D/F OUTFITS FM 11 & 12

LA27

1. GENERAL.

D/F Outfits FM11 and FM12 are ships L/F and M/F direction-finding sets working on the Bellini-Tosi principle and employing fixed frame aerial systems. They differ in the frequency range covered and the input circuit of the receiver.

Outfit FM11 is fitted in submarines and Outfit FM12 is fitted in trawlers and above.

The following table gives brief details of the sets:-

	FM11.	FM12.
Date of Design:-	1943	1942
Receiver used:-	FMA	FMB
Frequency range:-	15/580 kc/s.	42/1060 Kc/s.
Type of Aerial:-	Frame Coil S21, with submarines fixed aerial as Sense Aerial.	Frame Coil S19 or S22 with a vertical 30/40 feet single wire as Sense Aerial.
Power Supplies:-	Single phase A.C. at 230V.50-cycles	Single phase A.C. at 230V.50-cycles.
Power Consumption:-	60 Watts.	60 Watts.

Photographs of Receiver FMA/FMB are given in Figs. a and b and simplified diagrams of input circuits in Figs. d and e.

A simplified circuit diagram of receiver is given in Fig. f.

2. CONSTRUCTION.

The receiver is built in a sheet metal cabinet, the upper part of the front panel being sloped backwards in order to allow the tuning dial and radiogoniometer to be more easily read. A number of the minor controls are grouped at the back of the top cover of the cabinet, which also contains the access door through which all valves (except the sense valve) are reached (Fig. b). The sense valve is accessible through a cover plate at the bottom left-hand corner of the front panel.

Included in the receiver assembly is a power pack, Radiogoniometer S33, Inductance correcting unit, gyro motor and filter circuit, sense aerial relay, an internal loudspeaker and a variable Noise-Suppressor, for use with an R.I.S. Outfit, in ships in which this is fitted.

The overall dimensions and weight of the receiver are as follows:-

Width	25 inches.
Height	23½ inches.
Depth	18 inches.
Weight	2 cwt. 11 lbs.

The receiver is mounted on a shock absorbing mounting designed for bench mounting. It has detachable front, side and rear cover plates which may be removed when access to components of the receiver other than valves is required. No components are fitted to the cover plates and provision is made to facilitate the easy removal of all knobs.

The interior of the receiver is arranged as a number of self-contained units, i.e. sense box, power pack etc., all connections between these units being made by leads terminating in plugs and sockets. They have been colour-coded so that the removal and replacement of a defective unit is a simple matter

3. CONTROLS AND FITTINGS.

INDUCTANCE CORRETOR SWITCH (9). Controls the amount of inductance that is shunted across the Fore and Aft loop and serves to reduce the quadrantal error due to the ships' magnetic field. The switch has 25 positions and the correct setting of the switch, for any frequency, is determined when the D/F outfit is calibrated.

LOOP SWITCH (10) Connects the aerials to the appropriate field coils of the goniometer, or alternatively, earths either or both the D/F loop aerials as required. It has four positions.

1. Both aerials connected to appropriate field coils of the goniometer.
2. Fore and Aft loop connected. Port and Starboard loop earthed.
3. Port and Starboard loop connected. Fore and Aft loop earthed.
4. Both loop aerials earthed.

It is used when testing and calibrating the set.

