DEPARTMENT OF TRANSPORT

RADIO DIVISION

REFERENCE DIAGRAMS

AND

OPERATING INSTRUCTIONS

FOR

MARCONI DIRECTION FINDER
TYPE M.D.F.-5

D E P A R T M E N T O F T R A N S P O R T

R A D I O D I V I S I O N

OPERATING INSTRUCTIONS

FOR

CANADIAN MARCONI MARINE DIRECTION FINDER

TYPE M.D.F.-5

I N D E X

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Para. 1

OUTLINE OF PRINCIPLES OF DIRECTION FINDING AS APPLIED TO NAVIGATION

The Marconi Direction Finder MDF-5 is essentially a radio pelorus, that is, it may be used to measure or determine the bearing of a fixed point relative to the ship's head.

The one requirement is that the said fixed point be fitted with a wireless transmitter, which is either in operation, or can be placed in operation by request.

The Direction finder may be installed either in the W/T cabin or in the chart room or pilot house. Both installations will give the same accuracy in bearings, provided that the loop aerial is installed over the keel line of the vessel and is clear of any unsymmetrical metal superstructure.

The equipment, if installed in the chart room or pilot house, is under the Master's supervision at all times, and is conveniently at hand for instant use. Moreover, owing to its location, the accuracy of bearings may be checked quickly in conjunction with the ship's pelorus, with a minimum of inconvenience to the Master or his navigating officers.

As an aid to navigation, the Direction Finder may be employed in several ways. For example, when during foggy weather, a ship is proceeding towards a point on shore equipped with a wireless transmitter such as a radio beacon, the course may be checked. A bearing direct ahead, i.e. zero degrees from the ship's head, would indicate that the course is correct.

If the course of the ship were such that the radio beacon would be passed, say, five miles off when abeam, the Direction Finder bearings may be watched and the rate that the angle from the ship's head changes as the vessel approaches is a good indication of the accuracy of the course. This method leads up to the well-known fourpoint bearing; such bearing may be taken by means of the Direction Finder as easily during fog as by the ship's pelorus in fine weather.

The Direction Finder may be used to advantage to avoid collision with an approaching vessel. For instance, by the interchange of wireless signals, when the ships are nearing each other, relative bearings may be observed until the bearing has passed the beam.

It will readily be seen that in the case of a vessel in distress, providing that the transmitter is operated at short intervals, bearings can be taken and the course set to keep the relative bearing of the distressed vessel at zero degrees to the ship's head. Occasions have arisen where vessels sending out a distress signal have only been able to give an approximate position, but, by means of the Direction Finder, it was possible to bear down on the vessel without loss of valuable time.

Frequent use of the instrument will enable the navigator to estimate approximately his distance from a transmitting land or ship station, such estimate being based solely on the strength of the signals. All that may be aimed at in this direction, however, is for the navigator, by careful manipulation of the volume control, to determine whether or not the transmitting station is in the immediate vicinity of his ship.

Another use, involving slightly more work, consists in getting a true bearing from a station to intersect with the course line, thus obtaining a position "fix". This application might

whether the ship's actual course is above or below the course desired.

An actual "fix" may be obtained by taking cross bearings on two or more stations and plotting their true bearing on the chart, due allowance being made for the distance steamed when the times of taking bearings are more than a few minutes apart.

It should be borne in mind that the accuracy of plotted bearings depends greatly on the accuracy with which the ship's head is converted to its actual bearing from true north. This point is particularly important when the ship is yawing, therefore the wheelman should endeavour to keep the ship's head right on the course, or he should indicate how much it is off.

It will be apparent that if a bearing was taken on the beam from a station fifty miles distant, an error of one degree on the ship's head would make an error of approximately one mile on the course line.

"Fix" bearings should be considered most accurate when they are nearly at right-angles to the course line. If the true bearing is almost parallel to the courst line, or cuts it at an acute angle, an error of, say, half a degree will produce quite an appreciable error in position along the course line.

As mentioned before, the radio Direction Finder can be compared to a pelorus; therefore it is necessary to know the exact bearing of the ship at the time the radio bearing is taken.

In order to facilitate handling of radio bearings and to prevent, as far as possible, errors due to magnetic correction calculations, etc., the 0-360 degree compass scale is used throughout. Thus, it will be necessary for the navigating officer to designate bearings not as N 20 E, but as 20 degrees, or again, not as S 20 W, but as 200 degrees.

If a true bearing from a distant transmitting station is to be laid off on a chart, the following procedure should be observed;

1. Note the magnetic heading of the ship's head at the moment the W/T bearing is taken.

2. Ascertain the magnetic variation for the approximate position of the ship.

3. Ascertain the magnetic deviation for the particular course set.

4. Correct the magnetic ship's head to the true ship's head by adding Easterly variation or deviation and subtracting Westerly variation or deviation.

5. Add the wireless bearing to the true ship's head, which will give the true bearing from the ship to the transmitting station.

   This bearing, when laid off on the chart, should cut the course line of the ship at the correct position for the time when the bearing was taken.

Two examples are given as follows:

SHIP'S HEAD BY COMPASS	74°	74°
VARIATION FROM CHART.....	3° E	3° (add)
		77°
DEVIATION FROM TABLE	4° W	4° (subtract)
SHIP'S HEAD TRUE		73°
OBSERVED W/T BEARING		24°
TRUE BEARING.....		97°

SHIP'S HEAD BY COMPASS	113°	113°
VARIATION FROM CHART	0°	0°
DEVIATION FROM TABLE	3°	3° (add)
SHIP'S HEAD TRUE		116°
OBSERVED W/T BEARING		273°
		389°
SUBTRACTING 360		360°
TRUE BEARING		29°

It should be observed that if the resultant of the true ship's head and the wireless bearing comes to more than 360 degrees, it is simply necessary to subtract 360 degrees from the total, the remainder being the true bearing required.

DESCRIPTION OF DIRECTION FINDER

The Marconi Direction Finder MDF-5 comprises two main units, i.e. the Direction Finder Receiver and the Direction Finder Loop Aerial.

Receiver

The Direction Finder receiver comprises all the electrical apparatus necessary for direction finding, with the exception of the loop aerial, and includes the receiver proper, the quadrantal error corrector and the goniometer.

The receiver proper is of the superheterodyne type. The valve complement consists of six octal-type 1.4-volt valves used as follows:-

1N5G - R-F Amplifier

1A7G - 1st Det. Converter

1N5G - I-F Amplifier

1G4G - Beat Frequency Oscillator

1H5G - 1st Audio - Diode Detector

1T5GT - Power Output Pentode

The receiver is designed for use with the following sources of power supply:-

Low Tension - 300 milliamps at 1.4 volts.

High Tension - 9 milliamps at 90 volts.

A heavy-duty 1.5-volt type "A" battery or, alternatively, an Air-Cell battery may be used for the 1.4 volt tubes. For emergency operation (when neither of the above are available) a No. 6 dry cell may be used. This matter will have a relatively short life. Two heavy-duty 45-volt "B" batteries should be used for the high tension supply.

The battery supply connections are brought into the cabinet via a 4-conductor cable, which connects to a terminal board inside the left-hand compartment of the cabinet.

The receiver cabinet is equipped with four pilot lights for illuminating the various scales on the unit. These lights are supplied from the ship's a-c or d-c mains and are controlled by a switch on the left-hand panel of the cabinet.

