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M.289.

W/T EQUIPMENT

OF

R.M.S. "QUEEN MARY"

H.M. Signal School,
Portsmouth.

August, 1936.

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1. INTRODUCTION. The information given in this report was obtained during a visit to "QUEEN MARY" at Southampton by Signal School officers on 16/6/36.

The equipment was provided and fitted by The International Marine Radio Co., Ltd. The principal points of interest claimed by the Company for the installation are:-

(i) Multiplex working. It is claimed that eight lines of communication, four in and four out, can be operated simultaneously and

(ii) Instantaneous wave change. A very quick wave change device operated by dials in a manner similar to the automatic telephone is fitted.

The frequencies and types of transmission used are as follows:-

Frequency. kc/s.	Wavelength. metres.	Type of Transmission.	Remarks.
111.5	2,690	C.W.	L/F hand or auto-morse transmissions to long distance shore and ship stations.
125	2,400	C.W.	
136.3	2,200	C.W.	
139.6	2,150	C.W.	
142.8	2,100	C.W.	
149	2,013	C.W.	
155.9	1,925	C.W.	
375	800	M.C.W.	M/F hand morse transmissions to short distance shore or ship stations.
411	730	M.C.W.	
425	705	M.C.W.	
473	635	M.C.W.	
500	600	M.C.W.	
8,254	36.35	C.W.	H/F hand or auto-morse transmisdons to long distance shore stations.
8,305	36.12	C.W.	
8,490	35.34	C.W.	
8,800	34.09	C.W.	
11,020	27.22	C.W.	
12,384	24.22	C.W.	
12,470	24.06	C.W.	
13,350	22.47	C.W.	
16,470	18.21	C.W.	
8,830	33.98	R/T	Radio-Telephony to shore stations or broadcasting.
8,860	33.86	R/T	
13,210	22.71	R/T	
13,320	22.52	R/T	
17,600	17.05	R/T	
17,640	17.01	R/T	

The receiving frequencies for duplex working may differ from the above but are all in the same groups of frequency

bands. In addition there is reception of Rugby L/F and other news broadcasts and a separate receiver is installed for the B.B.C. broadcasts from Droitwich.

2. POWER SUPPLY. The power supply for the entire W/T installation is provided by a protected type motor-driven alternator, 35 kW., 220 volts, 3 phase, 50 cycles, which is duplicated. The machines, together with their remote controlled auto-starters, are fitted in a compartment on E deck, near the engine room.

The power board, which contains the generating plant controls, Brown-Boveri auto-voltage control regulator and distributing board supplying the different transmitters and the Receiving Room, is fitted in the Transmitter Room.

The auto-voltage control was not in use because the regulation of the machine was sufficiently good without it for transmitting work and special devices were fitted in the rectified supply to each receiver.

It would appear that the machine was not designed to work with auto-voltage control apparatus since too good a regulation sometimes causes a tendency to hunt with auto-voltage control apparatus.

When all sets are in operation the total load taken from the machine was stated to be 21 kW.

3. GENERAL ARRANGEMENT. In order to allow of multiplex working, the principle of separated offices has been adopted.

The Transmitter Room, which contains the four main transmitters, one L/F, one M/F and two H/F, is situated on the after part of the Sun Deck, just forward of the mainmast.

The control gear for the transmitters and the telephone terminal equipment is fitted in the Receiving Room, which is situated two decks below the top of the superstructure in a position between the forward and second funnel. The whole office is entirely lined with copper which is connected to the ship's structure at only one point. Such importance is attached to this arrangement that an alarm circuit is provided, which rings a bell if accidental contact is made between the copper lining and the hull at any other point. Earth connections from the various receivers and associated apparatus are made to the nearest point on the copper lining.

The office has no definite silent lining but it is to be noted that the materials used in the fitting out of the ship are such that the general noise level is low. There can be no comparison between the "QUEEN MARY'S" office, surrounded by wood panelled and rubber decked compartments with the W/T offices in H.M. Ships, which are often surrounded by spaces with bare steel decks and bulkheads.

There is provision for four operators and, in general, for four simultaneous lines of reception. The receivers available are:-

2 H/F 1 M/F 2 H/F		2 operators.
2 M/F		1 operator.
2 L/F		1 operator.

Simultaneous reception with two or more receivers can be used on the M/F or L/F aerials. Each H/F receiver is given a separate aerial.

Automatic reception can be used on any one line of communication by means of a Creed Undulator.

R/T can be used on all four H/F receivers, and terminal equipment is provided for two simultaneous two-way telephone channels through the ship's telephone exchange.

All four operators are provided with typewriters for recording morse reception.

There is no provision for quick wave changing in the receivers but operators can switch over instantaneously from one receiver to another.

4. CONTROL OF TRANSMITTERS FROM RECEIVING ROOM. Each of the four lines of reception is associated with one of the ship's transmitters and the operator working the receivers has full control of his own transmitter.

The operator can change the wave of his transmitter to any of the spot waves by dialling the number allotted to the wave and a repeater shows him when the change is completed.

On the H/F waves frequency changing is accomplished by switching over entirely from one quartz master oscillator and set of tuned circuits to another by means of contactors.

On M/F and L/F waves dialling a new frequency changes the tapping points on the various inductances in the transmitter. The operator can then make a final adjustment in the frequency, up to 2 kc/s, by means of a tuning dial which remotely controls a variometer in the master stage of the transmitter through servo motor gearing.

Each of the operators has a hand key for operating his transmitter, or alternatively there are two Creed

automatic transmitters, each with its keyboard perforator, which can be used for automatic transmission on any two of the transmitters.

The controls for R/T are described on pages 10 and 11.

5. MAIN W/T TRANSMITTERS. The Transmitter Room is situated on the after part of the Sun Deck, just forward of the mainmast. It contains the four main transmitters.

One	L/F	160 - 110 kc/s.	(1875 - 2725 m.)
One	M/F	500 - 375 kc/s.	(600 - 800 m.)
Two	H/F	17,650 - 3,125 kc/s.	(17 - 96 m.)

