by means of the spiral tension spring connecting its two arms, it imposes a curvature on the leaf spring. A pair of governor weights are carried one on each arm of the back spring.

The rim of the flywheel face containing the governor is used as a slip-ring, and a small cylindrical carbon brush, held in a spring-loaded holder on the paxoline governor end plate, bears on the rim.

Opposing the nickel contact disc is a stationary contact consisting of a ring of carbon mounted on the end of a screw passing through the end plate of the governor. By rotating the moulded knob on the governor end plate the distance between these two contacts may be varied.

When the motor is switched on it accelerates, and the governor weights exert a centrifugal force outwards opposing the action of the tension spring, thus forcing the arms of the back spring apart, and reducing the curvature of the leaf spring. This causes the nickel disc to move towards the carbon ring, and when the speed of the machine is great enough, to touch it.

When the two contacts touch, the governor resistance in the field circuit is short circuited, the consequent increase in field current causing a fall in the speed of the motor This fall in speed causes a reduction in the centrifugal force exerted by the governor weights, the back spring arms close, and the nickel disc moves back, breaking contact with the carbon ring. The governor resistance is thus once more in circuit, and the motor speed rises again until the contacts once more meet. This cycle of events repeats itself continually while the machine is running.

When the carbon ring is screwed back, away from the nickel disc, the latter will have further to travel before contact is made and the speed checked. This greater movement of the nickel disc can only be produced by the exertion of a greater centrifugal force on the part of the weights, and thus calls for a higher speed than before. Thus to increase the speed of the motor th carbon ring should be screwed away from the nickel disc, and to decrease the speed the ring should be screwed closer to the disc.

25 **GEAR BOX AND GEARED DRIVES.**

A base plate in two halves divides the middle portion of the recorder into two main compartments.

On the back of the baseplate is mounted the motor, coupled through a short, flexible, coupling to the main worm reduction which transmits the drive to the lay shaft of the gear box. The gear box casing is cast integral with the upper half of the baseplate.

From the lay shaft the drive is transmitted to the hollow stylus shaft through a train of four spur wheels.

A worm on the stulus shaft engages a worm wheel on a cross shaft. One end of the cross shaft passes through the side of the gear box and drives the paper rollers by means of a worm reduction gear via a skew gear and coupling rod.

The drive to the time marking switch is taken from the opposite end of the cross shaft through a contrate reduction gear.

A worm is fitted on both the stylus shaft and the lay shaft. By means of an external control on the right-hand side of the recorder the worm wheel on the cross shaft can be meshed into either of these worms. This arrangement provides the following alternative paper speeds :—

(*a*) When cross shaft is driven off the lay shaft a constant speed drive to the paper rollers and time marking switch, irrespective of speed of stylus.

(*b*) When cross shaft is driven off the stylus shaft, a variable speed drive to the paper rollers and time marking switch proportional to the speed of the stylus.

26. **CHANGE SPEED CONTROL.**

The change speed control knob is situated on the left-hand side of the case, and when operated performs the following functions :—

(*a*) Engages the appropriate spur wheel on the lay shaft with the appropriate one on the stylus shaft for the speed desired.

(*b*) Operates an indicator showing the scale in use, *i.e.*, "FATHOMS" or "FATHOMS × 10."

(*c*) Alters slightly the moment of transmission so that the break mark shall appear at the corresponding break line on the scale whichever speed is used. This is done by imparting a small movement to the anchorage of the phasing pawl (and hence the transmission contacts) by means of a stiff spring (*see* paragraph 28).

27. **TRANSMITTING CONTACTS.** (Figure 13.)

The transmitting contacts and two slip-rings are mounted on a shaft which is free to revolve inside the shaft carrying the transmitting cam and stylus arm. The slip ring brush holders and transmitting contact terminals are mounted on a small insulated panel attached to the worm reduction box.

The lower arm of the contact assembly consists of two spring leaves with the outer leaf carrying a tungsten contact projecting through a cutaway portion of the inner leaf. The lower outer leaf is fractionally longer than the inner leaf to ensure that when "break" occurs the inner leaf will not hang up on the cam after the outer leaf has dropped.

Between the lower and upper arms of the assembly is a tongue of Keramot or other insulating material.

The upper arm of the assembly consists of two leaves, the inner carrying the second tungsten contact and the outer having a curved end bearing o

The five main components are clamped together at the base by a screw and the whole is mounted in such a way that the switch can be swung slightly about a pivot at the base, so that the distance between the contacts when the switch is broken can be varied By means of this adjustment the maximum lift of the upper leaves of the switch can be varied so as to obtain sparkless operation of the switch.

An extension of the stylus shaft to the rear of the recorder carries the transmitting cam which lifts the lower leaves and contact against the upper contact, and hence the upper leaves away from the Keramot tongue. This is shown in Figure 12 (A) and constitutes the period of "make" of the transmitter circuit.

When the "drop" edge of the cam is reached all leaves of the switch drop together under their combined spring action. The upper leaves and contact are then stopped by the Keramot tongue whilst the lower leaves and contact continue under the influence of their own spring action, and the added acceleration imparted to them by the deflection of the top leaves. A quick break is thus assured independently of the stylus shaft speed. The "drop" edge of the cam is under-cut to ensure that the leaves do not hang up on it whilst dropping.

It will be found that considerable sparking at the contacts can take place if the switch is not correctly adjusted The theoretical correct maximum "lift" of the upper leaf from the Keramot tongue is about ·04 inch, but slight variation from this figure may at times be necessary to obtain the best results.

Under correct conditions almost sparkless operation of this switch should be obtained. Any sparking, unless very slight, has a cumulative effect, and if allowed to continue will probably result in the arc persisting and the destruction of the switch by fire. The recorder should, therefore, never be run when the transmitting switch is operating unsatisfactorily.

28. **PHASING MECHANISM.**

On the front end of the inner shaft carrying the transmitting contacts is the phasing dial which can be turned by means of a friction disc attached to the handle mounted in front of the recorder.