The receiver circuit consists of the goniometer, the tuned search-coil circuit with its associated balance and "sense" couplings, one r-f pre-selection stage, one detector-mixer stage and the conversion oscillator. The output of the mixer is fed to an i-f amplifier consisting of one stage and thence to a diode detector. The diode detector rectifies the i-f signals and supplies audio signals to the audio amplifier. The output of the audio amplifier is fed to either a loudspeaker or headphone jacks, by means of an appropriate switch. A beat-frequency oscillator, controlled by an ON-OFF switch, is also coupled to the diode detector. This b-f-o, oscillating at or near the i-f frequency (175 kc), "beats" c-w (unmodulated) signals down to an audible tone which is then amplified by the audio amplifier in the usual manner.

The controls for the various circuits are located on the front sloping panel. These consist of:-

Volume & On-Off Switch.

With this control hard to the left, the receiver is turned OFF. Turning it to the right turns the receiver ON. With the receiver ON, the volume control provides adjustment of the gain of the r-f and i-f amplifiers, thus controlling the output of the receiver.

Main Tuning.

This control provides adjustment of the receiver to any desired frequency within the band from 265 kc to 670 kc (1132 metres to 448 metres).

Search Tuning.

This provides tuning of the goniometer search-coil circuit to the frequency as determined by the setting of the main tuning control.

DF- Sense.

This is used to determine the absolute direction or the "sense" of the signal. When on D-F, two bearings will be obtained 180° apart. When on SENSE, one bearing only will be obtained, the bearing being indicated by the SENSE pointer on the goniometer.

Balance

This control provides an adjustment for the clarification, i.e. sharpening, of "zeros" when taking bearings. It is used to greatest advantage when taking bearings close to the transmitting station.

C-W.

This switch turns the beat-frequency oscillator ON or OFF as required, depending, respectively, on whether c-w or modulated signals are being received.

Speaker.

This switch connects the output of the receiver either to the headphones or to the loudspeaker. With the switch OFF, the loudspeaker is rendered inoperative and the output of the receiver is applied to the PHONES jacks.

Phones.

These jacks are wired in parallel and high impedance

This unit is located on the small recessed sloping panel at the top centre of the cabinet. The purpose of this unit is to indicate the direction of the transmitting station, in degrees of arc, relative to the ship's head and true north.

On the face of the goniometer are two scales, one fixed, one rotatable. The fixed scale indicates the bearing of the transmitting station relative to the ship's head, and is always read with the pointer marked RELATIVE BEARING. The movable scale indicates the bearing of the transmitting station relative to true north, and is read with the pointer marked PELORUS BEARING.

In order that the PELORUS BEARING will read correct bearings relative to true north, the movable scale must be set so that the arrow, riding on the inside periphery of the scale, points to the ship's course corrected to true north.

Calibration Choke.

The calibration choke on the back panel of the right-hand compartment of the cabinet is simply a two-section choke coil with various taps taken off. The numbers engraved on the terminal panel indicate the number of turns between any two terminals.

E.G. - Between the extreme left-hand terminal and the one next above it is 1; i.e. there is one turn between these two terminals.

To find number of turns between any two terminals, find the sum of the number of turns between each individual pair of terminals included.

E.G. - Terminals in use: Top 2nd and bottom 5th (counting from left).

No. of turns = 4 + 7 + 10 + 12 + 14 = 47

The first section of the choke consists of terminals TOP 1st to 4th and BOTTOM 1st to 5th. The second section consists of terminals TOP 5th to 6th and BOTTOM 6th to 7th.

If less than fifty-two turns are required, the jumper between the two sections should be left off. If more than fifty-two turns are required, the jumper should be used.

The total number of turns available in the full choke is 217.

Sense Resistance.

This is the square section, nearest the front panel, of the long box adjacent to the balance circuit assembly.

The purpose of this resistance is to swamp the inductance and capacitance of the plain aerial and two render the circuit nearly aperiodic. It is used in conjunction with the sense coupling coils to obtain the phase shift in the plain aerial current necessary for the proper indication of "sense" bearings. This resistance is in circuit when on SENSE and out of circuit when on D-F. To insert resistance in series with the plain aerial, the tap lead is connected to the various terminals, the following relation existing:-

TAP LEAD AT TERMINAL NO.	RESISTANCE IN CIRCUIT
1	500 ohms
2	1,000 ohms
3	2,000 ohms
4	3,000 ohms

Sense Coupling Coils

These are the two lateral-wound coils mounted on the vertical movable brackets on the balance coil assembly. The purpose of these coils is to provide adjustment of the plain aerial coupling when on SENSE.

These coils are used in conjunction with the sense resistance to obtain the proper conditions for correct "sense" bearings.

Balance Loading Inductance.

This is the square section to the rear of the sense resistance.

The purpose of this inductance is to adjust the amount of plain aerial current necessary for clearing zeros. It is essentially a shunt inductance connected across the aerial section of the balance coil assembly.

The inductance consists of a 255-turn coil with taps at 20, 55, 105, 155 and 205 turns which are connected to the loading inductance terminal board. The terminal numbers indicate the number of turns between adjacent terminals, i.e. 20 indicates that there are twenty turns between the left-hand soldering lug (ground) and terminal 20; 35 indicates that there are 35 turns between terminal 20 and terminal 35.

To insert inductance in parallel with the balance coils, the tap lead is connected to the various terminals, the following relation existing:-

STARTING AT BACK LEFT-HAND TERMINAL	TURNS IN PARALLEL WITH PLAIN AERIAL
20 left	20
35 right	55
50 left	105
50 right	155
50 left	205
50 right	255

Loop Aerial

The loop aerial system consists of two shielded fixed loops at right-angles to each other. The wires of each loop are threaded through metal tubes.bent so as to form two circles, one fore-and-aft, and the other athwartship. The complete crossed aerial system is mounted on a metal pedestal which is bolted to the deck, or to a pedestal stand which is then bolted to the deck. Necessary cables are connected from the loop system to the receiver.

INSTALLATION OF DIRECTION FINDER.

The first point to be decided is a suitable position for the loop aerial and the receiver unit. As a general rule, the position of the loop aerial is the most important, as it has a direct bearing on the accuracy of the direction finder as a whole. It should be placed exactly over the keel line of the vessel, to ensure that all metal superstructure is located symmetrically around it, and it should be clear as possible from large metal ventilators, stays or tanks, etc. Its distance from the fore or aft end of the ship is not very important providing, as before mentioned, it is exactly amidships.

If an amidships position for the loop aerial is not available, a position as near as possible over the keel line should be chosen, but in this case, it is probable that a calibration chart will have to be supplied, giving the corrections for the errors occasioned by the non-symmetrical position of the loop.

Another important point to bear in mind is the distance from the loop aerial to the receiver. When absolutely necessary, it is possible to work with the loop aerial as much as 50 feet away from the receiver, but as a general rule, the shorter the distance, the better the results will be.

The distance is measured in length of cable required to join the loop aerial and the receiver together, not the physical distance between the two units.

The position of the receiver is not very important, but care should be taken that whatever position is chosen, it will lend itself to a neat layout of cables and wires. In some cases it will be possible to place the receiver against a bulkhead and bring cables and other wiring down behind the partition, and again, the cables may have to be run in conduit direct from the receiver to the loop aerial and the other wiring clipped on the outside of the wall or bulkhead.

As there is a certain amount of steel in the receiver unit, a check should be made that the ship's compass is not affected by the proximity of receiver. It is advisable to watch the compass needle as the receiver is placed in position. If there is no discernible movement, the position may be considered satisfactory. Where the receiver is installed in the W/T room, this precaution is usually unnecessary.

A plain aerial of about 25 or 30 feet is required in addition to loop aerial, so consideration should be given to the position of the aerial insulator. This may have to be put through the deck above or through the side of the cabin. In any case, it should be located as near the receiver as is convenient.