The transmitters are fitted on opposite sides of the room thus forming a central gangway with the power board at one end and at the other a motor-driven alternator to provide the modulation frequency for the M/F transmitter. They are bolted down on solid rubber balls to reduce the effects of vibration, which was said to be rather severe when going full speed ahead or when going astern.

All the transmitters are completely enclosed in solid covers fitted with glass windows opposite valves and instruments. Hinged doors, with power cut off safety switches, are fitted in front and access can also be obtained from the back by unbolting the back covers. The frameworks and covers are of steel, finished in a bluish colour.

Very liberal space is allowed inside the cubicles, so that coils carrying high frequency currents can be kept well away from the metal work, thus reducing the eddy current losses.

L/F and M/F Transmitters. These are single stage master controlled sets and are essentially the same in design. They are tuned to the twelve spot frequencies specified on page 1.

The rectifier has three mercury vapour valves fed from a three phase transformer, the primary of which can be connected in star or delta to give 1400 or 2400 H.T. voltage. The total H.T. input power was stated to be 7 kW. and the aerial output power was estimated to be 2½ kW.

The rectifying panel carries the full complement of delay switches to prevent H.T. being applied before the cathodes have reached their saturation temperature. The cathodes are normally kept at about half voltage so that the delay in starting up after dialling from the Receiving Room is of the order of 4 minutes. A new valve, starting cold, requires ½-hour. A spare valve with its cathode maintained at about half voltage is mounted in the panel and can be linked into the circuit if any of the other three valves should become defective. These valves

have perforated rings mounted at top and bottom through which cooling air can be blown should their temperature rise sufficiently to trip a thermal relay. This feature is a desirable one to prevent arc back should the vapour pressure rise too high. No special provision is made, however, to keep their vapour pressure constant.

The same type of triode valve is used for the master circuit, which takes about 1 kW. H.T. input, as for the power amplifier, where three valves in parallel are used. The master circuit is of the Hartley type. The power amplifier is of the tuned anode circuit type, the aerial and anodes of the valves being directly tapped into the coil. Both the master and the aerial coil are wound single layer with solid copper wire. Brushes, driven by a motor, rotate round this coil and short circuit portions for remote wave changing from the Receiving Room. The motors are controlled by a dial switch and lock in a corresponding series of positions. A small variometer is provided for fine tuning. This is remotely controlled through servo motor gearing by means of a tuning dial in the Receiving Room.

The coils described have a second advantage in that single layer coils wound with solid wire have considerably less losses than a multi-layer coil (or even a single layer coil) wound with finely stranded wire especially if the correct spacing relationship is maintained. Space considerations limit their use for Naval designs.

The transmitters are capable of high speed keying which has been used up to a speed of about 100 w.p.m. The key, which is of the Creed type, is connected directly into the grid of the master valve. No absorbing circuits are fitted but it is possible that the power amplifier acts as a partial absorber.

In the medium wave transmitter a special modulation transformer is connected into the rectified supply lead to the power amplifier valves and the primary connected to the modulation frequency alternator.

H/F Transmitters. The two H/F transmitters are similar in design, each operating on 10 crystal spot waves and between them covering frequencies from 3125 - 17,650 kc/s. Eleven of the waves are used for telegraphy and nine for telephony. For privacy reasons, speech is inverted before applying it to the transmitters. As, however, privacy can be broken by beating the received speech with a 3,000 cycle oscillator, it has been arranged to wobble the carried frequency by approximately 1,000 cycles/sec. A small variable condenser is connected across the crystal and rotated by a motor, thus varying the crystal controlled frequency by a small amount.

Two way speech is controlled by voice operated relays. The system is the same as that used in the G.P.O. transmitters at Rugby. The delay was said to be set for about 40 milli-seconds. Speech is normally controlled from

the receiving end but an additional alternator and modulation meter is fitted to the transmitter.

It is believed that these H/F transmitters are identical to some seen at the Western Electric Company's works in U.S.A. In these sets the H.T. supply was automatically cut off from the valves after a predetermined interval if there were no further speech and at another interval the cathode supply was cut off. In addition, part of the speech was reflexed through the transmitter in the correct phase to reduce distortion owing to non linear valve characteristics. The operator stated that 100% speech modulation could be used with very little harmonic distortion which makes one suspect that this reflexing is employed in the "QUEEN MARY" set although the operating engineer did not appear to be aware of it.

The transmitters have 5 stages, namely the crystal oscillator which uses zero frequency/temperature coefficient cut crystals (believed to be the × cut at angle to optic axis), a first amplifier or frequency doubler where necessary, a second amplifier or frequency doubler if necessary, a third amplifier to which speech is applied and the power output stage. The ten crystal circuits are mounted in a box atthe bottom of the cubicle and screened from each other. The ten first amplifier tuned circuits are mounted in a second box which slides into a rack above the crystal unit. These ten circuits are also screened from each other. This formation applies throughout. At the back of the cubicle there are ten vertical rods carrying switches each of which connects up all the stages of one channel to the valves. The rods are operated by a large A.C. relay and a lever rod. On dialling a channel number a small relay makes the corresponding rod clutch and the large relay then operates the rod. The supplies are made at the same time but a delay of about 35 seconds occurs before the H.T. is switched on to the mercury vapour rectifying valves. There are three sets of these rectifying 2,400 volts for the power valves, 800 volts for some of the earlier stages and 200 volts for grid bias.

The individual circuits are all of the plug-in type and consist of a coil wound on a grooved isolantite former which is rotatable and, fixed on the same base, a semi-adjustable air condenser. A rod bridge carries a wheel contact which presses on the coil wire so that rotation of the coil former varies the inductance. The only difficulties experienced with the transmitter were due to the short life of the modulating valve. One coil former had also cracked and additional smoothing had to be added to eliminate ripple of which the B.B.C. complained. Dummy aerial circuits are provided to enable the adjustments to be made without radiating power. It is understood that in one of these

transmitters the aerial is inductively and the other capacity coupled to the primary circuit.