D/F OUTFITS FM11 & 12
RECEIVERS FMA & FMB

FRONT VIEW

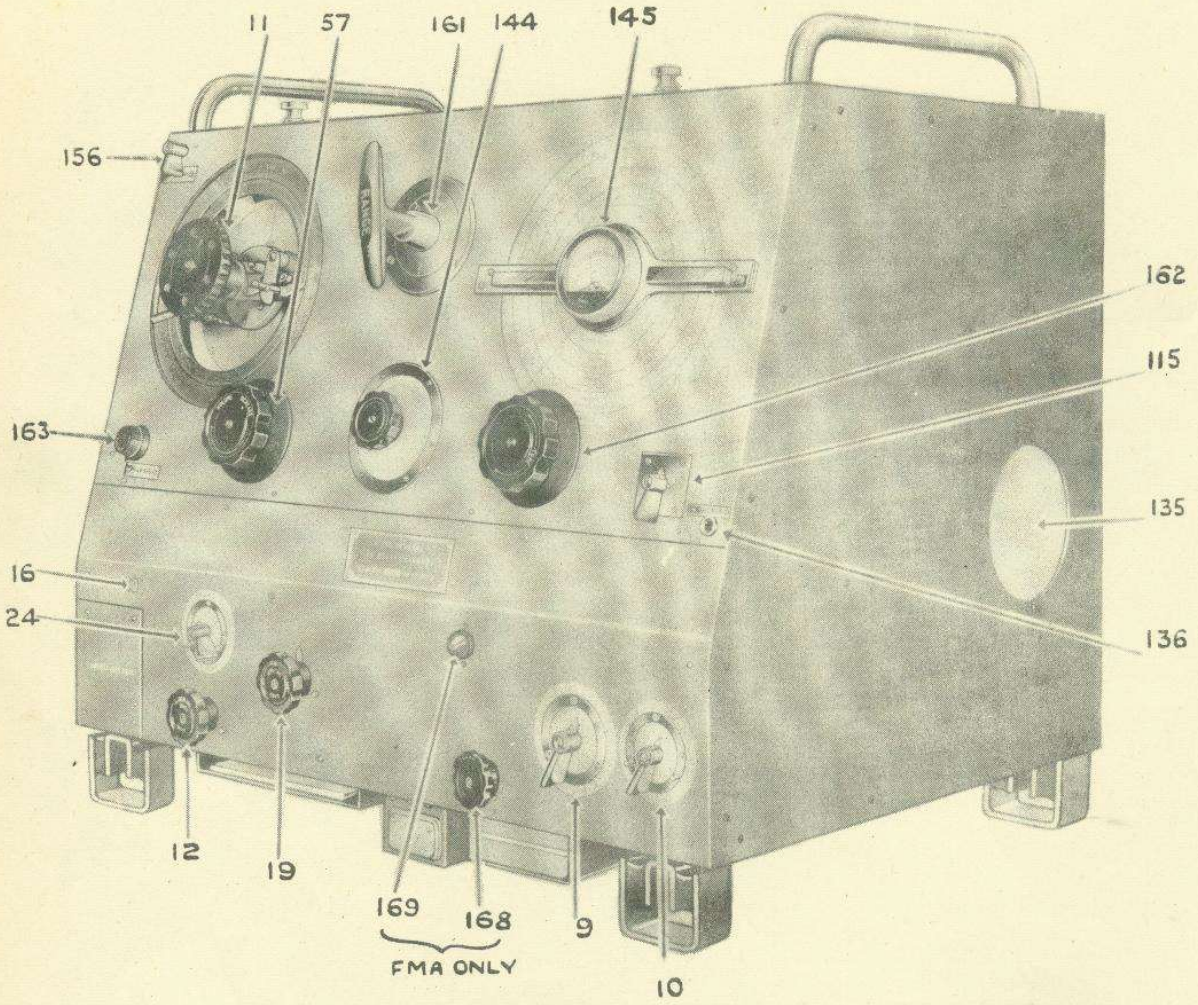

FIG. a

TOP VIEW

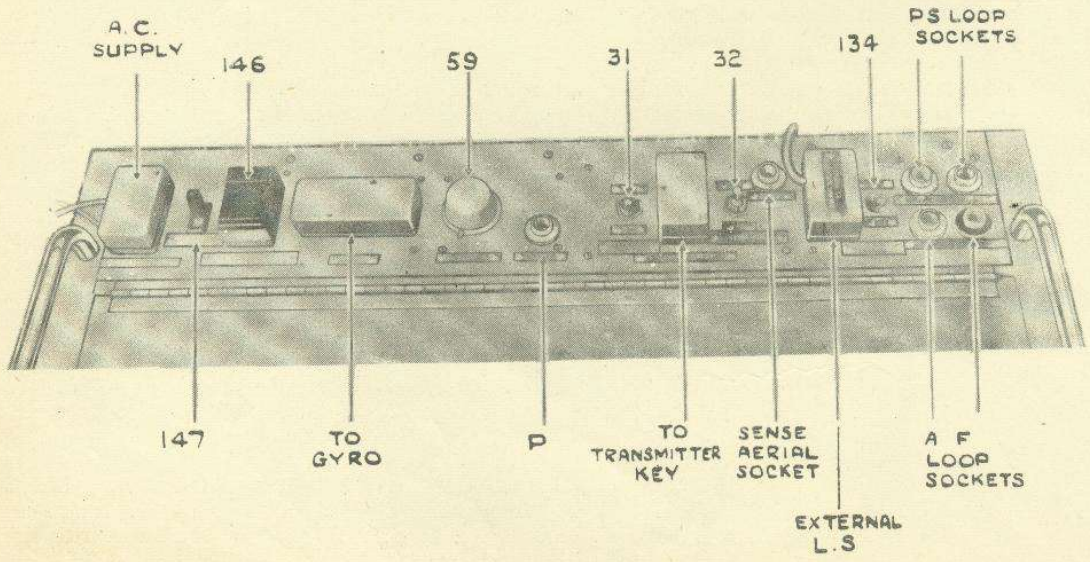

FIG. b

RADIOGONIOMETER POINTER (11) — Revolves the search coil of the radiogoniometer when taking bearings.

SENSE OUTPUT CONTROL (12) — Used to control the output from the sense valve to give a well-defined sense minimum. It varies the amplitude of the signal applied to the Search coil circuit from the Sense Valve. The adjustment is fairly critical but once it is obtained no change is required unless a large change in frequency is made (See para. 5).

SEMI-CIRCULAR CORRECTOR (19). — Is used to obtain a well-defined minimum when taking a bearing. When not in use, it must be set at zero position, i.e. pointer upwards.

AERIAL SWITCH (24) — Has 4 positions marked "Search", "Loops", "Corr" and "Sense", is used to connect the receiver to the required aerial circuit. (See para. 9(a)).

RELAY SWITCH (31) — When the receiver is in use and a transmitter in the ship commences operating, the Sense Aerial is earthed by a relay operated from the transmitter. This relay may be disconnected when necessary by the Relay Switch.

SENSE AERIAL SWITCH (32) — Is used to earth the Sense Aerial when the receiver is not in use.

VOLUME CONTROL (57) — Varies the cathode bias applied to the second and third R/F valves by means of a potentiometer.

R.I.S. CONTROL POTENTIOMETER (59) — Is used with an R.I.S. outfit in ships in which this is fitted.

HET. SWITCH (115) — Has 3 positions marked "OFF", "1" and "2" introduces the Beat Frequency Oscillator when receiving C.W. With switch in position 2 the amplitude of the oscillations produced by the B.F.O. is reduced. (See para. 9(f)).

INTERNAL LOUDSPEAKER "ON-OFF" SWITCH (134) (Marked-Internal L.S.) — Switches on and off the loudspeaker (135) built into the receiver assembly. Provision is also made for connecting an external loudspeaker.

