TECHNICAL DESCRIPTION

OF

TRANSMITTER TYPE T.1154

(Stores Ref. 10D/97)

RECEIVER TYPE R.1155

(Stores Ref. 10D/98)

RAAF (S4) 319/200/8/44

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TRANSMITTER TYPE T.1154 AND ACCESSORY EQUIPMENT.

RECEIVER TYPE R.1155.

TRANSMITTER TYPE T.1154

(Stores Ref. : 10D/97)

INTRODUCTION.

1. The transmitter type T.1154 is designed for use in aeroplanes to provide two-way, air to ground, or air to air communication, and is used in conjunction with receiver type R.1155. The T.1154 provides transmission on C.W., M.C.W., and R/T. Another version of this transmitter, the T.1154A (Stores Ref. : 10D/99) provides transmission on C.W. and M.C.W. only.

2. The transmitter T.1154 consists of a master oscillator stage driving two pentode valves in parallel, which form the output stage. A triode valve is used for modulation and sidetone. Power is obtained from two motor generators, one supplying H.T., and the other L.T. It should be noted that the latter motor generator also supplies H.T. and L.T. for receiver type R.1155.

3. The transmitter is designed to cover frequency bands of 10 Mc/s to 3 Mc/s, and 500 kc/s to 200 kc/s, the radiated frequency being stabilised by the master oscillator circuit. The frequency bands are divided into three ranges, viz. :

Range 1.	10 Mc/s — 5.5 Mc/s	(30 metres — 54.05 metres)
Range 2.	5.5 Mc/s — 3 Mc/s	(54.05 metres — 100 metres)
Range 3.	500 kc/s — 200 kc/s	(600 metres — 1,500 metres)

4. On Ranges 1 and 2 (H/F) each master oscillator stage is tuned by a variable condenser. The output circuits are tuned by variable condensers, and the aerial is matched by means of a tapped inductance. On Range 3 (M/F) the master oscillator stage is tuned by a variable condenser. The output circuit is tuned by means of a tapped inductance, fine adjustments being made by means of a sliding core. A third control, the Anode tap, adjusts the circuit for correct loading. All controls on Range 1 are coloured Blue, Range 2 Red, and range 3 Yellow.

5. A total of eight frequencies can be pre-selected in both Range 1 and 2, by click-stop mechanisms embodied in the master oscillator and output circuit tuning. A further eight frequencies are obtainable by a click-stop mechanism attached to the master oscillator control on Range 3. The eight frequencies in each range may be of any value within the frequency limits of that particular range, and a vernier adjustment is provided on the master oscillator click-stop mechanisms on Range 1 and 2. This vernier adjustment gives a frequency variation of plus or minus 0.1 per cent.

6. The overall dimensions of the transmitter in its case are approximately 17½ inches by 16⅜ inches by 11 inches. The weight of the transmitter complete with its suspension units and valves is approximately 45 lbs. The weight of the H.T. power unit complete with brackets is approximately 30 lbs. 4 ozs., and the weight of the L.T. power unit complete with brackets is approximately 27 lbs. 12 ozs.

GENERAL DESCRIPTION.

7. The action of the transmitter will be described with reference to the complete circuit diagram Fig. 21, but the principal features will be more easily understood with the aid of simplified theoretical diagrams Figs. 1 and 3. The same notation is employed in all diagrams.

8. The basic circuit is very simple and consists of a master oscillator stage V_1 coupled to two power amplifiers V_2, V_3 in parallel. On the two H/F Ranges 1 and 2, the output circuit consists of a parallel circuit tuned by variable condensers C_{15} and C_{16}, respectively. The aerial is matched to the anode by a tapping at a suitable point on the inductances L_4, L_5. A sufficient number of tapping points is available to enable any normal fixed or trailing aerial to be matched to the transmitter.

9. On the M/F Range 3 the aerial is tuned by means of a low loss tapped inductance, L_6, fine tuning for coverage between the taps being accomplished by permeability tuning. The aerial circuit is matched to the anode by tapping the anode of the output stage to a suitable point on the inductance. A sufficient number of aerial and anode taps is provided on the inductance to enable the full frequency range to be covered over a wide range of aerial capacities.

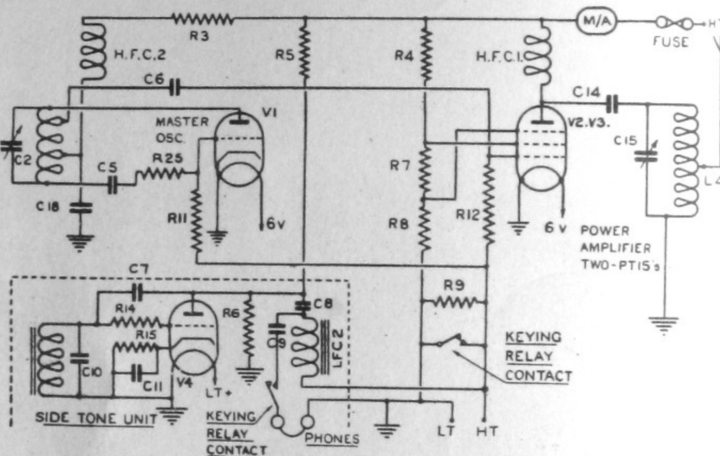


FIG. 1. Simplified diagram of Transmitter T.1154 using C.W. on Range 1.