A spring loaded pawl engages in slots cut in the periphery of the phasing dial to determine definite angular displacement. The pawl is secured to an arm which is pivoted about the stylus shaft carrying the transmitting cam and whose angular movement is controlled by two adjustable screws. By

means of a stiff spring a small movement is imparted to the anchorage of the phasing pawl (and hence the transmitting switch) by the change speed control (*see* paragraph 26). This arrangement automatically corrects the timing of transmission to allow for change in recorder speed.

It will be seen that displacement of the phasing dial and hence the transmitting contacts through a known angle results in a definite interval between actual transmission and the instant the stylus passes the zero.

29. DEPTH MARKER AND TIME SWITCH.

The depth marker consists of a Keramot disc carrying a number of metal insets in the form of a commutator alongside which is a brass ring and both slip ring and commutator are integrally mounted on the stylus shaft. Two fixed brushes bear on the slip ring and commutator respectively, and these brushes are in series in a battery circuit connected to the stylus. A small mark is, therefore, made on the paper every time the commutator brush is on a metal inset, and the insets are arranged so that a permanent mark is made on the paper at two-fathom intervals.

Actually the depth marker stylus circuit described above is also in series with a time marking switch. This is a disc driven by the cross shaft through contrate gears (*see* paragraph 25), and on the rim of the disc is a pair of small projections. Once every revolution of the time marker switch these projections close a switch in series with the depth marker/stylus circuit, and only under these conditions are the depth marks made. Thus a permanent depth scale and time record is printed on the paper at fixed intervals dependent on the recorder and paper speeds (*see* paragraph 23).

30. TANK FOR PAPER ROLL.

The roll of impregnated and moistened paper (Pattern 3606) is housed in a cradle in a tank cast with one-half of the baseplate. The lid or face of the tank hinges outwards for inserting the roll and, when closed, serves as a contact surface for the paper and stylus to pass over. The lid is held closed by a spring plunger lock on each side and the joint between the lid and the tank is sealed by a strip of sponge rubber. This makes a sufficiently airtight joint to preserve the moisture in the paper for several months.

31. PAPER DRIVE AND DRYER.

The paper, passing out of the tank and down the face, is rove and gripped between two rollers, the lower roller being held against the upper roller by a leaf spring at each end. These leaf springs are connected by a stirrup which houses in niches at each end. When the stirrup is in the two forward niches the rollers are close together, but when the stirrup is pulled down about $\frac{1}{2}$ inch and moved backwards about $\frac{1}{2}$ inch into the second pair of niches, the rollers are separated about $\frac{1}{10}$ inch and the paper can be rove between them.

The upper roller is driven through reduction gearing from the stylus shaft (or alternatively, if desired, from the lay shaft) (*see* paragraph 25). The final drive to the roller is transmitted from the worm wheel on the roller shaft through a helical spring. This allows of positive drive in one direction and slipping in the other. Consequently the upper roller can be revolved quickly by hand in the direction of the drive without damaging the final worm and worm wheel drive.

At the opposite end of the upper roller to the worm drive is a large spur wheel engaging with another spur wheel behind it. This wheel has chamfered edges and fits into a " V "-shaped pulley wheel attached to one end of the spent record spool. The latter is frictionally driven, and after the paper has passed through the mangle rollers it is wound on to the spent record spool. The friction drive between the upper roller and the " V "-shaped pulley compensates for the increasing diameter of the spent record roll as more paper is wound up.

In the trough under the spent record tube is a heater element (Pattern No. 6819 for 110-volt recorders and Pattern No. 6820 for 220-volt recorders). The object of this is to dry the paper and " fix " the record as the paper is wound up.

Ventilation holes are provided at the bottom of the trough under the heater element, and there is also a ventilation slit at the bottom of the glass window. The object is to create a current of warm air to pass up inside the door of the recorder to prevent condensation on the inside of the window. A ventilating cowl at the top of the recorder allows heated air to escape.

32. STYLUS. (Pattern A. 974.)

The stylus consists of an iridium tipped piece of wire located in two grooves in the rotating carrier arm and secured in place by two small swivelling clips. A light helical spring exerts the necessary pressure on the stylus point when traversing the record. The pressure is applied to the spring by giving it one complete turn from its normal position and then anchoring the end of the spring over the stylus arm.

The other end, or " heel," of the stylus wire serves as a stop pin when the stylus point is not resting on the paper, and it also ensures the safety of the stylus point by traversing a ramp prior to the beginning, and before the end of each traverse of the stylus. This action causes the stylus point to be raised before commencing the traverse and then lowered on to the stylus track, and again to be raised before leaving the track.

The stylus carrier arm is secured by two screws to a brush fed slip ring, and the latter is locked to the Keramot disc on the stylus shaft by three pinch screws ; the stylus arm is therefore adjustable relative to the stylus shaft. The use of this adjustment will be referred to when the shipping of the scale and the lining up of the recorder is described.

ELECTRICAL CIRCUITS.

33. GENERAL.

The electrical circuits of Recorder A/S 50 can conveniently be considered separately as follows :—

(*a*) The motor and heater circuit.
(*b*) The transmitter circuit.
(*c*) The hydrophone circuit.
(*d*) The amplifying and recording circuit.
(*e*) The auxiliary circuits.

These circuits are shown in Figure 1.

The motor and heater circuit, the transmitter circuit, and the hydrophone circuit, are all controlled by the three-pole single-way switch in the base of the recorder. No fuses are incorporated in the recorder, which is protected at the fuse box from which the mains supply to the recorder is taken.

34. MOTOR AND HEATER CIRCUIT.

The positive main passes through the three-pole single-way switch to one of the slip ring brushes of the transmitting contacts and thence to the positive motor terminal. Leads are taken to the field, governor, and heater circuits, and the negative from these circuits and the armature return direct to the negative main through the three-pole switch.

A 2-microfarad condenser (Pattern 6858) is connected between the negative lead and earth to prevent sparking between the make and break of the governor contacts causing interference in the amplifier.