Loop Aerial

In cases where the loop aerial is installed on the deck above the room in which the receiver is located, it will be possible to take the cables down through the deck from the centre of the loop pedestal. This will necessitate the installation of the small water-tight tube or gland provided under the centre of the loop extending down into the cabin. When the loop cannot be installed in this position, the connecting cable will probably have to be taken out from the side of the loop pedestal and run in one and one-quarter inch conduit, A junction box is provided on the loop pedestal for this purpose.

The loop assembly should be installed with the smaller of the two crossed loops in a fore-and-aft direction. The small loop should be lined up exactly fore-and-aft by sighting on a distant part of the ship, such as a mast or funnel. The pedestal part of the loop aerial should be bolted to the deck or to the pedestal stand, if this is used, and the stand bolted to the deck. Good water-tight joints should be made by means of white lead and the rubber gaskets supplied.

It is essential that the metal framework of the loop be thoroughly earthed to the metal framework of the ship's hull. If the deck is metal, the bolts will make the earth connection. If the deck is of wood, a special connection must be taken from the loop framework to any part of the metal hull of the ship. This connection should be made with the No. 6 earth wire supplied and should be kept as short as possible.

The loop pedestal may be mounted directly on the deck when the location of the loop aerial is such that it is higher

than any adjacent superstructure.

The medium pedestal stand, or the high pedestal stand, is used when it is necessary to raise the loop aerial and pedestal assembly higher than any adjacent superstructure which would otherwise be in the path of incoming signals.

Loop Cables.

In cases where the cables are under 25 feet in length, type "S" cable (2 conductor No. 18 B & S copper wire, heavy duty with jute filler) may be used. In cases where the cables are over 25 feet in length, special paper-insulated lead-covered cable must be used. This will extend the distance out to 50 feet. Distances beyond 50 feet are not recommended. The connections from the loop windings are brought down to the base of the loop pedestal by means of five wires which are distinctly color coded as below:

FORE:	Maroon
AFT:	Light brown
PORT:	Yellow with tracer
ST'BD:	Yellow
GROUND:	Black

The black ground wire should be connected to the ground lug at the pedestal junction box.

Installation with Type "S" Cable.

One length of cable (2 wires) should be connected to the FORE and AFT (maroon and light brown) leads, and one length of cable to the PORT and ST'BD (yellow with tracer and yellow) leads. When making these connections, the conductors should be thoroughly cleaned of any foreign matter and the joints made mechanically secure. The joints should then be soldered with resin core flux - ACID TYPE FLUX SHOULD NOT BE USED. The joints should then be taped with friction tape.

As the two wires in either length of the type "S" cable are color coded, a record should be made of the color code of the wires in each cable and their relation to the loop leads proper. This will be necessary when the loop leads are connected to the receiver.

The brass pipe should be installed in the deck to provide a lead-through for the two lengths of type "S" cable.

The cables should be brought down inside the cabin and fed to the receiver. These cables should be cleated to the walls and/or ceiling as required, and their length should be kept as short as possible. The rubber covering should be stripped off the cables only sufficient to allow connection of the conductors to the goniometer terminals inside the receiver. The FORE and AFT cable should be connected to the FORE and AFT goniometer leads and the PORT and ST'BD cable to the PORT and ST'BD goniometer leads. These connections are made at the terminals on the calibration choke and are plainly marked. The color code record which was made when the loop aerial was installed should be used to insure that the leads are connected to the proper terminals.

Installation When Loop Leads are Over 25 Feet.

This installation requires the use of special lead-covered paper-insulated cable run in metal conduit. This cable requires very careful handling in order to prevent any possibility of dampness getting at the paper insulation. Whenever a length is cut off the main

supply, the ends of the lead covering must be pinched together and soldered up at once, and great care must be taken not to work at the ends in any place exposed to moisture. Connections to the loops must be made in the junction box on the loop pedestal.

The black wire from the loop should be connected to the ground lug on the junction box. The other four leads should be brought direct to the junction box terminal board. One length of the lead cable should be connected to the FORE and AFT loop leads and another length to the PORT ST'BD leads. The lead covering should be stripped far enough back so that there is no danger of the covering shorting any of the junction box terminals. A record should then be made of the color coding of the wires in each cable and their relation to the loop leads. The junction box should then be filled with the special compound supplied. The sealing compound should be heated over a stove and poured into the junction box while hot.

The lead-covered cables should be protected by conduit or casing of some sort if they are to be run where they will be liable to damage. It is impossible to give any hard and fast rules for running the special cables, as conditions vary on every ship, and the installing engineer will have to make different arrangements for every job. The cable must not be bent around any curves of less than nine inches radius, and it must always be realized that the utmost care should be taken in carrying out these instructions, as if any damp penetrates to the inside of these cables, the cable insulation will be destroyed and the direction finder will be useless until it is replaced.

The lead-covered cables and the shielding conduit should be run to the cabin where the receiver is housed and there terminated at the junction box supplied for this purpose. The junction box should be located as close as possible to the receiver. The lead-covered cables should be soldered to two paids of twin twisted flex, one pair to the leads from F and A, and the other pair to the leads from P and S. The joints should be tucked down inside the box and the box filled with compound. A record of the color coding of the two twisted pairs should also be kept so that when they are connected to the receiver, there will be no error in connections. The flex leads may be cleated to the wall as required, or may be left loose if the distance is quite short to the receiver terminals. Each pair should be brought through the appropriate holes in the back of the receiver case and connected to the four goniometer terminals as in the case of the type "S" cable. Care should be taken that each pair is twisted as close up to the receiver terminals as is possible.

Receiver.

The receiver should be mounted on a table or bench of such height that the goniometer scales can be easily read. Sufficient space should be left clear behind the cabinet to allow the entrance of the loop leads, plain aerial, etc. The ground terminal on the back of the cabinet should be connected to the hull of the ship (i.e. the steel deck, etc.) by means of the No. 6 earth wire supplied. This lead should be kept as short as possible. The "A" battery and the two "B" batteries should be mounted either behind the receiver or on a shelf below the table. They should be placed so that they will not be exposed to weather or water spray. They should not be placed near hot steam pipes. The battery cable from the receiver is fitted with plugs which are so wired that it is only necessary to insert these plugs into the receptacles on top of the batteries to insure them being connected up properly.

If the heavy-duty 1.5-volt type "A" battery is used, all that is necessary to place it in service is that the "A" battery lead from the receiver be plugged in.

If the air-cell "A" battery for 1.4-volt tubes is used, it should be prepared for service exactly as per instructions on the side of the container.

The rubber-covered cord from the back of the left-hand side of the cabinet is for the pilot lights. It should be plugged into the nearest outlet from the ship's mains either a-c or d-c 110-volts. Special lamps may be supplied for 220-volt operation.

Plain Aerial.

The aerial deck insulator should be installed in a convenient place, and should be made water-tight by means of white lead. The aerial should be about 25 feet long, measured from the deck insulator to the free end. The lower end should be sweated into the special lug provided. The upper end should be secured to any convenient stay or triatic. Three aerial insulators are provided for staying or suspension. The lead from the inside of the aerial deck insulator should be run over to the receiver and connected to the terminal marked A. inside the receiver cabinet. This lead should be kept clear from the loop leads unless they are in conduit, in which case, they are adequately shielded.