Very great difficulties had been experienced by cross modulation of the long and short wave transmitters through their aerials. This was finally reduced by fitting condensers presenting a large impedance at low frequencies in series with the H/F aerials and a fixed rejector type circuit in series with the L/F aerials. It is thought that this circuit consists of a coil in series with the aerial and shunted to earth by a fixed condenser which presents a high impedance to the medium frequencies.

6. AERIALS AND TRUNKS. The general arrangement of the aerials is shown in Fig.1.

(a) Transmitting Aerials and Trunks. Each of the main transmitters has its own aerial.

The L/F and M/F aerials are slung between the masts and consist of two phosphor-bronze wires spaced 12-ft. apart. As will be seen from Fig.1, the aerials are in tandem but are separated by insulators.

The L/F aerial is of inverted L shape, the roof being approximately 400-ft. long. The roof of the M/F aerial, which is T shaped, is 60-ft. long. A standard type of transmission line suspension insulator, with the porcelain in compression, is used but was stated to be unsatisfactory. The cause of trouble was stated to be spray but from past experience with this type of insulator it is considered that it is probably brushing at the pins.

One H/F aerial is of the inverted V type, consisting of two wires run one to each end of the yard and thence to the stern. The second H/F aerial consists of twin wires running one to each side of the after funnel. The former was stated to give an increase in field strength of 6 decibels in the fore and aft direction over that athwartships and is thus directional to London and New York on passage. Twin wires were found to be necessary because it was found that the unsymmetrical disposition of a single wire aerial of this type moved the axis of the beam 8° away from the fore and aft line of the ship.

The aerials are lead up to the upper deck through 18-inch square steel trunks, the central conductors being 12 guage solid wire, supported at intervals by pillar insulators on the side of the trunk. The H/F trunks carry two conductors so that dipole aerials can be used, if desired.

As the Transmitter Room is immediately below the feet of the aerials, the trunks are merely protecting tubes about 8-ft. in length.

(b) Receiving Aerials. There are seven separate aerials available for reception as follows:-

1 Dipole for 17 mc/s band.
2 Quadripole for 8 - 13 mc/s band.
2 Open wires for M/F.
1 Long open wire for L/F.
1 Open wire - emergency either transmission or reception.

As will be seen from Fig.1, six out of the seven receiving aerials are supported to and between the forward and second funnel. The L/F receiving aerial is extended aft to the third funnel casing to give greater pick up.

The 17 mc/s dipole aerial consists of two horizontal quarter waves placed athwartships and the lead down to the receiving trunk is by means of a pair of transmission lines spaced about 9-inches by teak spacers. These lines are not crossed. The quadripole aerials for 13 - 8 mc/s consist of one 13 mc/s quarter wave and one 8 mc/s quarter wave connected to the termination of each feeder and placed diagonally with respect to the fore and aft direction. The feeders are similar to the 17 mc/s. transmission line.

The M/F and L/F aerials are open wires stretched from the receiving trunk to the funnels.

The aerials are directional to London and New York when on passage.

The use of teak insulators in the transmission line feeders is of interest. It was stated that considerable difficulties had been experienced with ceramic and glass insulators owing to moisture condensing on them, and that teak, owing to its poor heat conducting properties and somewhat oily surface, gave much better results.

7. RECEIVING AERIAL TERMINATIONS AND FEEDERS TO RECEIVING ROOM. The aerials are led to the Receiving Room through a vertical trunk about 25-ft. long and 3-ft. × 1-ft. section. Each aerial is led down through a feeder having a central copper conductor, a concentric copper return and a lead sheathing. The lead sheathing is in contact with the outer copper conductor internally and with the ship's structure externally.

The method adopted for connecting the aerials to the feeders was stated to be the result of a large amount of experimental work directed to reducing the amount of interference from the ship's own transmitters. It was stated