The governor action is described in detail in paragraph 24.

35. TRANSMITTER CIRCUIT.

The positive lead from the mains is the same as for the positive lead to the motor circuit as far as one of the transmitting contact slip ring brush terminals. From this point the transmitter circuit passes through the transmitter contacts (when closed) to the other slip ring brush terminal, thence direct to the transmitter junction box, through the resistance therein, and then through the transmitter coils. The return lead comes back to the recorder, through the three-pole switch and back to the negative main.

A lead is taken from one of the transmitter leads to one side of a very small condenser (about 50 picofarads or 0·00005 microfarads), and the other side of this condenser is connected direct on to the grid terminal of the valve holder. When the transmitter circuit is made by the transmitter switch closing, the small condenser is charged up, and when the transmitter circuit breaks, the condenser discharges on to the grid of the valve. This causes a small synthetic signal to appear on the record and gives an indication of the exact position of the stylus when the transmitting circuit breaks. This information is required when lining up the scale and recorder.

The transmitter circuit is highly inductive and a 2-microfarad condenser is therefore connected across the transmitter switch contacts to minimise sparking at these contacts. This condenser (Pattern No. 6858) is housed behind the motor baseplate, and is conveniently connected across the transmitter circuit at the switch slip ring terminals.

36. MICROPHONE CIRCUIT.

The microphone circuit is a closed circuit partly outside and partly inside the recorder. The external part of the circuit is from one hydrophone terminal at the recorder down to one side of the battery housed in the hydrophone junction box, Pattern 9971A ; then from the other side of the battery through the microphone in the hydrophone and back through the junction box to the other hydrophone terminal at the recorder. The circuit inside the recorder is from one hydrophone terminal through the three-pole switch to one terminal of the primary of the input transformer, A/S 42. From the other terminal of the primary a lead goes direct to the other hydrophone terminal in the base of the recorder.

Thus the complete circuit passes through the battery, microphone, switch and primary of the input transformer, all in series.

37. AMPLIFIER CIRCUITS.

Amplification of the incoming signal is effected by a single valve amplifier incorporating a pentode valve, N.R.43 (Pattern 3704).

The filament, anode and auxiliary grid volts and grid bias are applied to the valve from the mains as follows. In a 220-volt recorder the filament is supplied from the positive mains terminal, through the switch, through a 600 ohm resistance (Pattern 1680), through the filament (resistance 13 ohms when hot), through a 200 ohm resistance (Pattern 1280), and back to the negative mains terminal through the three-pole switch. In the 110-volt recorder the respective resistance values are 300 ohms (Pattern 1296) and 75 ohms (Pattern 1207).

These values give voltage of 3·5 volts across the filament and a filament current of ·27 amps.

The anode and auxiliary grid voltages are 160 volts (= ·27 × 600) in the 220-volt recorder and 80 volts (= ·27 × 300) in the 110-volt recorder. These voltages are applied from the positive main (in the case of the anode through the primary of the output transformer) and are, in fact, the I.R. drop across the 600 ohms and 300 ohms resistance in the 220-volt and 110-volt recorders respectively. The characteristics of the N.R. 43 valve enable it to fulfil requirements in these recorders under the differing values of anode and auxiliary grid voltages mentioned above.

A variable grid bias can be applied by a lead from a sliding contact on the 75 ohm or 200 ohm resistance used as a potentiometer. The maximum grid bias in each case is 54 volts (= ·27 × 200) and 27 volts (= ·27 × 75) respectively and is in each case the I.R. drop across the whole of the 200 or 75 ohm resistance. The actual grid bias applied is the I.R. drop across that part of the resistance from the filament end to the sliding contact

38. AMPLIFYING CIRCUIT.

When the microphone vibrates to an echo the effective resistance of the microphone circuit is varied resulting in a variation of current through the primary of the input transformer, A/S 42. This induces an E M F. in the secondary of the transformer, across the terminals of which is placed a potentiometer This potentiometer can be set to three positions (excluding the "OFF" position), and in these positions one-ninth, one third or all of the voltage induced in the secondary of the transformer is applied to the grid of the valve. The potentiometer, therefore, acts as a sensitivity control operated by a small disc on the right-hand side of the recorder The three positions referred to above are marked respectively "MINIMUM," "MEDIUM" and "MAXIMUM."

When the voltage is applied to the grid of the valve an instantaneous change of current occurs in the anode circuit, of which, as noted above, the primary of the toroidal output transformer (Pattern 2164A) is a part

This change of current in the anode circuit induces a pulse in the secondary of the output transformer, the terminals of which are connected to the A.C. terminals of a Westinghouse rectifier (Pattern 6832).

39. RECORDING CIRCUIT.

The negative D.C. terminal of the rectifier is earthed direct to the body of the recorder whilst a lead from the positive D.C. terminal goes direct to the stylus brush and thence via the stylus slip ring to the stylus point. Consequently, when the induced current in the secondary of the output is rectified a D.C. pulse flows to the stylus point, through the paper and completes its circuit through earth on the tank under the paper. The paper is impregnated with a solution of potassium iodide and it is this pulse of current through the paper which liberates iodine and makes a record on the paper in the form of a small brown stain.

40. AUXILIARY CIRCUITS.

There are three auxiliary circuits supplied from a 9-volt dry battery secured in clips alongside the motor. These circuits are the electric pencil, the depth and time marker and the "fix" circuit. Each of these is fed from a positive point in the battery, the negative being earthed direct to the body of the recorder.

The Electric Pencil.—A positive lead from the battery is connected to a plug connection at the side of the recorder. The pencil lead is plugged on to this connection and the pencil is then able to make a permanent record on the paper in the same manner as the stylus.

The Depth and Time Marker Circuit.—From a positive terminal of the battery a lead is taken to one side of the time marker switch. From the other side of this switch the lead goes through a 1,000 ohm safety resistance to the slip ring brush of the depth marker. The circuit then goes through the slip ring and commutator of the depth marker to the commutator brush, from which a lead is taken to the stylus where the circuit is completed through the paper and on to the body of the recorder.