The Direction Finder is now ready for service, and should be checked for sensitivity and general quietness of operation, and a preliminary test made as follows:

With about one-hundred turns in the calibrating choke connected across F and A terminals, get a bearing from a station in a known direction. If the cable and loop connections have been carefully followed through, the station should appear in its right quadrant, but if, through some mistake, either of the loop leads have been crossed, it will appear in the wrong quadrant (Port bow instead of Starboard bow, or Port quarter instead of Starboard quarter). If this is so, the loop leads at the terminal board on back of calibration choke assembly will have to be interchanged. Cross either the Port-and-Starboard or Fore-and-Aft leads from the loops.

When certain that stations appear in their right quadrants, observations should be taken on all quadrants if possible, at least in two adjacent quadrants, as a check.

Now proceed to set the phasing unit as follows:

Get a zero in the D-F position and switch to SENSE. One of five things will be found, viz:-

(1) Switching to SENSE obliterates the D-F zero without showing any signs of moving it. This means that the plain aerial is not aperiodic and more resistance is required.

(2) The weakest point is moved 90 degrees but is not zero. This means that the all-round component is too strong, and the coupling must be weakened. With very strong signals there is too much direct reception for a true sense zero, so reduce volume control until the signal is of reasonable intensity.

(3) Two weak points can be found close together and moved about 90 degrees from the D-F zero. This means that the all-round component is too weak, and that the sense coupling must be tightened or, if necessary, the sense resistance slightly reduced.

(4) A good sharp zero will be found 90 degrees from the D-F zero, and signals opposite to the zero much stronger than the D-F maximum position. This is correct.

(5) Switching to SENSE makes no difference at all. Sense circuits broken or aerial not connected.

To make certain that all is well, it should be possible to go from 2 to 3 of the above by moving the coupling. Set the coupling for best results on the normal bearing frequency and lock the moving coil by tightening the lock screw. Finally, see that the sense is in the right direction. If not, the two leads from the goniometer going to the

terminals marked SC-1 and SC-2 on the terminal board should be reversed. This will reverse the sense direction 180 degrees.

A check should also be taken on the balance adjustment at this time. It is impossible to predict the magnitude of the re-radiation signals that have to be balanced out in any particular ship; consequently, an adjustable loading inductance is shunted across the variable balance coils, so that part of the plain aerial component may be shunted to earth if found to be too much.

In some quadrants, more balance will be required than in others and, when adjusting the loading inductance, it should be so arranged that the balance pointer is about three-quarters to the right or left for maximum compensation on any of the quadrants. This ensures that, for the smaller compensations, the balance adjustments will not be crowded in towards the centre position too much.

If the plain aerial is too long and has too much pick-up, the balance will have to be almost short-circuited by the loading inductance. In this case, the length of the plain aerial should be reduced. If there is not enough pick-up in the plain aerial, the loading inductance should be disconnected or the length of the plain aerial should be increased.

The length of the plain aerial may be considered ideal when the loading inductance requires to be about half to three-quarters in, i.e. 105 to 205 turns.

Any change to the length of the plain aerial will necessitate a slight readjustment of the sense circuits. It will probably be found that a slight variation of the sense coupling will be sufficient.

Calibration.

The principles on which the accuracy of a Direction finder depends are as follows:-

(1) That the receiving power of the two loops shall be equal.

(2) That they are exactly fore-and-aft and athwartships and also vertical.

(3) That the top of each loop shall be electrically exactly opposite to the earthed centre of the field coils of the goniometer.

(4) That the capacity between the search coil circuit and the rest of the amplifier shall be kept very small.

(5) That the D-F as a whole be adequately shielded.

The first of these is assured by arranging the sizes of the two loops. The receiving power of a loop depends upon its area, its width being more important than its height. The bigger the loop, the better the signals, less amplification need be used, and less trouble is experienced from direct pick-up in the receiver and other kindred evils. It must be remembered, however, that the ship herself also acts as a receiver and assists the fore-and-aft loop. Therefore, the calibrating choke is normally shunted across the leads from the fore-and-aft loop. Provision is made at the terminal board so that the leads to the choke may be connected across the Port-and-Starboard loop if ever required, as in some cases, due to the design of the ship, there may be more pickup athwartships than fore-and-aft.

The effect of the calibrating choke, when properly adjusted, is to slightly reduce the output from the loop across which it is connected until the receiving power of both loops is the same.

The second point is assured by careful and accurate fitting and can always be verified. It is essential that both loops be exactly at right-angles to each other,

The third, fourth and fifth points are assured by accurate fitting of the aerials and by the proper construction of the calibrating choke and direction finder.

The calibrating choke is an inductance connected across the loop output leads. It is not to be regarded as a tuning inductance, but as an absorption choke; the less the number of turns, the more effect it has, and the less the receiving power of the loop. In the limit, when the turns are reduced to zero, the receiving power of the loop would be reduced to zero as the loop leads would then be short-circuited. Therefore, the effect of reducing the turns in the parallel choke is to effectively reduce the size of the loop. In this way, the receiving ability of the loops on any particular ship is made substantially the same.

Nearly all direction finders on board a vessel have an error, due to the ship herself acting as a large aerial, causing an effect which tends to pull the bearings in a fore-and-aft direction. The greatest amount of pull is noticed at 45, 135, 225 and 315 degrees, while at 0, 90, 180, and 270 degrees there is no appreciable pull. The error is negative in the first quadrant (0-90), positive in the second (90-180), negative in the third, and positive in the fourth. The error may be plotted on graph paper as a sine curve, that is, zero at 0 degrees, gradually increasing up to 45 and decreasing back to zero again at 90 degrees.

For example, consider a station transmitting signals and bearing 45 degrees on the Port bow. The direction finder, if there was a fore-and-aft error of 5 degrees, would show an apparent direction of only 40 degrees. If the station was bearing 135 degrees, the direction finder would show it at 140 degrees.

As a general rule, the installing engineer will have to make a trip with the ship, unless the Master can swing the ship on a nearby transmitting station and then land the engineer.

The best method of calibration is carried out in conjunction with simultaneous sight and D-F bearings. For this method, a pelorus is used. This instrument is usually found on any ship's bridge or chartroom.

The ship should be about two miles or more away from the transmitting station, consistent with good sight bearings on the masts of the station, and should be well clear of land or anything which is likely to cause refraction or shielding. The pelorus should be set with its zero aligned with the ship's head, so that sight bearings taken on the station will be in relation to the ship's head only and entirely independent of magnetic effect or direction.

The ship should be manoeuvred so that the station bears about 45 degrees on the bow or quarter, and simultaneous bearings taken by sight and D-F. Any discrepancy between the two bearings will be the error on the direction finder, as the pelorus will give a dead correct bearing with relation to the ship's head.

The calibrating choke should be altered until bearings by sight and D-F are exactly alike. If the observed D-F bearing is being pulled fore-and-aft, the turns in the choke should be reduced, but if the bearing is pulled athwartship, the choke should be increased.

If the bearing is still being pulled athwartship with the choke completely disconnected, the choke will have to be connected across the Port-and-Starboard loop and turns decreased until the error is eliminated.

If the loop aerial is installed exactly amidships, it can be presumed that when the error is eliminated at 45 degrees, there will be no error at any other point on the quadrants. As a check, however, simultaneous sight and D-F bearings should be taken about every 10 or 15

degrees around the four quadrants.

In cases where the loop aerial is installed off the centre line of the ship, it will nearly always be found that the calibrating choke will not entirely compensate for quadrantal error due to the fact that there is a slight error at 0, 90, 180 and 270 degrees. This, of course, is caused by the loop aerial not being symmetrically placed with respect to the hull and superstructure of the vessel. The only remedy under these circumstances is to reduce the error at 45 degrees as much as possible with the calibrating choke, then take a record of the error at every 10 degrees around the quadrants. With this information, a correction chart can be made up.