LOUDSPEAKER (135) — The loudspeaker built into the receiver assembly and is controlled by the Internal Loudspeaker Switch (134).

PHONES (136) — The telephone plug is inserted into the Telephone Jack, marked "Phones", when tuning or operating the receiver.

METER SWITCH (144) — Switches the Test Meter (145) into the required circuit. It has 7 positions; 1 to 5 the meter reads the anode current of the 1st R/F, 2nd R/F, 3rd R/F, Detector and A/F valves. In "Output 1" and "Output 2" positions; the meter reads the A/F component of the anode current in the output valve thereby measuring the strength of a signal. "Output 2" gives a higher sensitivity than "Output 1". (See para. 7).

TEST METER (145) — is mounted at the centre of the Tuning Dial, which is calibrated in approximate frequencies. This meter can be connected as an Output Meter to assisting in the determination of the sense of a signal (when this cannot readily be determined aurally) and may also be connected by means of a switch (144) to read the anode currents of the R/F, detector and A/F valves. (See para. 7).

SUPPLY SWITCH (147) — makes and breaks the A.C. supply to the Mains Transformer. The supply is also broken when the access door on top of the receiver is open.

GYRO MOTOR SUPPLY SWITCH (156) — Used for switching on and off the Gyro Motor. It is used when resetting the Gyro Scale on the Radiogoniometer Dial Bearing Indicator (See para. 8).

RANGE SWITCH (161) — Operates a turret drum when shifting from one frequency range to another. There are 5 frequency ranges in each receiver.

TUNING CONTROL (162) — Operates a five-gang condenser for tuning within the frequency range set by the Range Switch (161).

GYRO SCALE RESET KNOB (163) — when pushed in, engages the Gyro Scale on the goniometer and allows the scale to be varied to be in step with the Master Gyro Compass. It is used when setting or resetting the gyro scale and is fitted with a return spring which disengages the knob from the Gyro Drive when the knob is released (see paragraph 8).

MATCHING TRANSFORMER SWITCH (168) (FMA ONLY).	Connects the submarines' loop aerial via the matching transformer (167) to the input of the receiver. Used when the receiver is being operated for submerged reception.
WARNING LAMP (169) (FMA ONLY).	Lights when the matching transformer (167) is connected to input of receiver. Provides a warning that the receiver cannot be used for direction finding while the lamp is alight.
TERMINAL BOX (170)	Situated on the base of the receiver assembly and is used to provide the connection between the submarines' loop aerial and the matching transformer switch (168).

4. TUNING AND OPERATION.

The procedure for operating the D/F Outfit is as follows:-

(i) Make the Supply Switch (147).

(ii) Set the Aerial Switch (24) to the "SEARCH" position and the Semi-Circular Corrector (19) to its zero position, i.e. upright.

(iii) Set the Inductance Corrector Switch (9) to the frequency in use, as stated in the Report of Calibration.

(iv) Set the Range Switch (161) to the required frequency band.

(v) Set the HET. switch (115) to position "1".

(vi) Set the Tuning Control (162) to the required frequency as shown on the calibration scale.

(vii) Tune either side of the indicated position until the signal is heard. If the signal received is I.C.W., set the HET. Switch (115) to "OFF", otherwise leave it at position "1".

(viii) Set the Volume Control (57) to give reasonable signal strength in the telephones. The signal should not be too loud.

(ix) Set the Aerial Switch (24) to the "Loops" position and obtain bearing (or reciprocal) by adjusting the goniometer pointer to a position of minimum signal strength. Increase the setting of the Volume Control (57) if necessary. Note the gyro and relative bearings, reading from the white pointer if the cam corrector is in use, otherwise from the black pointer.

(x) Set the Aerial Switch (24) to "Sense" (this operation brings in the sense aerial and the strength of signals should increase). See that the Sense Output Control (12) is in the working position. If the working position is not known it should be obtained as instructed in para. 5.

(xi) Turn the Goniometer Pointer (11) clockwise but not more than 90°. If the signal strength decreases when the pointer is rotated clockwise, the bearing on which the pointer was trained (i.e., the bearing noted in operation (ix)) is the true bearing. If however, the signal strength increases, the bearing noted is the reciprocal and the Goniometer Pointer should be turned through 180° from that position and trained on the true bearing before proceeding with the next operation. If the sense indication is poor, check the setting of the Sense Output Control (12) as detailed in para. 5.

(xii) Set the Aerial Switch (24) to the "Corrector" position and adjust the Semi-Circular Corrector (19) until a well-defined minimum is obtained, keeping the goniometer pointer trained on the true bearing. This procedure will give a well-defined minimum with a blurred reciprocal.

(xiii) Read off the gyro and relative bearing and, if time permits, check the sense.

(xiv) If the Cam Corrector is not being used, apply correction for quadrantal error from the curves provided. (See Note (ii) below).

NOTES:-

(i) The minimum obtained in operation (ix) may be good enough to allow the omission of operation (xii).

(ii) To avoid confusion when applying correction to relative bearings, as opposed to gyro bearings, the following rule is recommended:-

Apply all POSITIVE corrections CLOCKWISE and all NEGATIVE corrections ANTI-CLOCKWISE along the scales concerned, irrespective of whether gyro or relative bearings are being corrected.

It should be noted that the sign of the correction given by the curves is arranged for application direct to the gyro reading. If the gyro is out of action and relative bearings are being reported, the sign of the "RED" correction must be reversed if the correction is to be applied numerically. The rule recommended above makes it unnecessary to reverse the sign.