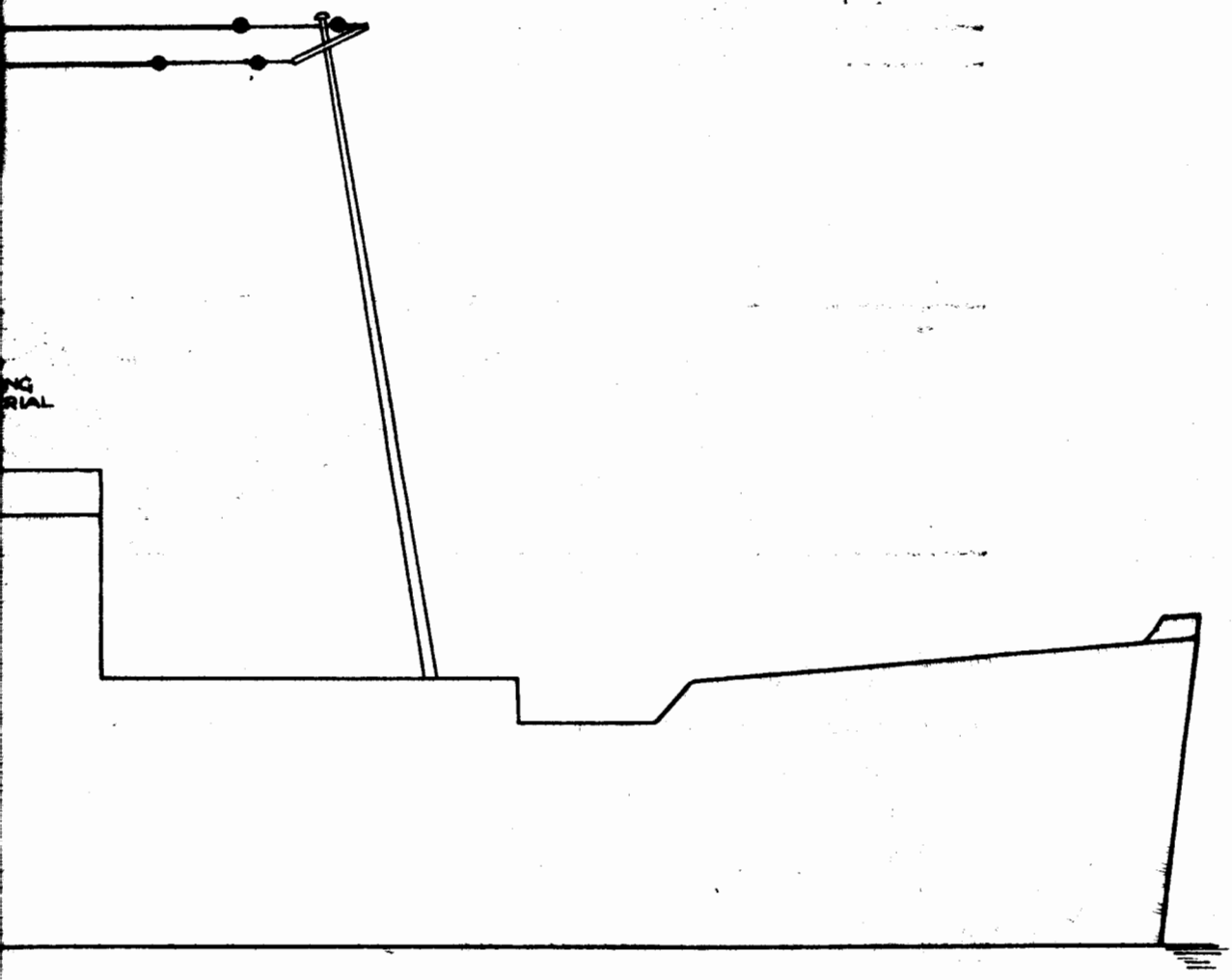
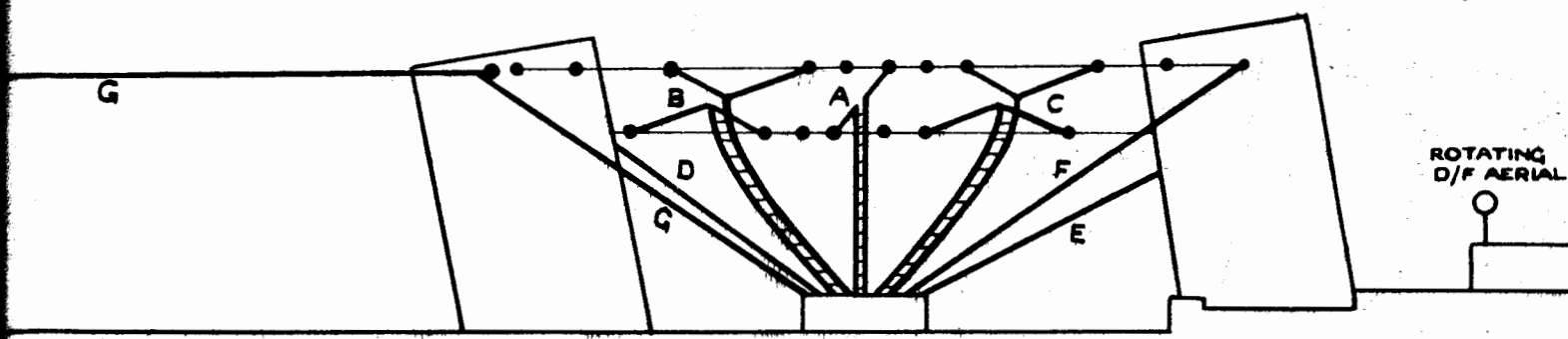


FIG. 1.

R.M.S. "QUEEN MARY."

W/T AERIAL RIG.

L/F AERIAL



c/s DIPOLE.

MC/S QUADRIPOLE.

MC/S QUADRIPOLE.

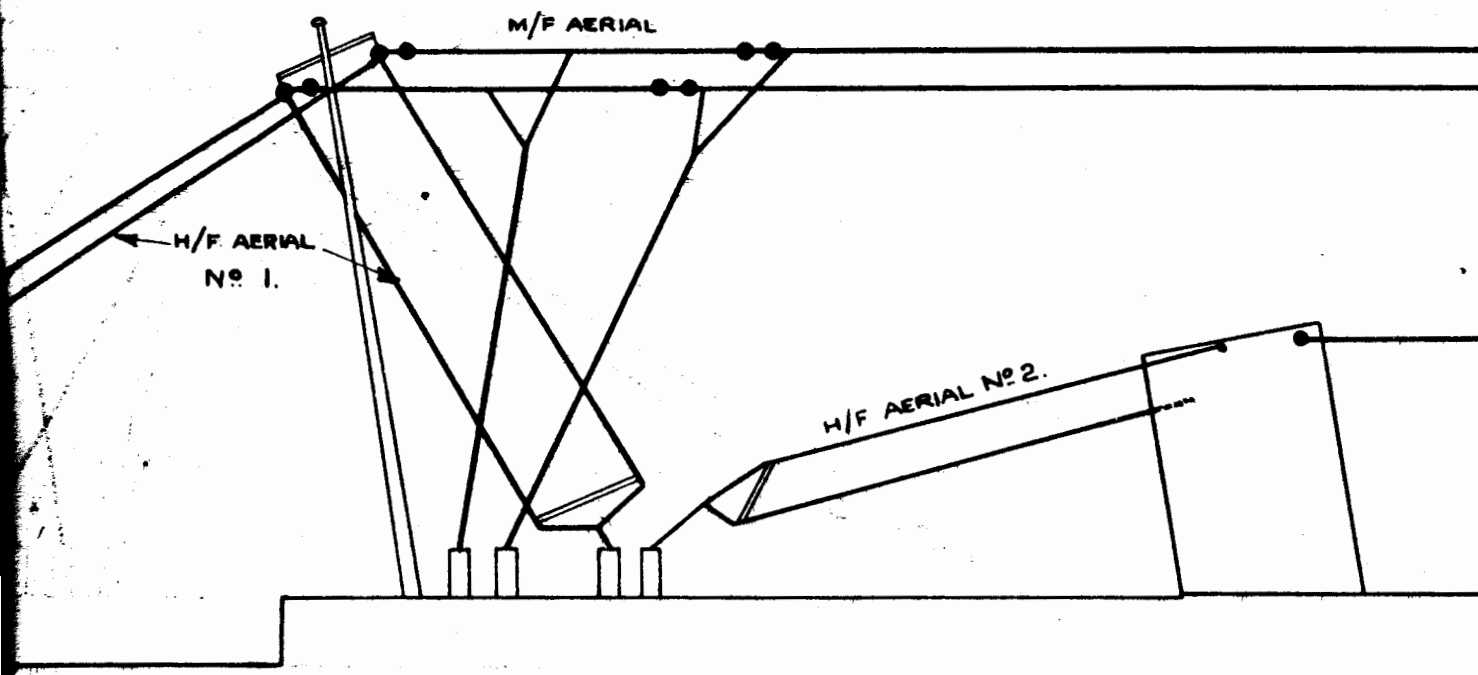
D. 500 Kc/S OPEN AERIAL.