It will often be possible to calibrate while steaming by a station as long as sight bearings can be taken. In the first quadrant, the difference between sight and D-F bearings should be ascertained, and by making quick adjustments to the calibrating choke, the calibration can be checked in the second quadrant. This requires quick work and should only be resorted to when it is impossible to swing the ship.

In fine weather, calibration may often be accomplished without taking sight bearings. This requires an exact knowledge of the ship's position, together with accurate corrections for variation and deviation. Bearings should be taken from stations at moderate distances away, and compared with the correct true bearings as taken from the chart. This latter method will, however, be a somewhat long and tedious task and should never be resorted to unless sight bearings are impossible.

Calibration should not be attempted if the ship is alongside a wharf where there are metal buildings or structures, as these masses of metal will cause considerable errors.

OPERATION OF DIRECTION FINDER

The loop aerials are mounted exactly athwartship and fore-and-aft. The receiving powers of these two loops are made almost the same, and they are joined up to the goniometer field windings in such a way that when the goniometer pointer is rotated it is electrically the same as rotating the loops themselves. When a signal is intercepted by the loops, it produces a field inside the goniometer which is identical with the field of the radio wave in space. If the direction of the radio wave changes, the field inside the goniometer will change in like proportion. The search coil of the goniometer is arranged so that it may be rotated inside the goniometer, and in this way is cut by the field produced by the signal.

If the search coil is turned so that its plane is in the direction of the field, a voltage will be produced around the coil which causes a current to flow. The current is passed on to the receiver, is amplified, and produces a sound in the headphones.

If the search coil is turned so that its plane is at right-angles to the field, current is produced in both sides of the coil simultaneously. These currents, being in phase and of equal strength, cancel each other and there is no circulating current to be passed on to the receiver. Consequently, there is no signal heard in the headphones. This is called zero position.

If the search coil is moved one way or the other from zero position, the signal will be heard, depending upon how much the loop is moved off the zero position.

The latter, or zero signal method, is the one used in nearly all types of direction finders.

If the search coil is rotated 180 degrees from its zero position, it will again show a zero signal position, because then it would be in exactly the same plane as regards the goniometer field as it was before, i.e. right-angles to the field. Therefore, when

taking bearings there are two zero signal positions shown on the scale.

Either of these positions would show a correct bearing because, in the majority of cases, all that is wanted is a bearing line, as it is usually known if a station is ahead or astern. If, however, it were not known whether the transmitting station is ahead or astern, or on the port or starboard side. a "sense" adjustment is provided which will quickly differentiate between the two zero positions and indicate which quadrant on the scale to use. On the other hand, were a station known to be, say, 10 degrees on the starboard bow, a radio bearing would give one direction as 10 degrees and the other as 190 degrees or the reciprocal. It is usual to have the pointer so that the right quadrant is used when reading a bearing.

Main Aerial

IT IS ESSENTIAL THAT THE SHIP'S MAIN AERIAL BE DISCONNECTED FROM THE SET IN THE WIRELESS CABIN WHEN BEARINGS ARE BEING TAKEN. IF THIS IS NOT DONE, THERE WILL BE SOME DIFFICULTY IN GETTING SHARP ZEROS AND THEY WILL ALSO BE DISPLACED, THUS GIVING ERRONEOUS BEARINGS. IT WILL BE ADVISABLE TO HAVE SOME WORKING AGREEMENT WITH THE OPERATOR WHEREBY HE WILL ALWAYS LEAVE HIS AERIAL DISCONNECTED AT THE SWITCH WHEN NOT WORKING. IN ANY CASE, WHEN BEARINGS ARE BEING TAKEN (OTHER THAN PRACTICE BEARINGS) THE OPERATOR SHOULD BE ADVISED TO FREE HIS AERIAL. IN THE SAME WAY, ALL OTHER AERIALS SHOULD BE DISCONNECTED AND LEFT FREE IF BEARINGS ARE TO BE RELIABLE.

Volume

The receiver should be turned ON and the volume control set at approximately 7.

DF-Sense.

This should be set at SENSE when tuning in or searching for signals and at D-F when taking bearings.

Speaker Switch.

Should be OFF or down in headphones are used, or up if loudspeaker is used.

C-W.

Should be OFF if modulated (phone) signals are to be received and ON if receiving c-w signals. It is a good practice to keep the c-w switch ON when searching for signals, as in this condition weak signals are more easily detected. The beat note may be altered to that most desirable by slightly adjusting the setting of the main tuning control.

Main Tuning & Search Tuning.

Both these controls should be rotated simultaneously and at approximately the same setting when searching for signals. The MAIN TUNING control is fairly critical and should be carefully and slowly turned until the signal is brought into tune. The SEARCH TUNING control is fairly broad and should be tuned for maximum output after the MAIN TUNING control has been brought into tune with the signal. Both dial readings may be logged for future reference when picking up known stations.

When the signal is in tune, the C-W switch should be kept either ON or OFF depending, respectively, upon whether the signal is c-w or phone. The DF- SENSE switch should now be turned to D-F.

Balance Knob.

Balance knob should be set at zero before commencing

Taking Bearings.

Rotate the goniometer pointer, starting at zero, through 90, 180, 270 and back to zero again. It will be noticed that the signals rise and fall in strength as the pointer is rotated. This, as previously explained, is due to there being two minima or zeros 180 degrees apart. If the station is known to be somewhere ahead, turn the pointer until a minimum is observed somewhere in the forward quadrants corresponding to 270-0 and 0-90 degrees. Now listen carefully and turn the pointer until a minimum is observed.

Signals Too Strong.

If the signal is too strong, it will be hard to decide just where the minimum is. In that case, adjust the volume control until the intensity of the signal is such that the position of minimum signal strength is well defined.

Balance.

Turn balance knob slowly to the left or right, as the case may be, and it will be noticed that the signals fade out altogether in the headphones when the pointer is at position of minimum.

Check Zero.

Swing the pointer back and forth over a few degrees and the signals will be heard again each side of the zero position.

Increase Volume.

Increase the colume control a little. The space over which signals are inaudible will be closed up until perhaps there is no position of zero signals left, but the position of minimum strength is much more clearly defined.

Rebalance.

Now make another small adjustment with the balance knob and, at the same time, turn the pointer of the goniometer back and forth over a small arc.

Sharp Zero.

It will be possible, by a simultaneous adjustment of the balance and pointer, to narrow down the position of zero signals to one degree or less, so that if the pointer is turned one way or the other a loud signal is heard on either side.

Reciprocal.

If the pointer is now turned through exactly 180 degrees, the reciprocal zero will not be heard until the balance knob is turned to the other side of its zero mark. In some cases, a sharp zero will be obtained with the balance knob at zero, and then it will be possible to obtain the two zeros by merely swinging the pointer 180 degrees from each other.

Weak Signals.

If the transmitting station is a considerable distance away and the signals are very weak, the position of zero signals may be quite wide, even though the volume control is full on.

Swing.

It will now be necessary to take swings with the goniometer pointer in order to get two positions of equal strength each side

of zero. Turn the pointer until the signal is just heard; now swing the pointer through zero until the signal on the other side of zero is the same strength as before.

Mean Bearing.

The mean of these two readings will be the correct bearing. For example, suppose the first reading is 45 and the second is 57 . Half the difference between these two readings added to 45, or subtracted from 57, will give the bearing, or 45 plus 6 would give the correct bearing at 51.

Width of Swing.

Swings may be considered accurate up to 50 degrees difference, but practice is required in judging intensities of signals so that they may be matched correctly.