5. PROCEDURE FOR OBTAINING WORKING POSITION OF SENSE OUTPUT CONTROL (12).

(i) Set the Aerial Switch (24) to the "Loops" position and train the Goniometer Pointer (11) on the true bearing.

(ii) Set the Aerial Switch (24) to "Sense" and turn the Goniometer Pointer 90° in a clockwise direction.

(iii) Adjust the Sense Output Control (12) until the Signal strength is a minimum. If the goniometer pointer was trained on the reciprocal bearing in (i) above, no sense minimum will be found and the goniometer pointer should be turned through 180°. The sense minimum is very pronounced and it is not likely to be confused with normal variations in signal strength caused by adjusting the the Sense Output Control. The adjustment is fairly critical, but once it is obtained no change is required unless a large change in frequency is made.

6. PROCEDURE FOR OBTAINING SNAP BEARINGS.

When taking bearings of a station which has already been tuned-in and which is only working for short periods, the Aerial Switch (24) may be left in the "Corrector" instead of the "Search" or "Loops" position, thereby reducing the number of switch movements. Care should be taken to see that the Semi-Circular Corrector (19) is set to its zero position, i.e. upright, when not in use.

7. USING THE TEST METER.

The procedure for obtaining bearings by using the Test Meter is exactly the same as that described in para. 4 above, only the signal strength is now indicated on the Test Meter (145) as well as being audible.

The Meter Switch (144) must first be put to the "Output 1" position. This is the less sensitive of the two "Output" positions of the switch, the more sensitive "Output 2" should never be used unless a satisfactory bearing cannot be obtained on the first position.

The procedure to be adopted is as follows:-

(i) Tune the receiver to the signal as described in operations (i) to (vii) of para. 4 above.

(ii) Set the Aerial Switch (24) to "Loops".

(iii) Rotate the Pointer (11) of the radiogoniometer until a minimum is found. This will be shown by the Test Meter (145) reading zero, or very nearly so. This position of the radiogoniometer gives either the bearing or its reciprocal.

(iv) If the minimum thus obtained is not sharp, set the Aerial Switch (24) to "Corr", and adjust the Semi-Circular Corrector (19) until the smallest deflection of the Test Meter (145) is obtained.

(v) Set the Aerial Switch (24) to "Sense". This operation brings in the Sense Aerial and the strength of signals should increase. See that the sense output control (12) is in the working position. If the working position is not known it should be obtained as instructed in para. 5 above.

(vi) Turn the Goniometer Pointer clockwise but not more than 90°. If the signal strength decreases when the pointer is turned, the bearing on which the pointer was trained in operation (iii) was the true bearing. If, however, the signal strength increases as the goniometer is turned clockwise, the bearing found was the reciprocal and the goniometer should be trained on the true bearing. If it is found that the signal is too weak to give a good deflection of the Test Meter (145) or a clean minimum cannot be obtained, reduce the gain of the receiver by means of the Volume Control (57) and set the Meter Switch (144) to the "Output 2" position. Care must be taken to ensure that the meter is never overloaded; it should be used only in conjunction with the telephones. Except when actually in use for D/F purposes, the Meter Switch (144) should be set so that the meter reads the anode current of one of the valves.

8. GYRO RESETTING.

If it is found that the gyro scale on the radiogoniometer dial bearing indicator is out of step with the master gyro compass, the following procedure is necessary.

(a) Switch off gyro meter by the Gyro Motor Supply Switch (156).

(b) Push in Gyro Scale Reset Knob (163) and engage it with the gyro drive. Turn the knob until the correct setting of the dial is obtained.

(c) Release the knob and switch on the gyro meter.

9. BRIEFF TECHNICAL DESCRIPTION.

Each receiver is a completely self-contained D/F assembly. The receiver itself comprises three stages of R/F amplification with tuned transformer coupling, a cumulative grid detector, a beat frequency oscillator, and one state of A/F amplification. A single tuning control tunes all stages including the beat frequency oscillator. The tuning dial is calibrated in kc/s, the range in use being illuminated by a dial light. A five position range switch (161) operates a turret drum containing the R/F and beat oscillator coils and trimming condensers to cover the frequency range of the receiver.