E. 500 Kc/S OPEN AERIAL.

F. EMERGENCY AERIAL.

G. 125 Kc/S OPEN AERIAL.

NOT TO SCALE.

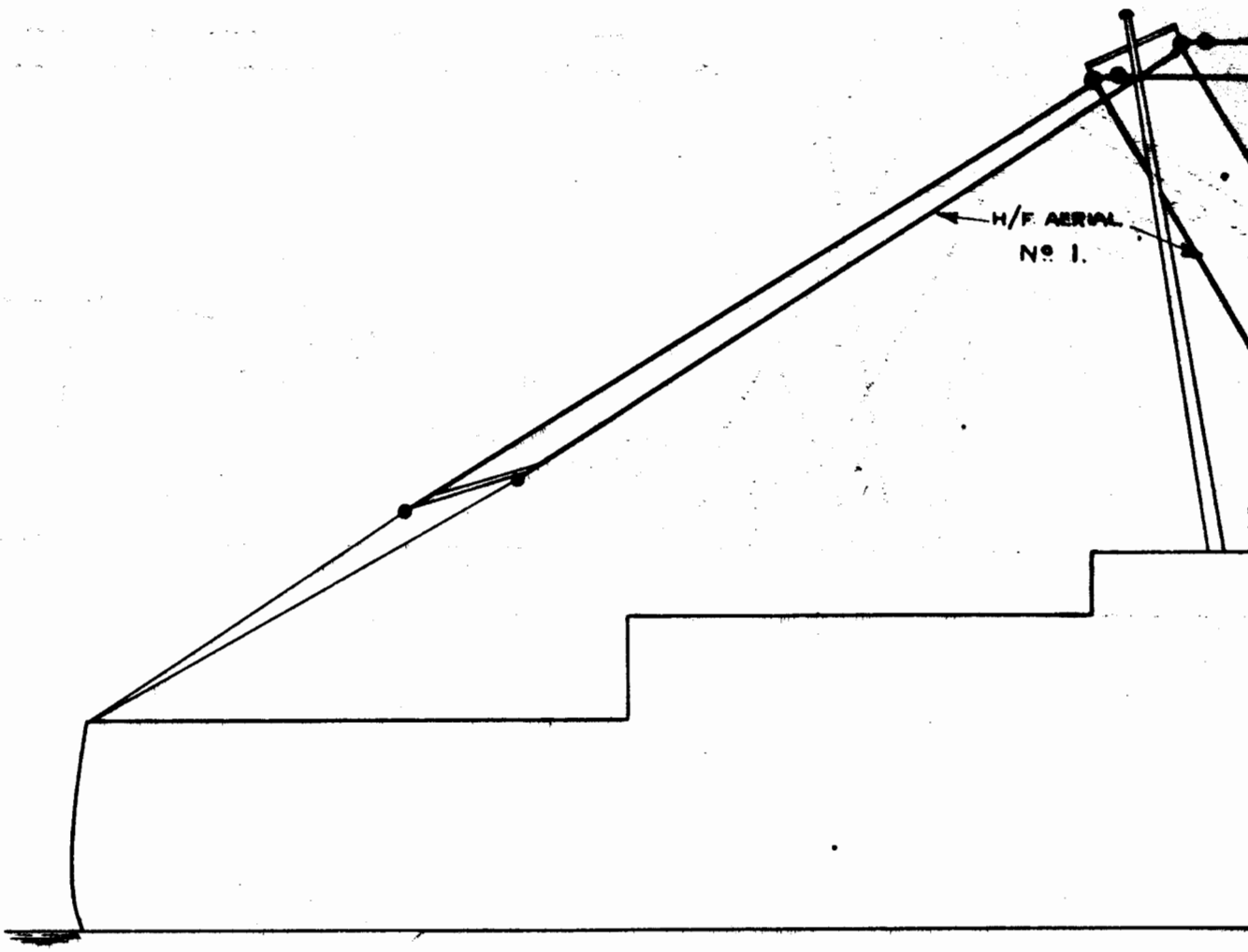


A. 17 MC

B. 13 - 8

C. 13 - 8

10/54 AP.


H/F AERIAL
No. 1.

CIRCUITS TO OVERCOME INTERFERENCE FROM OWN TRANSMITTERS WHEN RECEIVING ON L/F AERIAL.