Ambiguity of Direction.

As before mentioned, a bearing on a station will give the line of bearing only, but will not give the actual direction. If a bearing is read on the scale at 10, also at 190, and it is required to know which is the right direction, it may be accomplished quickly by means of the DF- SENSE switch.

Sense of a Station.

To arrive at the direction of a station after a bearing has been taken, turn the switch to the SENSE position. The D-F zero will now be obliterated, but if the goniometer pointer is slowly rotated, a minimum will be found approximately 90 degrees from the D-F zero.

Sense Indicator.

The actual direction of the station will be indicated by the pointer marked SENSE. This will point to a position on the scale corresponding to the actual direction of the station relative to the ship's head or to the true north, depending upon which scale is being used.

Sharpness of Sense Minimum

Sense minima will not be as sharp as those obtained when using the D-F adjustment, but there should never be any doubt, as there is only one minimum for a complete revolution of the pointer.

Sense Volume.

If the signals are too strong, it will be necessary to reduce volume otherwise it will be difficult to pick out the minimum position.

Uncertain Bearings.

For about half an hour before and after both sunrise and sunset it will very often be found that bearings become erratic. This uncertainty is quite noticeable when taking bearings; the effect is that it becomes difficult to decide on any minima and the whole operation gives a feeling of uncertainty. The errors introduced in this way are seldom more than five degrees and are generally about three degrees, but they are constantly varying both in direction and magnitude, so that it is impossible to allow for them.. These errors are generally called "night effect" and are due to the effect of sunlight or the absence of sunlight on the upper atmosphere. They sometimes occur at odd moments during night, but very rarely by day.

MAINTENANCE OF GEAR

Loop Aerial.

The outside metal work of the loops may be painted whenever necessary, but care should be taken that the four main loop insulating gaskets and the cross strut bushings are kept free from paint. The gaskets are located between the ends of the round loop tubes and the centre castings, while the strut bushings serve to insulate the struts from the small inter-connecting castings located on the tubes. All conduit work connecting the loop to the receiver may also be painted.

Balance Aerial.

The small balance aerial, used when the D-F installation is located on the bridge or pilot house, should not require much care other than periodically making sure that the connections at the aerial lead insulator are kept clean and tight. Do not allow the aerial to become grounded by contact with swinging wires or halyards.

Grounds.

All ground connections to the frame of the vessel should be inspected periodically and kept clean and tight.

Receiver.

The tubes used in the receiver are rugged and should have a long life with careful handling.

Towards the end of their life, the electronic emission falls off, which causes the receiver to lose its sensitiveness. It should be arranged that tubes are periodically checked at a radio service station and if the emission is found to be low, the tubes which are low should be replaced with new ones. If it is suspected that any particular tube is low, a check may be made by interchanging it with a good spare and noting whether there is any difference in signal strength.

All connections should be periodically checked through the receiver and tightened where necessary. Vibration is quite severe on some vessels and will sometimes cause loose or broken connections. Trouble of this sort will usually give variable signals or bad noises in the headphones when the receiver is knocked or shaken. It is best located by swinging out the receiver panel, switching the set on, and while listening in the headphones, shaking or pulling each individual wire in sight. Noises would indicate trouble with that particular wire or circuit.

Battery.

The battery connections should be kept clean and tight. Periodically the Radio Inspector, or a representative from a service station, should check the battery voltages, and low batteries should be replaced with new ones. The 45-volt batteries should be replaced when the voltage of each has dropped to 30 volts with the receiver turned ON. The "A" battery should be replaced when the voltage has dropped to 1.1 volts with the receiver ON. If the heavy-duty 1.5-volt type "A" dry battery is used, no attention other than periodical voltage checks is required. If the air cell is used, periodical checks should be made to ensure that the water level is maintained up to the specified water line. No charging is necessary, and when the voltage has dropped to 1.1 volts the battery should be replaced. If a spare air cell is carried for replacement, it should be kept at a moderate temperature and should not be allowed to stay in either freezing or very high temperatures.

To place this unit into service, the airtight seal should be broken and the battery filled with fresh water as per instructions located on the side of the battery. It is not advisable to carry spares for the dry type "A" battery as these gradually deteriorate over a long period of time, even when not in use, and may not be serviceable when

required for replacement.

Pilot Lights.

Spares should be carried and put in circuit in case of failure. The pilot lights are connected to the ship's mains and do not constitute a load on the D-F batteries. They may be left alight as long as required without damage.

Fuses.

The pilot lights are fed from the ship's mains via two fuses which are located under a cover on the back panel of the left-hand compartment of the cabinet. If any one of the lamps fails to light when the switch is turned on, the lamp should be replaced. If all the lamps fil to light, the fuses should be replaced. Spares should be carried for this purpose.

Line Filter.

A line filter is shunted across the ship's mains in order to bypass to ground any electrical noises etc, which are induced in the line. This unit is located under the fuse holder cover on the back panel of the left-hand compartment of the cabinet.

SERVICE INSTRUCTIONS

Calibration Choke.

This is adjusted by the installing engineer when the vessel is calibrated. Upon the adjustment of this choke depends the accuracy of the Direction Finder, consequently it should not be altered unless the vessel is re-calibrated by a competent operator or engineer. Particular care should be taken to keep the terminals and connections tight. If the connections were broken or loose, there would be an error of anything up to five degrees which would not be apparent to the operator, and which could not be noticed until a number of faulty bearings had been taken.

Receiver Adjustments.

Equipment Required.

Standard signal generator calibrated at 175, 300, and 620 kc. Output meter capable of reading 50 milliwatts across 20,000 ohms. Plug the output meter into either of the phone jacks.

I-F Amplifier.

Connect the high side of the signal generator through a 0.1 uf condenser to the 1A7G grid; the other side directly to chassis. Set signal generator at exactly 175 kc with 30% modulation. Turn main tuning to minimum frequency, volume control at 10, C-W switch and speaker switch both off. Increase or decrease input from signal generator so that the receiver output is approximately 50 milliwatts. Then adjust the iron cores on the back sides of the i-f transformers (D89780 and D89781) for maximum output, meanwhile decreasing input from the signal generator so that the receiver putput remains approximately 50 milliwatts. These adjustments should be repeated several times.

When both transformers are properly adjusted, the sensitivity should be approximately 220 microvolts for 50 milliwatts output. With the signal generator connected to the i-f grid (1N5G) the sensitivity should be approximately 6,500 microvolts for the same output.

Beat-Frequency Oscillator.

With signal generator at 175 kc, unmodulated, connected to 1A7G grid, switch C-W on. Adjust the BEAT OSC iron core (on top of the chassis base to the left of the front section of the main tuning gang

adjustment should then be carefully locked by tightening up the locking nuts.

R-F Adjustment.

All r-f circuits are aligned to the main tuning scale at 620 kc by the trimmer condensers on top of the gang condenser, and tracked to the main tuning scale at 300 kc by the iron core adjustments on the tops of the r-f (D89767) detector (D-89775) and oscillator (D-89770) shield cans.

The front section of the gang condenser is the r-f section, the rear section is the detector and the middle the oscillator. The trimmer on top of the search tuning condenser should be aligned to the search tuning scale at 620 kc.

Disconnect the four outside loop leads from the terminal board on the calibration choke. Disconnect the two jumpers from the calibration choke to the fore-and-aft (yellow-green) goniometer leads. Disconnect the plain aerial from the "battery terminal" board.

Connect high side of signal generator through a 0.1 uf condenser to the "P" terminal of goniometer and the other side of signal generator to ground (i.e. chassis). Set RELATIVE BEARING pointer on goniometer at 0 degrees on fixed scale.