D/F OUTFITS FM 11 & 12

EQUIVALENT INPUT CIRCUITS

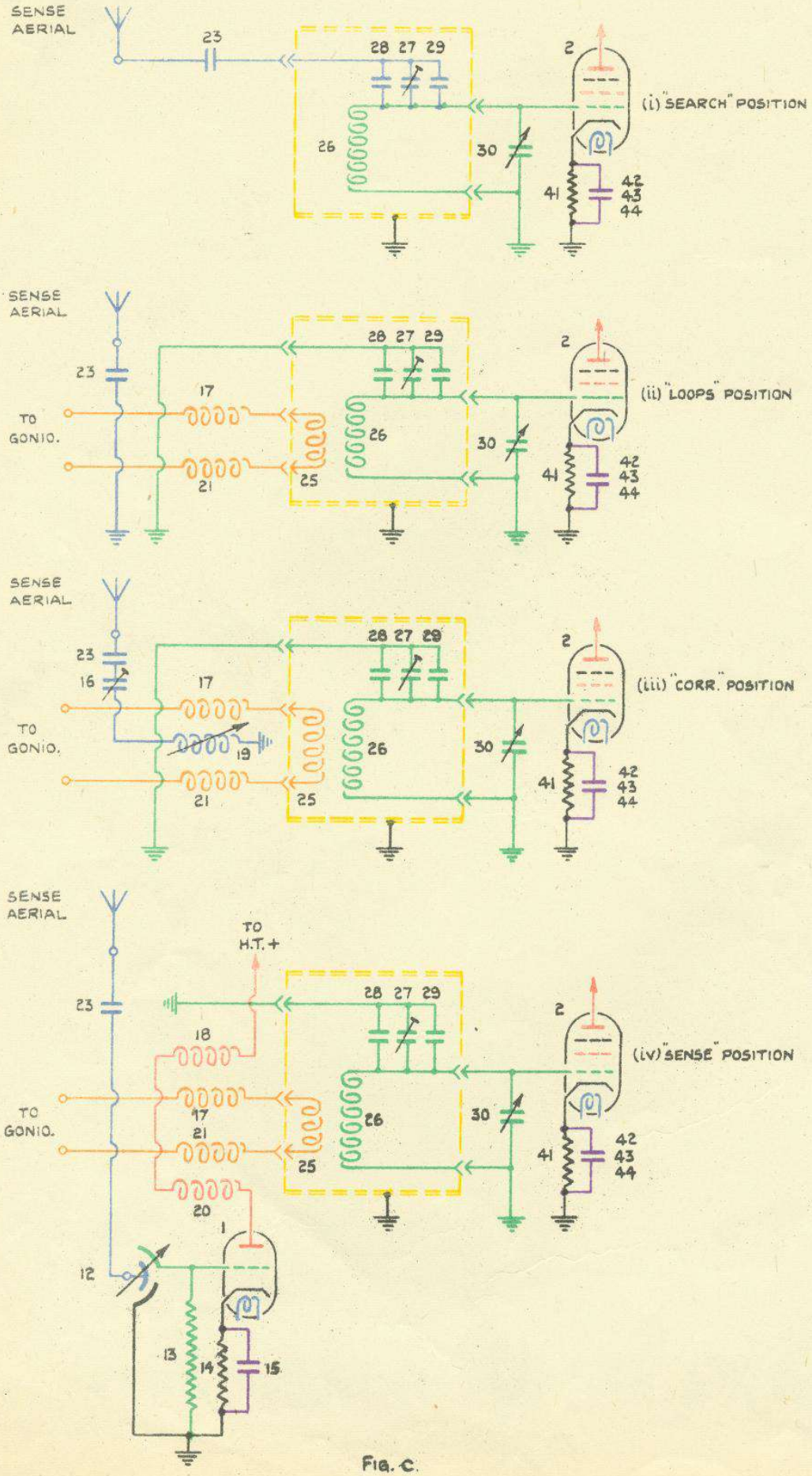

Fig. C.

(a) Input Circuits.

The arrangement of the input circuits of the receiver is determined by the setting of the Aerial Switch (24), as described below (See Figure c).

With the Aerial Switch (24) set at "Search" Fig. c (i), the Sense-Search Aerial is connected to the grid of the First R/F Valve (2) through a fixed aerial series condenser (23) and three parallel condensers (27 to 29).

In all other positions of the aerial switch (24), the aerial side of these parallel condensers (27 to 29) is earthed, thus connecting these condensers in parallel with the 1st R/F Tuning Condenser (30).

With the aerial switch (24) set at "Loops" Fig. c(ii), the Sense -Search Aerial is earthed and the radiogoniometer Search Coil is permanently connected to the Primary Winding (25) of the Input R/F Transformer so that bearings can be taken.

With the aerial switch (24) set at "Corr". Fig. c (iii) the Sense-Search Aerial is connected to the moveable winding (19) of the Semi-Circular Corrector through the aerial series condenser (23) and a Pre-Set Condenser (16). When calibrating the set, correction for a blurred zero due to the semi-circular effect of the Ship's magnetic field may be obtained by adjustment of the semi-circular corrector control (16).

With the Aerial Switch (24) set at "Sense" Fig. c (iv), the Sense-Search Aerial is connected to the grid of the sense valve (1) via the Aerial Series Condenser (23) and the Sense Input Differential Condenser (12).

The Sense Valve (1) has, in its anode circuit, two coils (18 and 20) which are coupled to the search coil circuit inductances (17 and 21) of the semi-circular corrector.

A signal, in phase or anti-phase with that obtained from the radiogoniometer, is thereby injected into the search coil circuit, which enables the true direction of the transmitting station to be obtained.

In receiver FMA , (Fig. d) a five pole, two position switch allows the submarines loop aerial to be connected to the receiver for submerged reception. A matching transformer is introduced in order that the impedance of the loop aerial will correspond with the input impedance of the receiver, and thus allow a given signal to be received at a considerably greater depth under water.

Two poles of the switch connect the loop aerial to the primary of the transformer. A further two poles connect the secondary of the transformer to the sense unit and thus to the receiver. A fifth pole connects a warning lamp 169, into circuit as an indication that when the lamp is alight the receiver cannot be used for direction finding. The lamp is supplied from the heater circuit of the receiver through a small voltage dropping resistance 166.

With the switch 168 in the "OFF" position, the warning lamp circuit is broken the primary winding of the matching transformer disconnected and the loop aerial earthed, and the secondary winding disconnected and the search coil connected to the receiver.

The Matching Transformer Unit is a component of receiver FMA only.

(b) First R/F Amplifier.

The First R/F Amplifier stage uses an R/F pentode valve (2) (NR64).

The tuned circuit, which is connected between grid and earth, consists of the secondary winding (26) of the input R/F transformer shunted by a section of the tuning condenser (30).