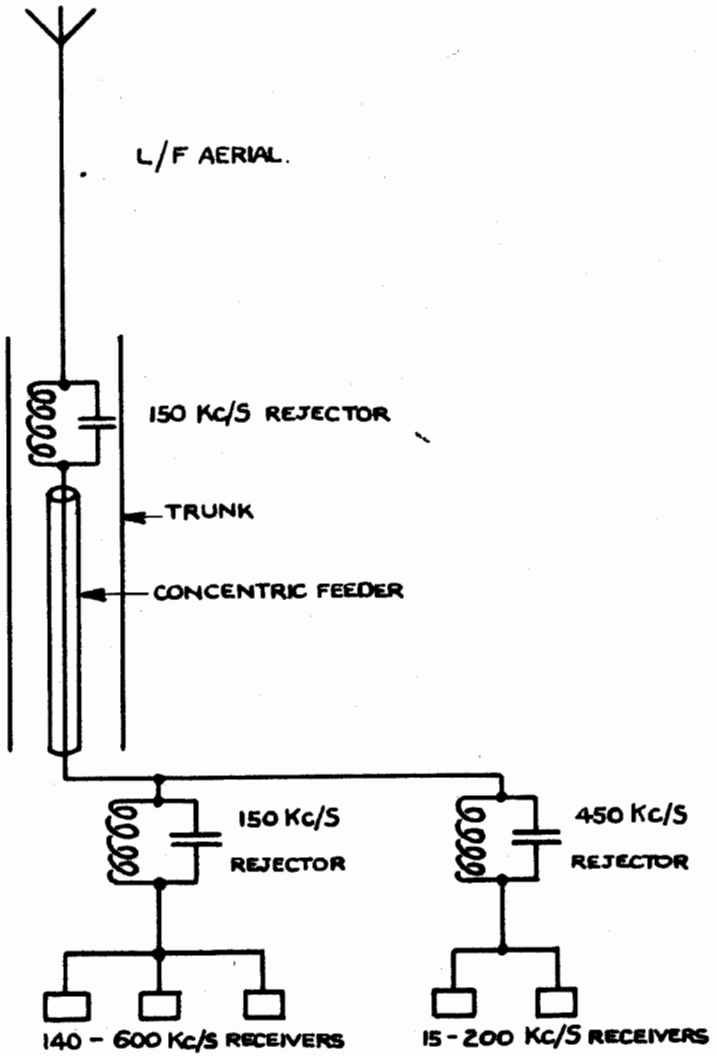


FIG. 2.

AERIAL TRANSFORMER CIRCUITS FITTED WITH H/F AERIALS.

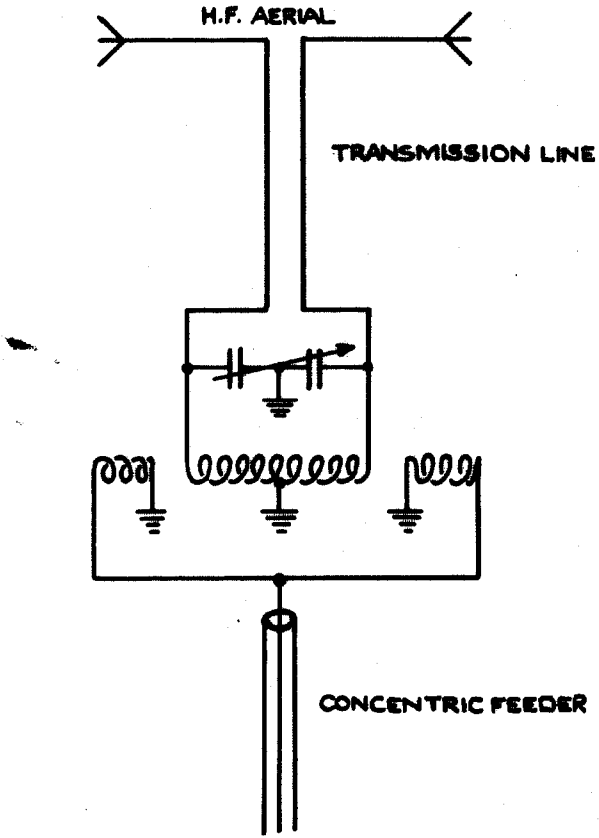


FIG. 3.

SIGNAL SCHOOL, PORTSMOUTH. DRG. Nº. M289/2. TR. D.M. 22.8.36. CH. J.A.B 25/8/36 AP.

that potentials up to 800 volts were measured at the foot of the L/F receiving aerial when the ship's main transmitter was working. The effect of this potential was reduced by connecting a rejector circuit tuned to 150 kc/s between the aerial and the feeder, as shown in Fig.2. This resulted in a large reduction in efficiency when receiving on this frequency which is equivalent to a reduction of the size of the aerial but was not very material since the long aerial is required for reception on the longer waves, e.g., Rugby.

The M/F aerials are apparently connected directly to the concentric feeders leading to the Receiving Rooms. The junctions between the H/F aerial transmission lines and the concentric feeders are through transformers tuned to the frequency band for which the aerial is intended, as shown in Fig.3. This arrangement with earthed centre point does much to cut out the pick up from the vertical feeders, besides giving H/F selectivity. Furthermore, the transformer gives an efficient coupling between the aerial transmission line with an estimated surge impedance of 500 ohms and the concentric feeder with a surge impedance stated to be 70 - 100 ohms.

The L/F rejector circuit and H/F transformers are housed in the top of the receiving trunk.

8. AERIAL EXCHANGE. The seven downcoming concentric aerial feeders are terminated in the Receiving Room at jacks in the aerial exchange. Similar jacks are connected to concentric leads to the individual receivers and connections between pairs of jacks are made by flexible concentric leads with plugs. This gives screened aerial leads right through to the receivers.

9. PRESELECTORS AND RECEIVERS.

(a) L/F and M/F. When using a common aerial, the L/F and M/F receivers are grouped as shown in Fig.2, with rejector circuits in the aerial leads. Each receiver has a "Preselector" associated with it. These preselectors are simply 3-stage tuners with small capacity couplings between the circuits as shown in Fig.4. The receivers have two stages of R/F amplification, separate heterodyne detector and A/F stages. 1,000 cycles note filters are available for auto reception.
The L/F receivers cover a range of 15 - 180 kc/s.
The M/F receivers cover a range of 100 - 600 kc/s.

(b) H/F. As in the case of M/F and L/F the preselectors are merely tuners which can be introduced in front of the receivers, but for H/F the preselector has the additional function of balancing out, both in amplitude and phase, any vertical aerial component from the dipole feeders. These balance adjustments are called "Noise Balance Resistance" and "Noise Balance Capacity" on the diagram of the preselector given in Fig.5.

The H/F receivers cover a range of 550 to

22,000 kc/s with five sets of plug-in coils, each set consisting of three coils fixed on one base with appropriate plug connections. The receivers are of the super-heterodyne type having one R/F stage, 1st heterodyne and 1st detector with ganged tunings, two I/F stages, 2nd heterodyne, 2nd detector and output stage, also a valve operated A.V.C. system. The nine valves are all pentodes of various types.