Increase or decrease input from signal generator while making adjustments so the receiver output is approximately 50 milliwatts.

Step No. 1

Set signal generator at 620 kc, 30% modulation.
" main tuning at 620 kc
" search tuning at 620 kc
" other controls as under "I-F Alignment"

Then adjust r-f, detector and oscillator trimmers on main tuning condenser and the trimmer on search tuning condenser for maximum output.

Step No. 2

Set signal generator at 300 kc, 30% modulation.
" main tuning at 300 kc
" search tuning at 300 kc (approx) and adjust this control for maximum output.

Then adjust r-f, detector, and oscillator iron cores for maximum output.

Repeat steps 1 and 2 several times until adjustment at one end of the scale makes little or no difference at the other end.

With these adjustments completed, the iron-core locking nuts should be carefully tightened and the following sensitivities obtained:

INPUT AT	620 kc	450 kc	300 kc
"P" & GND.	2 uv +/-25%	1.4 uv +/-25%	1 uv +/-25%
1N5G Grid (R-F)	38 " +/-25%	33 " +/-25%	22 " +/-25%
1A7G Grid (DET)	230 " +/-50%	280 " +/-50%	350" +/-25%

Balance Circuit Test.

Goniometer terminals on calibration choke panel to be free of connections.
Tap lead on inductance box at terminal 20.
Goniometer set at 0 degrees.
DF-SENSE switch at D-F.
Signal generator at 450 kc, 30% modulated,

Adjust main tuning and search tuning for maximum output.
All other controls as under "I-F Alignment".

With BALANCE full positive or full negative, sensitivity should be 350 uv +-25% for 50 milliwatts out.
The receiver outputs at full positive and full negative should be within 10% of one another.

Sense Circuit Test.

Goniometer terminals on calibration choke panel to be free of connections.
Goniometer set at 0 degrees.
DF-SENSE switch at SENSE.
Tap lead on resistance box at terminal 1.
Signal generator at 450 kc, 30% modulated, connected via standard dummy (or 250 uuf condenser) to aerial terminal.
Adjust main tuning and search tuning for maximum output.
All other controls as under "I-F Alignment".
Sense coupling coils set close together.

The sensitivity should be 10 uv +-50% for 50 milliwatts output.

Voltages - Currents.

Voltages measured with receiver ON.

H-T	90 volts 9 milliamps.
L-T	1.5 volts 300 milliamps.

PARTS LIST.

PART NO.	DESCRIPTION	MANUFACTURER	TYPE NO.
RESISTORS			
R1	Part of Coil & Resistor Ass'y No. 90232 (5,000, 2,000, 1,000 500 ohms - ½ watt)	I.R.C.	BT½
R2	.25 meg. ½ watt	"	"
R3	.2 meg. ½ watt	"	"
R4	.12 meg. ½ watt	"	"
R5	50,000 ohms, ½ watt	"	"
R6	35,000 ohms, ½ watt	"	"
R7	1 meg. ½ watt	"	"
R8	3 meg. ½ watt	"	"
R9	.25 meg. ½ watt	"	"
R10	.5 meg. ½ watt	"	"
R11	2 meg. ½ watt	"	"
R12	800 ohms, ½ watt	"	"

CONDENSERS

C1	442.2 uuf	Marconi	D-89766
C2	441.7 uuf	"	D-89782
C3	Trimmer (part of C2)	"	
C4	.05 uf, 200 v, Paper Tubular	Aerovox	
C5	.25 uf, 200 v, Paper Tubular	"	
C6	.05 uf, 200 v, Paper Tubular	"	
C7	441.7 uuf (2nd section of C2)		
C8	Trimmer (part of C7)		
C9	150 uuf +-20%	Aerovox	1468
C10	.1 uf, 200 v, Paper Tubular	"	
C11	645 uuf +-1%, Silver Mica	"	1469
C12	441.7 uuf (3rd section of C2)	"	
C13	Trimmer (part of C12)		
C14	175 uuf +-3%, Silver Mica.	Aerovox	1469
C15	175 uuf +-3%, Silver Mica.	"	1469
C16	.05 uf, 200 v, Paper Tubular	"	
C17	250 uuf +-20%	"	1468
C18	225 uuf +-3%, Silver Mica	"	1469
C19	.1 uf, 200 v, Paper Tubular	"	
C20	175 uuf +-3%, Silver Mica	"	1469
C21	175 uuf +-3%, Silver Mica	"	1469
C22	.01 uf, 400 v.	"	
C23	350 uuf +-20%	"	1468
C24	10 uf,	Marconi	D-89764
C25	.1 uf, 200 v, Paper Tubular	Aerovox	
C26	.02 uf, 400 v, Paper Tubular	"	
C27	.0025 uf, 400 v, Paper Tubular	"	
C28	.01 uf, 400 v, Paper Tubular	"	
C29	250 uuf +-20%	"	1468
C30	35 uuf +-3%, Silver Mica	"	1469
C31	2 uuf +-.5 uuf.	"	1468
C32) C33)	Line Filter	Cornell-Dubilier	IF-25
C34	Trimmer (part of C1)		