The anode of the valve is connected to the H.T. supply line through the primary winding (47) of the second R/F transformer. The secondary winding (48) is in the grid circuit of the second R/F amplifier.

(c) Second R/F Amplifier.

The second R/F amplifier stage which is transformer coupled to the 1st stage uses a triode hexode valve (3) (6K8G), with the triode grid and anode strapped together, thus forming an injector grid.

The injector grid is connected to the suppressor control potentiometer (59) for use in ships fitted with R.I.S. outfit.

(d) Third R/F Amplifier.

The third R/F Amplifier Stage which is transformer coupled to the 2nd stage uses an R/F pentode valve (4) (NR64).

The output of the beat oscillator valve (6) is capacity coupled to the suppressor grid of valve (4).

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RECEIVER FMA - INPUT CIRCUIT

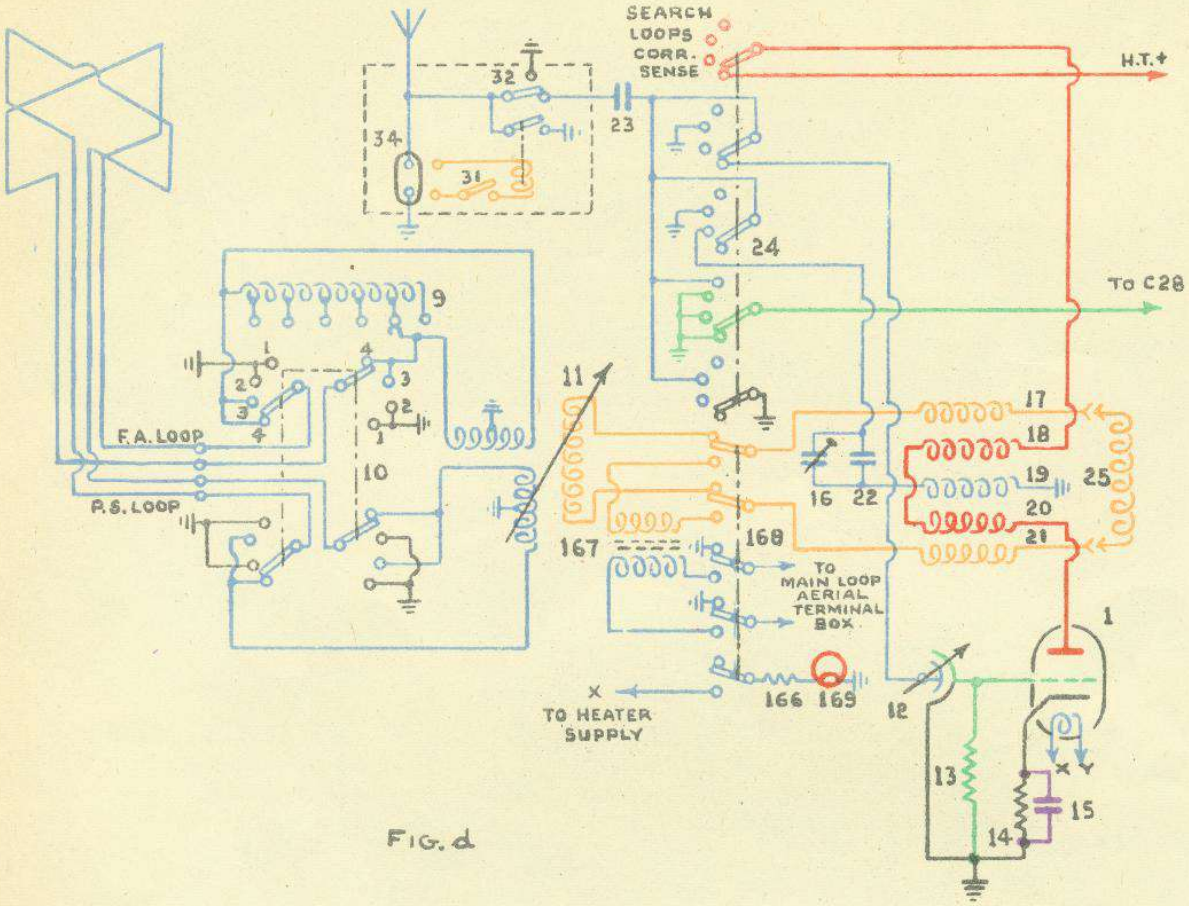

FIG. d

RECEIVER FMB - INPUT CIRCUIT

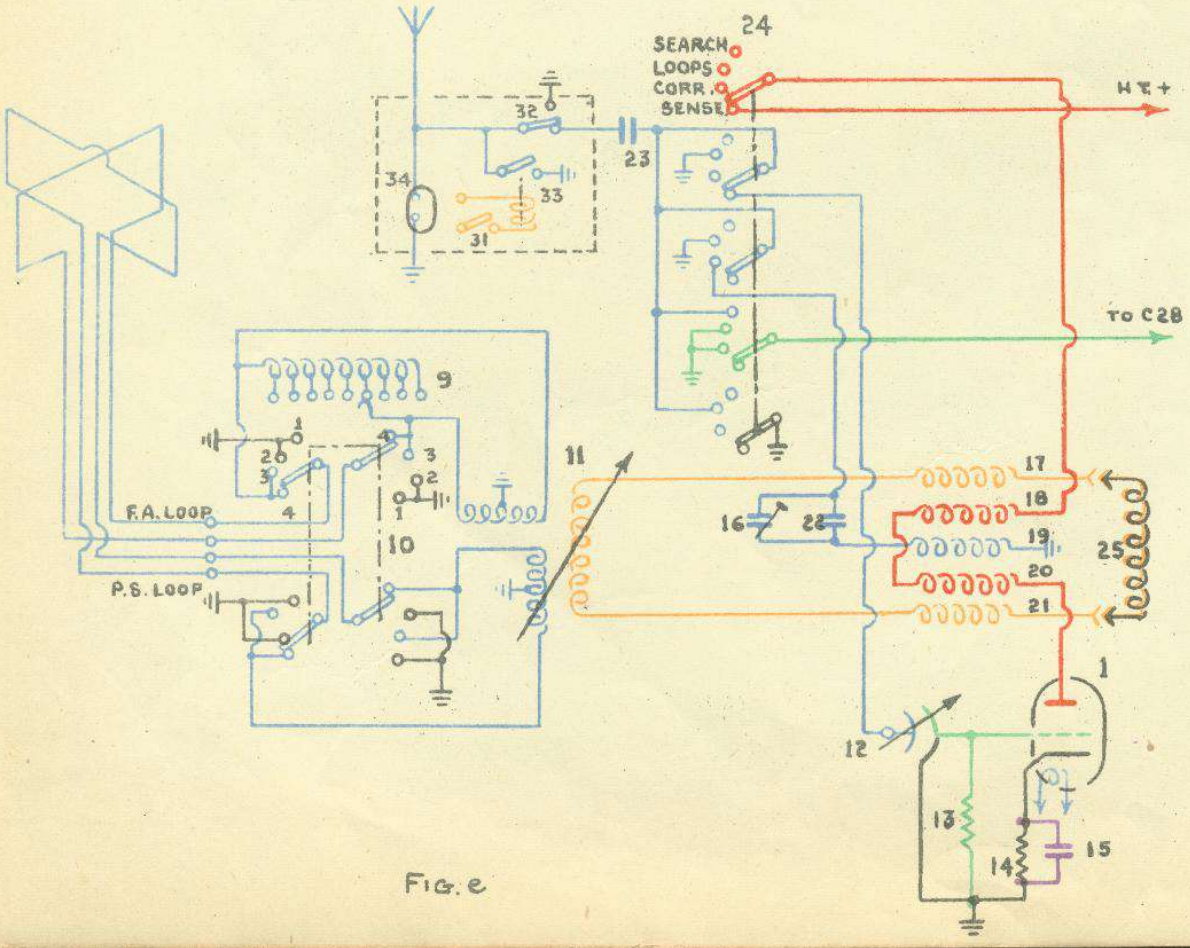

FIG. e

(e) Detector.

The detector stage which is transformer coupled to the 3rd R/F stage employs an R/F pentode valve (5) (NR64) and a tuned grid circuit.

(f) Beat Oscillator.

The beat oscillator stage employs a triode valve (6) (NR78) with a tuned circuit connected between grid and cathode and using mutual inductive feed-back to render the circuit self-oscillatory.

The anode of the valve is taken to the H.T. supply line through two resistances (118 and 117) and the HET switch (115) which has three positions changing the circuit as follows:-

"OFF"	Anode of valve not connected to H.T. supply.
"1"	Top of decoupling resistance (117) connected direct to H.T.
"2"	Top of decoupling resistance (117) connected to H.T. through a resistance (55).

When the HET. switch (115) is in positions "1" or "2", the anode of the beat oscillator valve (6) is capacity-coupled to the suppressor grid of the 3rd R/F valve (4).

(g) A/F Amplifier.

The A/F amplifier stage employs a tetrode valve (7) (6V6G) the grid of which is resistance capacity-coupled to the detector valve (5).