The 1,000 ohm safety resistance is inserted to protect the battery from a short circuit if the recorder should happen to be stopped with the time marker switch made, the depth marker commutator brush on a metal inset and the stylus on the paper.

The "Fix" Circuit.—A positive lead from the battery goes direct to one side of a push button "fix" switch on the side of the recorder, from the other side of which a lead is taken to the stylus. When the "fix" switch is pushed the stylus will make a continuous line during its passage across the paper, and the fix push therefore forms a ready means of marking the record at any specific desired moment.

For convenience the leads to the stylus from the rectifier and the depth and time marker are commoned on one side of the fix switch whence a single lead is taken through to the front of the recorder and connected to the stylus slip ring brush

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CHAPTER V—OPERATION.

41. TO OPERATE THE SET.

Warning.

(i) Make certain that the transmission contacts are lined up correctly.
(ii) Do not operate the gear change unit unless the recorder is running.
(iii) The phasing gear should normally only be operated when the recorder is running, but if it should be operated when stopped the phasing disc MUST be turned in a clockwise direction.

(*a*) Make the main 3-pole single way switch
(*b*) Open the front cover and turn the right-hand knurled knob until stylus pen is traversing fresh (*i.e.*, moist) paper drawn from tank. Close front cover.
(*c*) Sharply rotate the gear change control knob to engage low speed (when "FATHOMS × 10" will appear in window) and confirm that the figure 0 is showing above the centre of the scale on the phasing disc.
(*d*) Pull out the paper speed control knob to give slow paper speed.
(*e*) Adjust sensitivity control knob until echo trace can be most clearly seen.
(*f*) Read off depth from *black scale* and *multiply by* 10.

When Soundings in Greater Detail and Accuracy are required.

(*g*) Sharply rotate the gear change control knob to engage high speed (when "FATHOMS" will appear in the window).
(*h*) If in less than 20 fathoms, adjust sensitivity control as required and read depth off *glass* scale with figure 0 showing above the centre of the scale on the phasing disc.
(*j*) If the sounding, as shown by operation at low speed, was *over* 20 fathoms, the phasing knob must be simultaneously pressed in hard and turned *clockwise* until the figure showing above the centre of the scale on the phasing disc, namely either 20, 40, 60 or 80, is the nearest one *below* the expected sounding.
(*k*) Adjust sensitivity control as required and read off the black scale *adding* the figure shown above the scale. The total of these two readings is the depth.
(*l*) If the echo-trace goes off the paper at either end of the scale, rotate the phasing control knob as before in a *clockwise* direction until the echo re-appears and read depth as before.
(Following the above sequence of operations (*a*) to (*l*) on every occasion will ensure that a "second" or "double" echo is not accidentally taken for a true sounding).

To Read "Soundings to the Surface."

The soundings measured by the methods so far described are all "Soundings below the Keel" because the recorder has been measuring the time between the sound leaving the ship and its echo returning to the ship The sound impulses leave from and return to the transmitter and hydrophone tanks which are in the bottom of the ship and at a distance below the surface approximately equal to the draught of the ship.

If it is required to read the recorder direct in "Soundings to the Surface," a correction must be added accordingly. This can be done automatically by so adjusting the recorder that the transmission leaves the ship when the stylus is opposite a point on the scale equal to the draught, instead of opposite the zero mark.

Separate settings of the transmission mark will be required for each stylus speed because, as previously explained, the scale is read differently for each speed.

42. TO FIT A NEW ROLL OF PAPER.

(*a*) Remove "used record" spool.
(*b*) Open tank and detach the empty paper holder from its cradle. Fit a new roll of paper freshly removed from its storage container. Each roll is supplied with its own ebonite centre tube. The ebonite tube and paper container are to be saved for salvage.
Place the new roll in the cradle *with paper feeding from the top of the roll*, and draw off about 18 inches of paper before closing the tank.
(*c*) Pull down the stirrup about ¼ inch and move backwards about ½ inch into the second pair of niches. The paper can now be rove between the two rollers. Replace the stirrup in the two forward niches, making sure that the paper lies centrally between the rollers.
(*d*) Insert the end of the paper, cut off square, into the slot in the used record spool; wind on a few times and replace the spool in position.

Note.—The paper should be led *under* the slotted used record spool.

43 TO REMOVE RECORD.

(*a*) Unship "used record" roller. Unscrew ends, noting the LEFT-HAND THREAD, and record, complete with spool, can be removed, after detaching it from the remaining unused paper.
(*b*) Turn the driving roller and feed out about 6 inches of the unused paper.
(*c*) Ship spare empty spool and insert the end of the paper (folded square) into the slot in the spool of the used record" roller. Turn the roller round a few turns until the paper is tightly secured. Ship the "used record" roller.
(*d*) If it is desired to preserve the record the paper should be dried after it is removed from the recorder. It should be dried against an electric fire and NOT against a coal fire.

CHAPTER VI.—CARE AND MAINTENANCE.

ELECTRICAL TESTS.

44. TO MEASURE THE INSULATION RESISTANCE AND CONTINUITY OF THE ELECTRICAL CIRCUITS. (Figure 1.)

(*a*) Transmitter Circuit.

Put main switch to "OFF." Disconnect the two leads to terminals marked "Transmitter + and —."

(i) Test for continuity between the two leads.

(ii) Test insulation between both leads and earth. This should be at least 2 megohms.

(*b*) Hydrophone Circuit.

Put main switch to "OFF." Disconnect the two leads to terminals marked "Hydrophone + and —."

Test insulation between ends of leads (shorted) to earth. This should be at least 2 megohms.

Note.—It is most important that the megger voltage should not be applied unless the leads are shorted or severe damage to the microphone may result.

(*c*) Motor Circuit.

Disconnect the two leads at the motor terminal block and test the insulation between the motor terminals and earth. This should be at least 2 megohms.

(*d*) Transmitting Switch.