The A.V.C. operates on the R/F and two I/F stages in the normal manner when R/T is being received. For morse reception a rectifier is switched in to the controlled G.B. line; this offers only a low resistance to the current charging the grid decoupling condensers when a signal comes on. Overloading is therefore instantaneously checked by negative bias applied to the amplifying valves. When the signal stops, however, the grid decoupling condensers have to discharge through the high reverse resistance of the rectifier and consequently the return of the amplifier to full sensitivity is slow and the noise level does not come up during the spacing of ordinary morse signals.

10. APPARATUS SPECIAL TO PUBLIC RADIO TELEPHONE SERVICE. A very large amount of subsidiary apparatus is required for the efficient working of a public radio telephone service between any subscriber on the ship's telephone exchange and any other subscriber on a network connected with the distant shore stations. The items of principal interest are:-

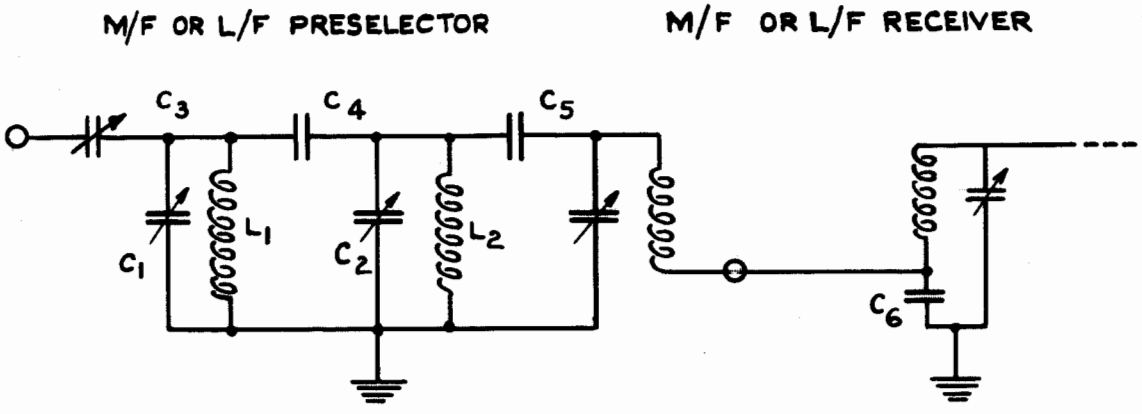
(a) Speech level indicator. This meter, attached to each pair of H/F receivers under one operator, is connected by a three position switch to indicate

(i) Incoming speech level from ship's subscriber, so that this may be amplified or attenuated to a suitable value to pass on to the modulator of the transmitter.

(ii) Modulation depth of ship's outgoing transmission.

(iii) Received radio speech level, so that amplification or attenuation may be adjusted to comfortable level for the local subscriber.

(b) Side band invertor and carrier wobbler. These are included in the circuit for secrecy of subscribers' transmissions. The width of side bands inverted is 3,000 cycles/sec. The carrier is wobbled 1,000 cycles/sec. about once every second. In reception of inverted side bands the incoming signal is amplified in the normal manner, after which the output is re-inverted.



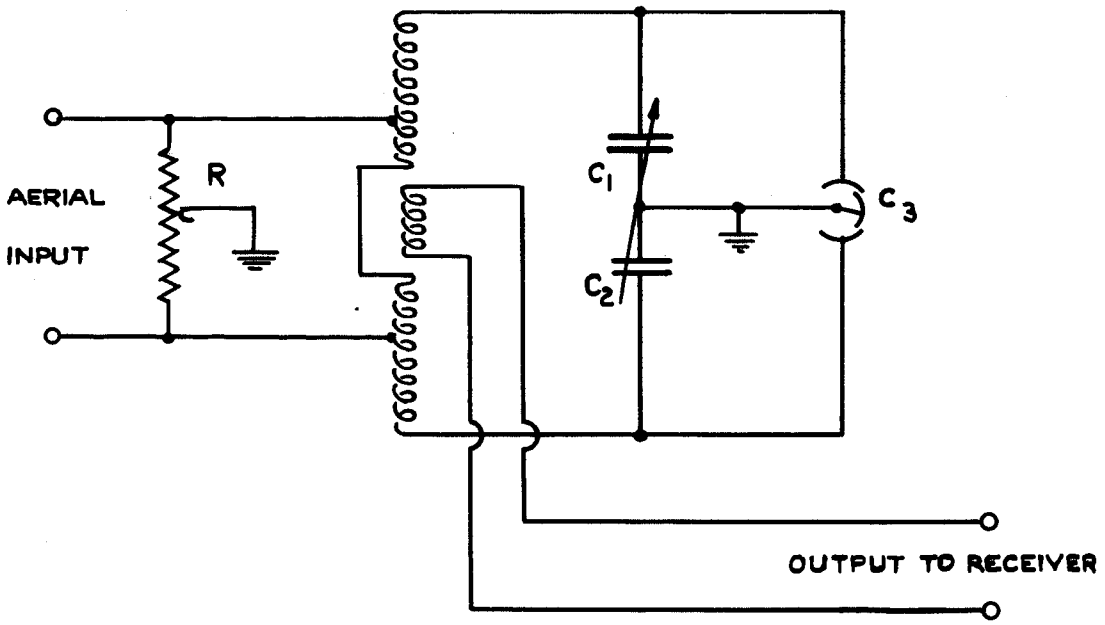
C_1, L_1, C_2, L_2 - TUNED CIRCUIT WITH SMALL $\frac{L}{C}$

C_3, C_4, C_5 - SMALL COUPLING CONDENSERS.

C_6 - LARGE CONDENSER GIVING SMALL COUPLING TO RECEIVER.

FIG. 4.

H/F PRESELECTOR



C_1, C_2 - BALANCED TUNING CONDENSER

C_3 - NOISE BALANCE CAPACITY.

R - NOISE BALANCE RESISTANCE.

FIG. 5.