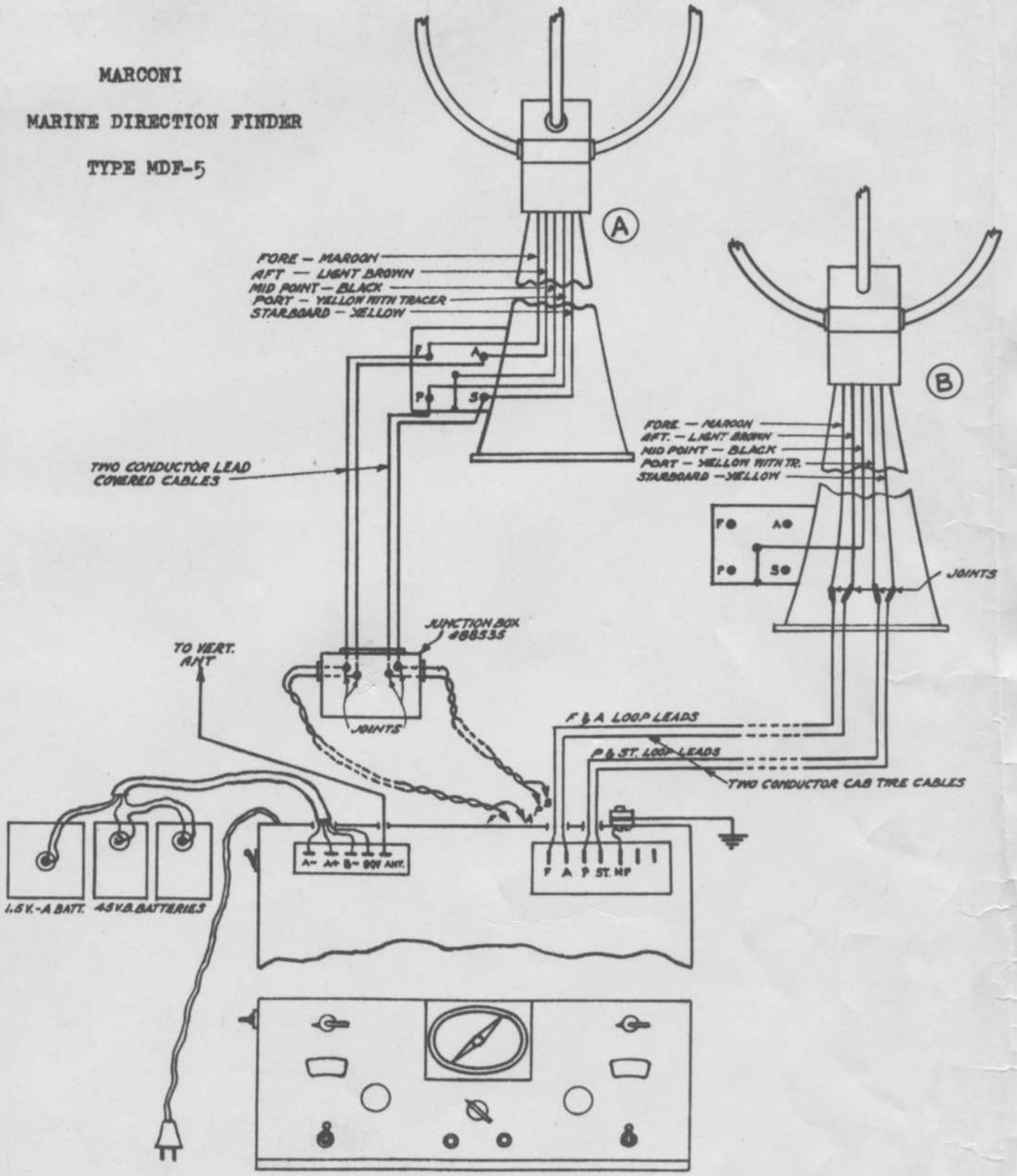
		NO.
INDUCTANCES & TRANSFORMERS		
Goniometer	Marconi	47763-A
Calibration Choke Ass'y.	"	89810
Coil & Resistance Ass'y.	"	90232
Balance Coil Ass'y.	"	89813
R-F Coil Ass'y.	"	D-89767
Det. Coil Ass'y.	"	D-89775
Osc. Coil Ass'y.	"	D-89770
1st I-F Trans. Ass'y.	"	D-89780
2nd I-F Trans. Ass'y.	"	D-89781
B-F-O Coil Ass'y	"	D-89778
Output Trans. Ass'y.	"	D-89784
Filament Choke Ass'y.	"	D-91447
SWITCHES		
Dial Light Switch, Toggle, S-P S-T, 3 amp, 110 v.- 1.5 amp, 220 v., BAT handle, lug type	H. & H.	
C-W Switch	Marconi	86655
On-Off Switch (on vol. control D-89783)		
D-F - Sense Switch	Marconi	D-89785
Speaker Switch, S-P D-T Lug type, BAT handle,	H. & H.	
VALVES		
R-F Amplifier	R.V.C.	1N5G
Converter	"	1A7G
I-F Amplifier	"	1N5G
Detector	"	1H5G
Output	"	1T5GT
C-W Oscillator	"	1G4G
MISCELLANEOUS		
Valve Sockets, Octal,	Marconi	68087
Socket, Candelebra	H. & H.	321
Dial Lights, 6-watt, 120 v., Mazda clear, candelebra base.	C.G.E.	S-6
Dial Lights, 10 watt, 220 v., Mazda clear, candelabra base.	"	S-8

MISCELLANEOUS (Cont'd)	MANUFACTURER	TYPE NO.
Terminal Board Ass'y for Battery Cable	Marconi	89809
Battery Cable Ass'y	"	D-89788
Fuse Cutout, D.P. Electrolier	C.G.E.	705
Fuses, 1 amp.	"	132765
Dial Light Line Cord	Marconi	89817
Knob - Tuning	Harry Davies	3000
" - DF-Sense	"	2110-P
" - Balance	"	2350 (black)
" - Volume	"	2350 (black)
" - Goniometer, large	"	50356
" - Goniometer, small	"	50357
Phone Jack, Imp. short.	Utah Carter	1
Tube shield caps	Goat	G-834
Tube shields	"	G-1224-D
Dial plate - main tuning	Marconi	89839
Dial plate - search tuning	"	89700
Dial friction Drive Ass'y.	"	89830
Loudspeaker	"	D-89784
Thumb screw - front panel	"	53852

MARCONI

MARINE DIRECTION FINDER

TYPE MDF-5



(A) FOR LEAD COVERED PAPER INSULATED CABLES

(B) FOR CAB TIRE CABLES.

INTER-UNIT CONNECTIONS
RECEIVER TO LOOP – M.D.F-5

MARCONI

MARINE DIRECTION FINDER

TYPE MDF-5

Number 1

Loop Assembly

MARCONI

Number 2

MARINE DIRECTION FINDER

TYPE MDF-5

External View

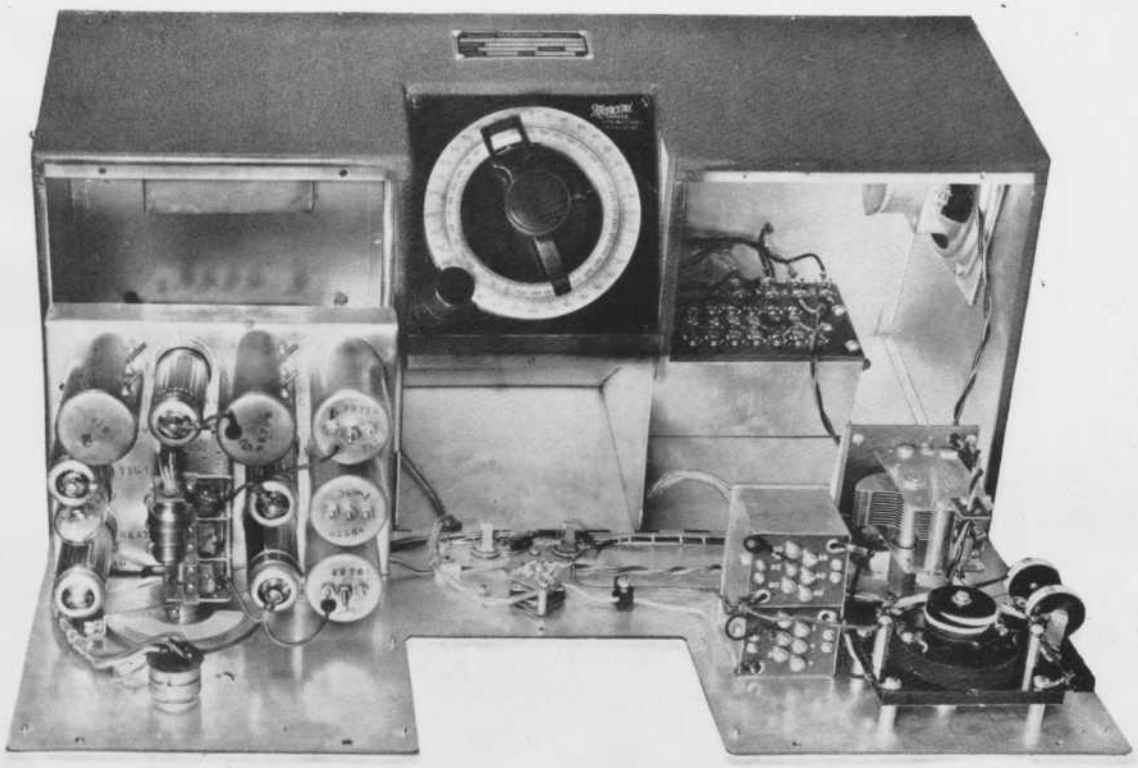
DIRECTION FINDER RECEIVER

MARCONI

MARINE DIRECTION FINDER

TYPE MDF-5

Number 3



Interior View - Front Panel Open

DIRECTION FINDER RECEIVER