Disconnect the leads to the two slip-ring brush terminals, replace the two terminals and test insulation between the terminals and earth. This should be at least 2 megohms.

45. TO TEST THE RECTIFIER.

A rectifier may be tested as follows, using an ohmmeter, but NOT a megger. The rectifier terminals are marked :—

D.C. negative = brown.
D.C. positive = blue.
A.C. terminals = red and yellow.

Canadian made rectifiers have a different colour code as follows :—

Leads.	*British.*	*Canadian.*
Positive.	Blue.	Green.
Negative.	Brown.	Black.
A.C.	Yellow and red.	Yellow.

The mean forward resistance between each D.C. terminal and each A.C. terminal (*i.e.*, four readings) should not exceed 120 ohms, whilst the reverse resistances between these points should theoretically be infinity. In practice a reading of about 200,000 ohms may be obtained, but should any one be below 100,000 ohms the rectifier should be considered unserviceable.

TRANSMITTER. (Figure 3.)

IMPORTANT.—In all cases (other than for fitting a new spring and the adjustment thereof) where it is necessary to open up the transmitter, the whole assembly should be detached from the transmitter tank and removed to a dry place. If this is not done, moisture may get into the coils and result in a subsequent burn out.

46. TO ADJUST THE SPRING.

This process is carried out with the transmitter in place:

Remove the watertight cap and the locking ring. Disconnect the short-circuiting link between the left-hand terminals in the transmitter junction box and insert the test resistance (112 ohms for 220-volt ship, 52 ohms for 110-volt ship).

Switch on the gear at the recorder and set the adjusting sleeve in such a position that a slight movement of the hammer can just be heard at the transmitter. The correct adjustment is most easily obtained by screwing down the adjusting sleeve until the hammer tapping ceases and then slacking back until it *just* recommences. Replace locking washer and cap. Disconnect the test resistance (which will probably be very hot) and replace the link in the junction box, taking great care that all connections are good and tight.

Properly adjusted, the spring is slightly compressed when the hammer is resting on the anvil, and owing to the difficulty in estimating this compression when the hammer is at rest it is necessary to resort to the above method.

This adjustment should only be carried out on first fitting a new transmitter or when it has been necessary to fit a new spring or any other transmitter component.

47. TO FIT A NEW SPRING.

(*a*) Remove cap.
(*b*) Remove locking ring and unscrew adjusting sleeve.
(*c*) Remove spring with finger, or, if broken far down, with a piece of bent wire.
(*d*) Screw gauge rod into top of hammer and ascertain that hammer has free travel. Check that travel of hammer is between 0·7 and 0·72 ins. by means of the adjustable scale nut on the gauge rod. (*See* Figure 4.)
(*e*) Insert new spring and set adjusting sleeve as described in paragraph 46.
(*f*) Replace locking ring and cap.

48. TO DETACH THE TRANSMITTER.

(*a*) Release pressure in tank.
(*b*) Detach the air-release pipe.
(*c*) Unscrew the cable gland nuts and withdraw brass sleeves, rubber washers, and ebonite bushes, by pulling out gently on the cab-tyre cables.
(*d*) Remove nuts securing transmitter to the tank (*i.e.*, the outer ring of nuts).
(*e*) Screw down the two forcing-off bolts *evenly* and the joint will be broken to enable the transmitter to be removed.

The forcing-off bolts are useful for slinging the transmitter whilst transporting.

49. TO FIT A NEW HAMMER.

(*a*) Detach transmitter and remove to a dry place.
(*b*) Unscrew casing nuts and remove casing, screwing down forcing-off screws *evenly*, if necessary.
(*c*) Disconnect leads from coils.
(*d*) Unscrew electro-magnet unit securing bolts and remove electro-magnet unit complete (comprising laminated core, coils and hammer guides). The hammer can now be removed.
(*e*) Thoroughly clean the hammer guides and serve with a small quantity of "Oil, Lubricating, for Heavy Dockyard Machinery" and fit new hammer, making certain that it moves freely in the guides. If it does not, the effect of fitting it the other way round should be tried. Make sure that the ball bearings on hammer revolve freely.
(*f*) Replace and bolt down electro-magnet unit. A guide pin is fitted on the bottom of the unit to prevent reassembly in a wrong position. Move the hammer up and down in the guides a few times to make sure it is still free.
(*g*) Connect leads to coils.
(*h*) Replace casing and bolt down, taking care that forcing-off screws are screwed back sufficiently.
(*j*) Replace transmitter on tank and bolt down taking care that the forcing-off bolts are screwed back sufficiently.
(*k*) Set adjusting sleeve for correct compression on spring as described in paragraph 46.

50. TO FIT NEW TRANSMITTER COILS. (Supplied in pairs.)

(*a*) Detach transmitter and remove to a dry place.
(*b*) Unscrew casing nuts and remove casing, screwing down forcing-off screws *evenly*, if necessary.
(*c*) Disconnect leads from coils.
(*d*) Unscrew electro-magnet unit securing bolts and remove electro-magnet unit complete (comprising laminated core, coils and hammer guides).

The hammer can now be removed.

(*e*) Remove the cheese-headed screws, having first marked both guide castings and laminated core to ensure correct reassembly.
(*f*) Disconnect the electric lead joining the coils.
(*g*) Remove wooden packing pieces and separate the guide castings from the laminated core.

Note.—For ease of manufacture the guide casting is made in two portions. These are accurately positioned on the laminated core by means of dowels which are a tight push fit in both casting and distance ring. (The distance ring is secured to the laminated core by screwed bushes.) The dowels (four in number) are not shown on the drawing. They should be very carefully driven out by a pin punch inserted in the ⅛-in. holes, which are drilled right through the laminated core and communicate with the tops of the dowels. (On *no* account should the guide castings be prised off the distance ring without first removing the dowels, otherwise damage will result.)