To the high resistance speaker terminal is connected a potential divider consisting of 2 resistances and a condenser, the junction of the 2 resistances being taken to the "High and Low Resistance Phones" terminal and to the Telephone Jack (136).

The secondary winding of the output transformer (125) is connected to the "Low Resistance Speaker" terminal and to the Internal Loudspeaker (135) via the loudspeaker switch (134).

(h) Sense Valve.

The sense valve (1) (NR78) is a triode valve, which gives a current in the Sensefinder windings (18 and 20) in phase with the aerial voltage.

These windings are wound on the same former which carries the semi-circular corrector coils (17 and 21) so as to be coupled with the latter.

The effect of the sense valve (1) is therefore to introduce into the search coil circuit a current which is in phase or anti-phase with that produced by the signal in the loops, thus giving the usual cardioid characteristic.

When the aerial switch (24) is set to "Sense", the Sense-search aerial is connected to the grid of the sense valve (1) through a differential condenser (12), labelled "Sense Output". This condenser serves as an input volume control for the sense valve.

(i) Frame Coils S19/S22.

These two Frame Coils are similar except in size of loops. Each coil consists of two unequal sized rectangular tubular frameworks disposed accurately at right angles and mounted as a common upright. The fore and aft loop consists of two turns in series, and the port and starboard loop three turns in series, of rubber insulated cable wound on Tufnol spacers fixed at each corner of the loops.

Frame coils S19/S22 are normally fitted on a bracket mounted on the forside of the bridge structure as high as possible without fouling the line of sight from the bridge.

Frame coil S19 will in general be fitted in cruisers and above and S22 in flotilla leaders and below.

Frame coil S21 consists of two unequal sized triangular tubular frameworks disposed accurately at right angles and are mounted on a short pedestal on the casing of a submarine abaft the bridge structure.

(j) Sense Aerial.