SIGNAL SCHOOL, PORTSMOUTH. DRG. Nº M289/4. TR. D.M. 24.8.36. CH. J.&B. 25/8/36 AP.

(c) Vodas. The connection between the incoming and outgoing R/T 4-wire system and the 2-wire system of the ship's telephone exchange is through the usual hybrid coil, and although the balance is stated to be good, it was considered necessary to instal vodas in the transmitter and receiver circuits to facilitate working under bad conditions of incoming noise level. The switching level and amount of delay are adjustable for various working conditions. The delay for normal working is 40 m.seconds. This can be increased to 125 m.secs. when the distant terminal is working into a long land line with echo. The artificial lines for the delay are situated behind the receiver racks and occupy, together with associated apparatus, a volume about equal to all the receivers.

In case of failure of the vodas, 4-wire telephony can be used from a few selected positions in the ship.

11. RECEIVER POWER DISTRIBUTION. The power supply to all the receivers, panel lights and control apparatus is rectified from the common 50 cycle W/T installation. Separate rectifiers are used for each receiver. The H.T. supplies are held constant by stabilivolt tubes and it was stated that the L.T. supplies were also stabilised by baretters to each receiver. Indirectly heated valves are used in all W/T receivers but battery valves with rectified supplies are used in some of the telephone circuits.

The lighting of the receiving office is normally from the W/T A.C. supply but it can be changed over to the ship's D.C. supply.

No effects are noticed in the receivers due to fluctuation of power supplies.

12. INTERFERENCE.

(a) With aerials disconnected. It was stated that no interference of this class had been encountered even from the Creed keyboard perforators. Slight clicks only could be heard in the adjacent receiver when dialling changes of frequency. It was stated that interference was introduced if unscreened wires were substituted for concentric feeders in the lead down the trunk.

(b) From ship's transmissions, through the receiving aerials. This has been eliminated after much trouble by choosing transmitting frequencies having no harmonics within 10 kc/s of receiving frequencies and by the system of rejectors and additional tuning provided at the top of the aerial trunk as described above.

(c) From stays and wire halyards and hull potentials, and picked up on receiving aerials. All junctions in wire stays are either insulated or properly bonded. Residual interference is reduced by use of horizontal dipole and quadripole aerials and adjustment of noise balance in preselector.

13. EMERGENCY W/T EQUIPMENT. The emergency apparatus is fitted in the Receiving Room. The transmitter is a standard International Marine Radio Company's set of the type usually fitted as main transmitter in small cargo and coastal steamers. The input power of ¼ kW. is supplied by a generator from a 110 volt, 100 amp-hour battery, which also supplies the receiver. Two glass valves - type 4211D - are used in parallel and transmissions can be made on 375, 425 and 500 kc/s, I.C.W.

The receiver is of the standard design supplied to trawlers and covers a frequency band of 150 - 2600 kc/s.

The batteries are charged from the main W/T supply through a rectifier.

A send-receive switch is fitted. Listening through is not provided.

14. LIFE BOAT W/T EQUIPMENT. Two of the ship's life boats are fitted with separate W/T and R/T sets. The W/T equipment consists of a ¼ kW. quenched gap spark transmitter operating on a fixed frequency of 500 kc/s, and a 3 valve receiver covering a range of 450 - 550 kc/s.

Power is supplied from a 20 volt battery and motor generator, a special tapping on the battery being provided for lighting the valve filaments.

In order that a qualified wireless operator may be unnecessary, an R/T set is provided and it was stated that the Boat's Crews received instruction in the use of this apparatus.

The transmitter is the International Marine Radio Company's T.S.3 transmitter, which is the firm's standard R/T set for trawlers. It has a frequency range of 1500 - 2500 kc/s and is fed by a dual purpose generator driven from the 20-volt battery. The receiver is the same as that fitted in the emergency set, a dry battery being supplied to provide H.T.

The aerial is a single wire vertical triangle suspended between the masts and can be used with either W/T or R/T sets by means of a change over switch.

15. D/F EQUIPMENT. A rotating coil system is fitted, the coil being approximately 2-ft. in diameter and enclosed in a 3-inch metal tube. The coil is fitted on the bridge between the foremast and the fore funnel, slightly off the centre line. The base of the coil is 5-ft. above the deck. The position did not appear to be a particularly good one for the type of aerial employed.

The office is a small compartment adjacent to the Chart Room and is immediately below the coil.

The vertical shaft which is about 8-feet long altogether, is coupled through a bevel gearing to a hand-wheel, in the office. The hand-wheel rotates outside the bearing indicator dial which slopes toward the operator at an angle of 45°. The movement appeared to be a little heavy and rough; no appreciable back-lash could be detected. A gyro repeater and usual scales and pointers are fitted.

A super heterodyne receiver covering a frequency range 260 - 550 kc/s is fitted. The sensitivity was claimed to be adequate in spite of the small aerial system. The selectivity appeared moderately good but the tuning is critical, i.e., the frequency change for a small movement of the tuning condenser is large. The controls are noticeably inaccessible. The low tension power supply is from an accumulator and the H.T. from a dry battery.

A minimum-sharpening device, similar to the Naval semi-circular corrector, is fitted.

It was observed that the quadrantal deviation, which was not perfectly symmetrical, amounts to about 20° and is allowed-for by means of a cam corrector. Good zeros with the aid of the sharpening device are obtained and good results in practice have been reported.

16. ECHO DEPTH SOUNDING. This apparatus is controlled from the chart room on the navigation bridge. The apparatus is the Fessenden Fathometer made by the Submarine Signal Corporation. The transmitter is a hammer acting on a diaphragm in the ship's bottom and the receiver is a hydrophone. The depth is indicated by the discharge in a neon tube, which occurs once during each rotation of the indicator round a calibrated dial. In addition, a continuous record of depth is shown on a graph. The range of the instrument is up to 150 fathoms. When the apparatus was seen in operation the indicated depth wandered between 6 and 9 fathoms. Occasional multiple reflections were observed. It was stated that the apparatus went out of action during the last passage up channel and indicated a steady 5 fathoms.