(*h*) The coils can now be slipped off.
(*j*) Having put on the new pair of coils, replaced the guide castings, and fitted the packing pieces, connect the coils in series and put them in series with a 50 c.p. carbon lamp across the ship's mains. If the coils are opposing each other a weak field will result, but if they have been connected correctly the magnetic pull will be strong.
(*k*) Proceed as for reassembly after fitting new hammer.

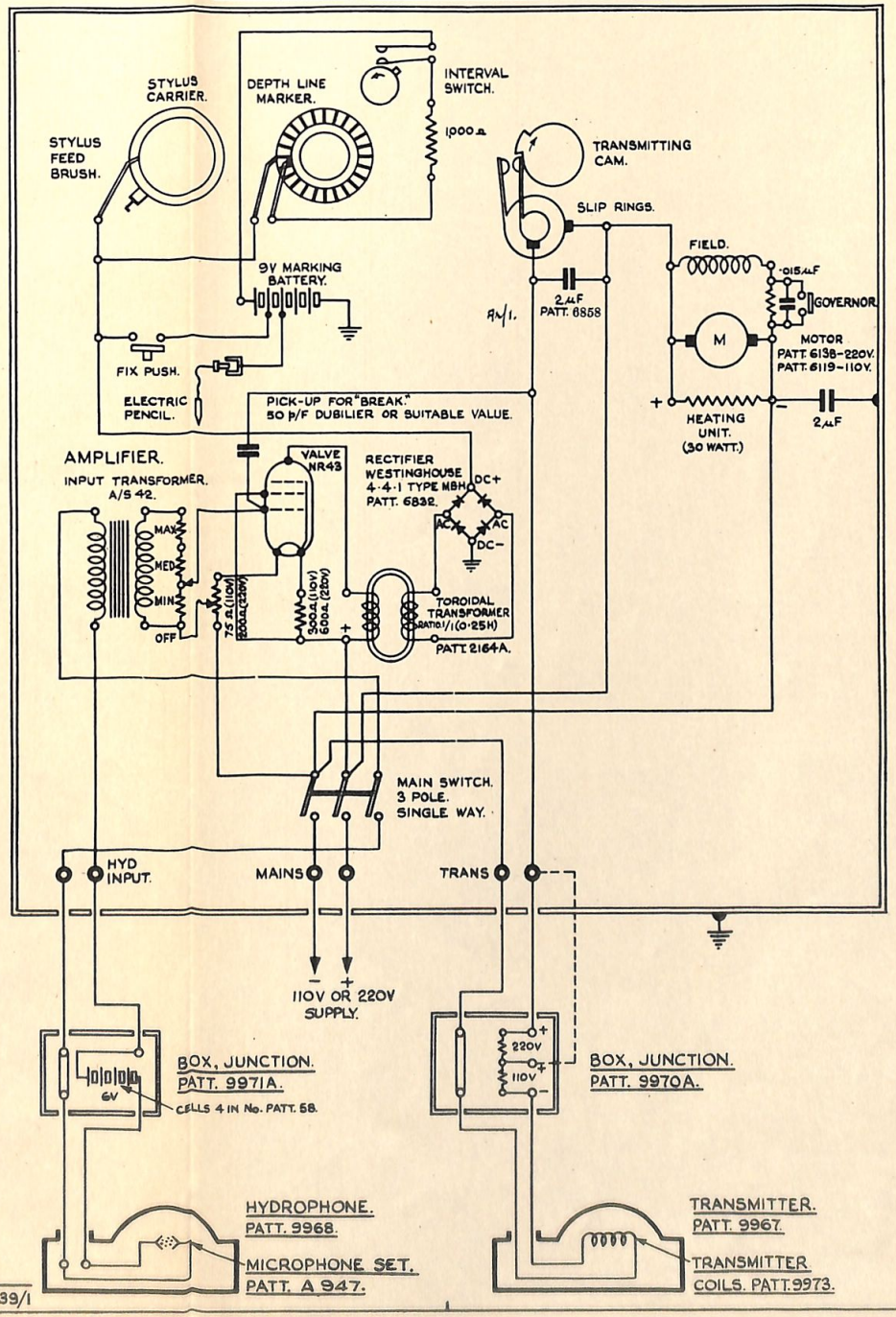
51. TO CHECK THE DYNAMIC LIFT OF THE HAMMER. (Figure 4.)

(*a*) Screw the gauge-rod and indicator into the hammer without altering the spring adjustment.
(*b*) Switch on the transmitter and by holding a pencil-point against the scale of the indicator verify that the lift of the hammer at each transmission is between ·5 and ·6 inches.
(*c*) If this is not so replace the spring. (Paragraph 47.)

TYPE 754 CIRCUIT DIAGRAM.

FIG.1.

RECORDER A/S 50. PATT. 5984 – 110V. PATT. 3612 – 220V.



DWG. No. A/S. 7639/1

C.B.H.20212

TYPICAL ARRANGEMENT. FIG.2.

ECHO SOUNDING GEAR TYPE 754.