With D/F receiver assembly FMA, in submarines, the sense aerial connection is made to the aerial exchange in order that the submarines fixed aerial may be used for this purpose.

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(k) Power Supply.

The H.T. and heater supplies are obtained from a power pack in the receiver, fed from a 230 volt A.C. supply. The current taken is 0·26 amps.

The A.C. supply is fed through a double pole supply switch (147) and fuses to the primary winding of a mains transformer.

This transformer has three secondary windings:-

(i) supplies the heaters of the receiving valves and dial lights at 6·3 volts.

(ii) supplies the anodes of the rectifier valve.

(iii) supplies the heater of the rectifier valve (8) at 5 volts.

The H.T. supply is smoothed by means of two electrolytic condensers and a choke.

10. CARE AND MAINTENANCE AND TESTS.

Full instructions for care and maintenance and routine tests are given in the Handbook S.S.106.

In general, however, the remarks given on pages LA20-24 apply equally to FM11, 12.

Places are provided on the base of the receiver assembly for stowage of a small tool case, supplied with the receiver, and for the Handbook.

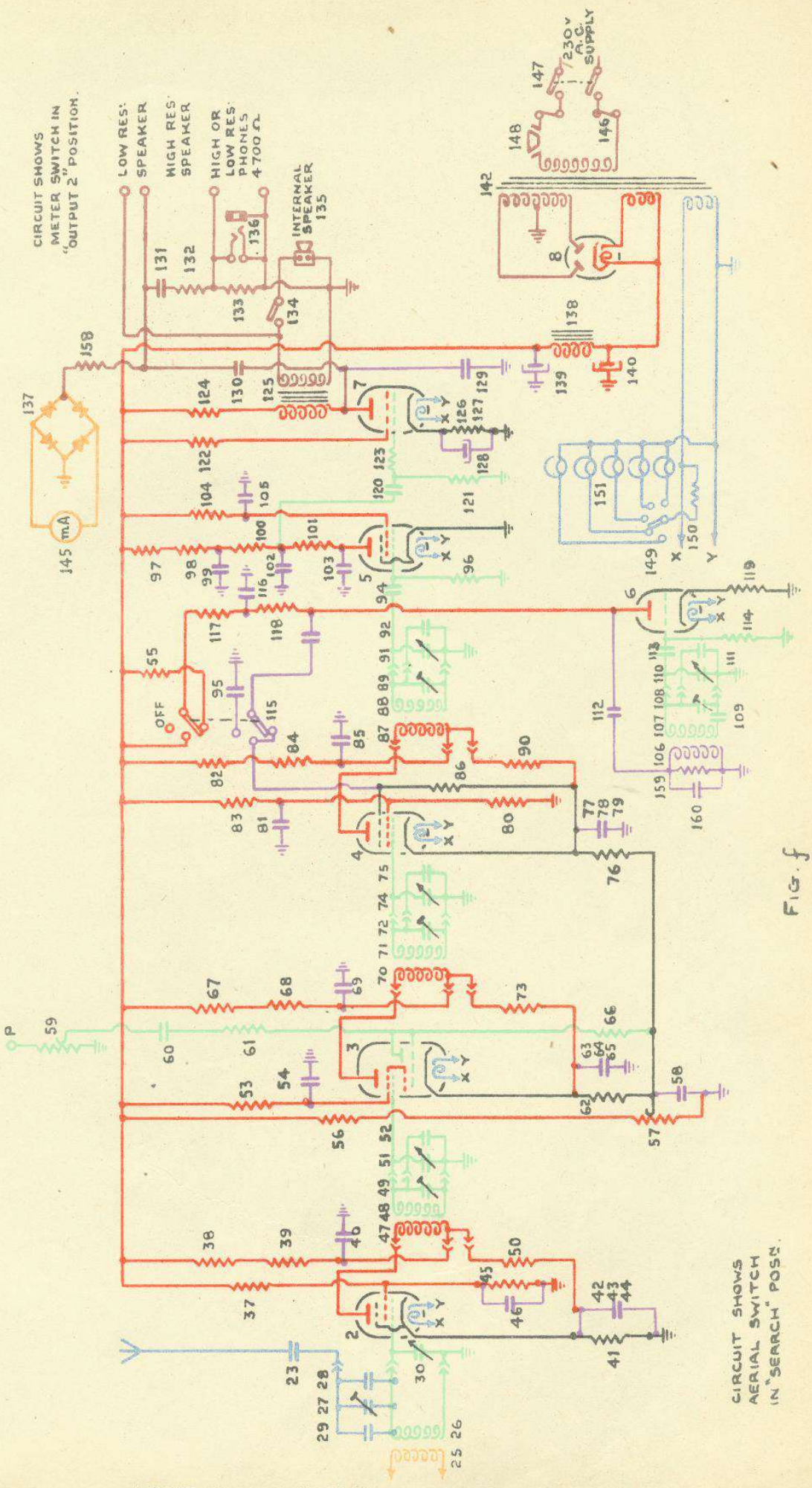
SIMPLIFIED CIRCUIT DIAGRAM
CIRCUIT SHOWS METER SWITCH IN "OUTPUT 2" POSITION.
LOW RES: SPEAKER
HIGH RES SPEAKER
HIGH OR LOW RES PHONES 4700Ω
INTERNAL SPEAKER 135
230V A.C. SUPPLY
OFF
mA
CIRCUIT SHOWS AERIAL SWITCH IN "SEARCH" POSN.
CONTINUED FROM FIG 4 OR 5 PAGE LA 34

Fig. 5