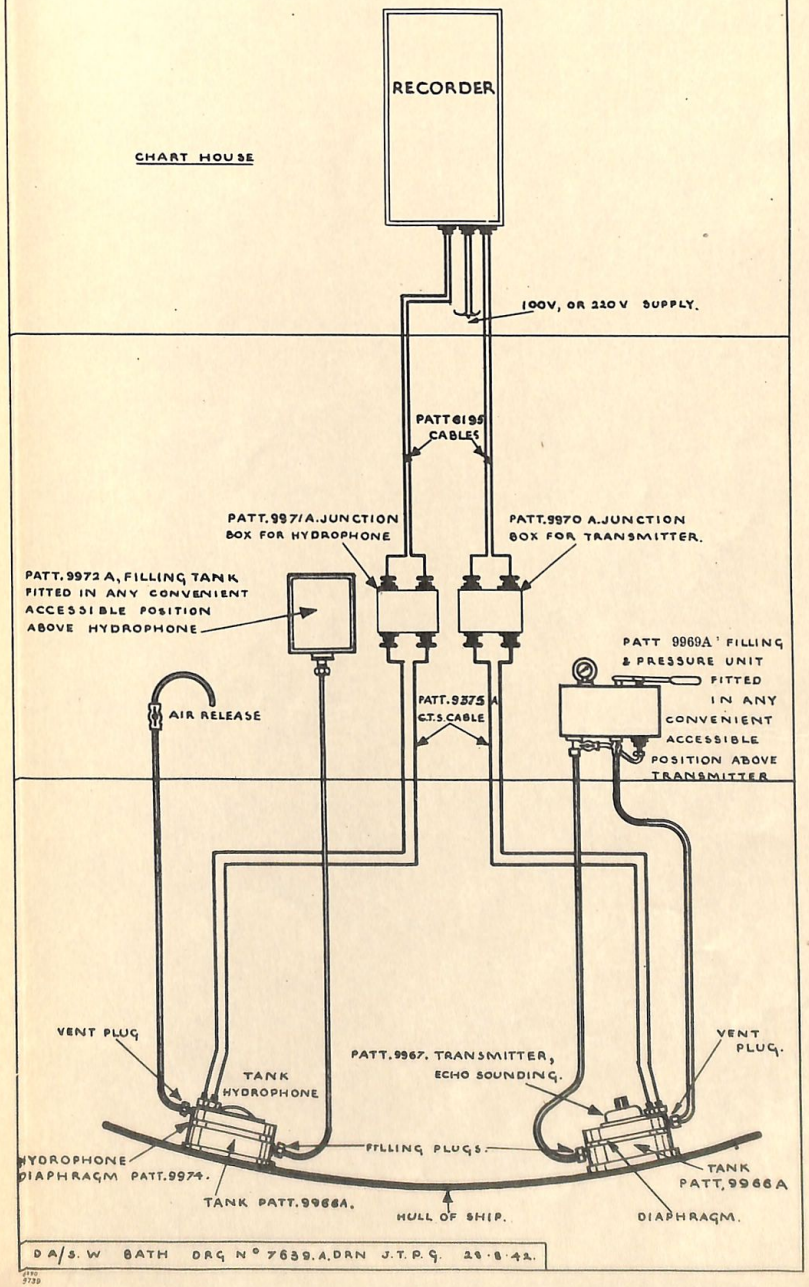
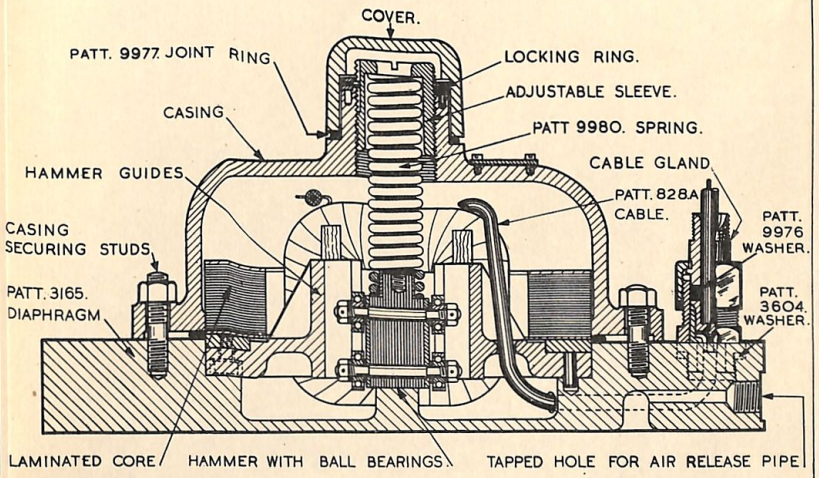
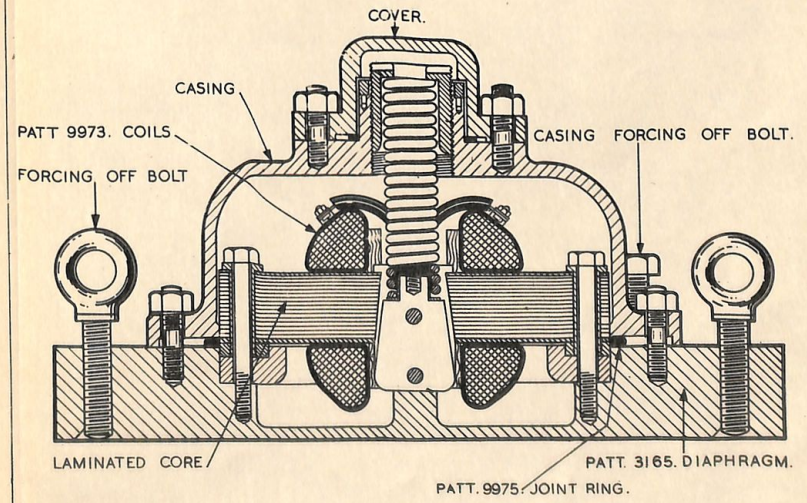


FIG. 3.

TRANSMITTER. A/S 2. PATT. 9967.



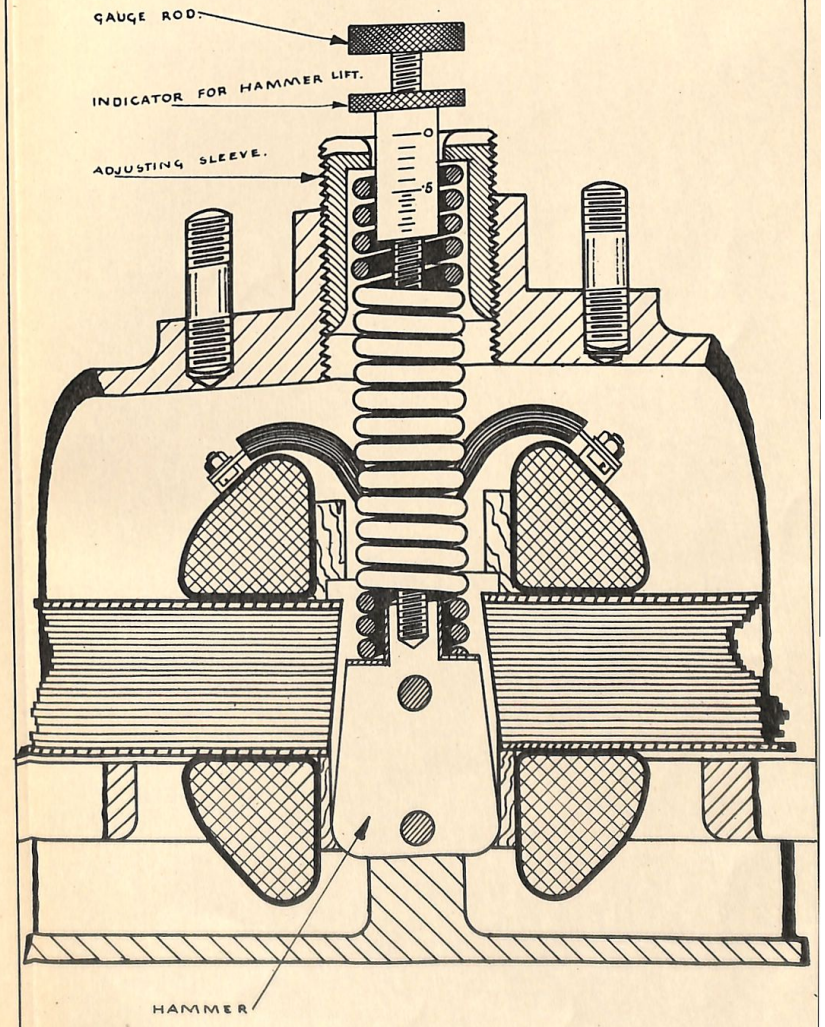


D. A/S. W. BATH. DRG Nº 7639B. TR. J.T.P.G.

FIG. 4.

MEASUREMENT OF HAMMER LIFT.

PART SECTION THROUGH TRANSMITTER.



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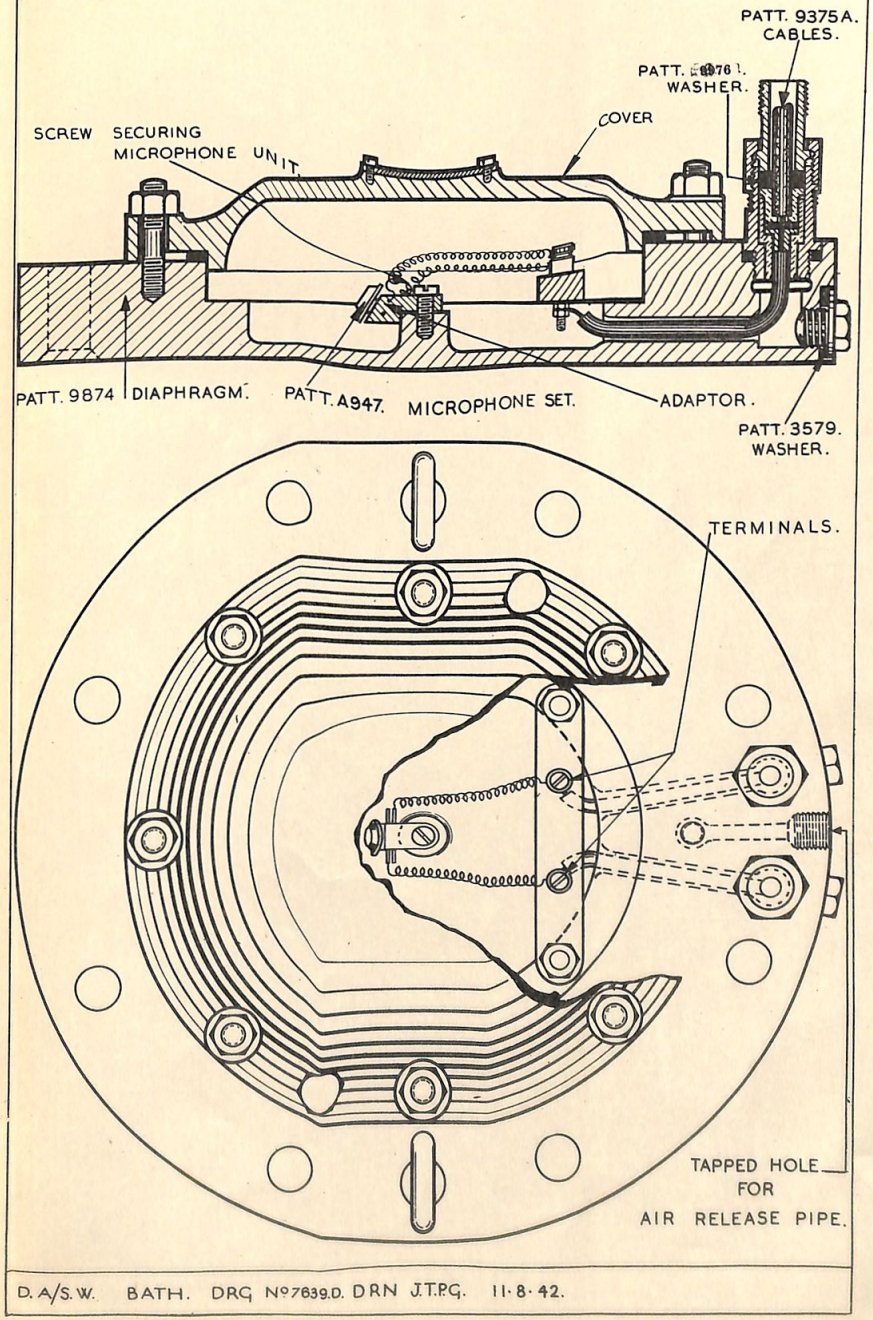
HYDROPHONE A/SI. FIG. 5.
PATT. 9968.



D. A/S. W. BATH. DRG No 7639.D. DRN J.T.P.G. 11·8·42.