10. A fourth valve V_4. performs several functions. When transmitting C.W. this valve is made to generate low frequency oscillations which are fed *via* a condenser C_9, and a pair of contacts on the keying relay to the telephones thus providing sidetone as a check to accurate keying. When transmitting on M.C.W. the oscillations from this valve V_4 are fed to the suppressor grids of the power amplifiers V_2, V_3, causing the output from them to be modulated at low frequency (approximately 1,200 cycles per second). Simultaneously, sidetone is provided as in the case of C.W.

11. On R/T transmission, the same valve acts as modulator ; variations in its anode voltage, due to speech at the microphone, being fed to the suppressor grids of the power amplifiers V_2, V_3. Speech sidetone is available in the telephones *via* the keying relay which, in this case is held in the TRANSMIT position during the period of speech transmission, by the manual depression of the morse key.

12. Either a carbon or an electro-magnetic microphone may be used for R/T transmission. The leads of the carbon microphone are connected direct to the microphone sockets which will be found on the front panel, immediately below the master oscillator

valve compartment. The electro-magnetic microphone is used in conjunction with amplifier A.1134 (Stores Ref. : 10A/11500). In this case the output from the amplifier is fed to the microphone sockets on the front panel.

13. When an electro-magnetic microphone is used, it is necessary to ensure that the small link switch engraved CARBON and ELECTRO-MAGNETIC is adjusted so that the engraving ELECTRO-MAGNETIC is showing (A, Fig. 2). The circuit changes effected by this switch are as follows :—

Carbon.

(i) The top end of the microphone transformer primary T, is connected to the positive side of the L.T. supply *via* choke LFC_3 and R_{27}.
(ii) The transmitter sidetone circuit is made.

Electro-magnetic.

(i) The top end of the microphone transformer is connected to earth.
(ii) The transmitter sidetone circuit is broken.

The adjustment of the link switch should be made before the transmitter is installed in an aircraft.

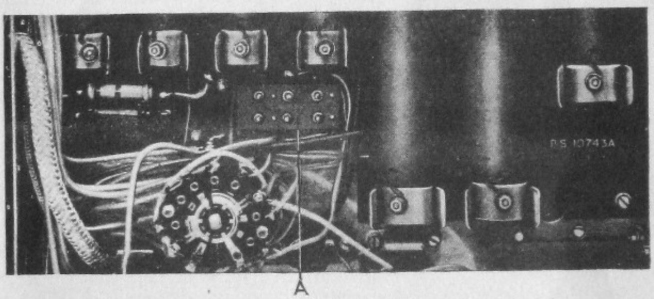


FIG. 2. Transmitter T.1154 back view of chassis showing carbon electro-magnetic microphone link panel (A).

14. When using amplifier A.1134, intercommunication is available between crew and operator, and sidetone is provided from the amplifier. The use of this amplifier is described in another publication.

Master Switch S5.

15. The switch S5 is divided into six sections F, G, H, J, L and M. The circuits affected by the switch in each of its positions are described in the following :

(i) *Off.* Both starting relay circuits of the H.T. and L.T. power units are broken, and the transmitter and receiver are therefore inoperative.

(ii) *Stand-Bi.* The starting relay system of the L.T. power unit is energized from the aircraft battery. The L.T. power unit supplies :—

(A) 6 volts to the heaters of both transmitter and receiver valves, there being no switching in the heater circuits.

(B) 6 volts for energizing one winding of the keying relay (coil A), thus drawing the relay over to the RECEIVE position. This relay connects telephones and aerials to the receiver.

(C) 220 volts approximately for receiver H.T.

Thus with the master switch in the *Stand-Bi* position the receiver becomes operative.

The energizing of the L.T. power unit relay is the only instance of the aircraft electrical supply being switched internally in the transmitter. Both L.T. and H.T. supplies for transmitter and receiver are derived from the outputs of the two power units, these units being driven off the main aircraft electrical supply. Thus the radio power supplies are totally isolated from the ordinary electrical service circuits of the aircraft.

(iii) *Tune*. The starting relay system of the L.T. power unit remains energized, this circuit being completed by section H of the master switch. The starting relay system of the H.T. power unit is energized from the 6 volt radio supply, *via* switch sections F and G which are connected in parallel. The aerial selector switch type J must be in any position with the exceptions of D/F or Earth, in order to complete the starting relay circuit of the H.T. power unit. See paragraph 31. The remaining two windings of the keying relay (coils B, C) are also completed so that when the key is pressed the relay snaps over to the TRANSMIT position, and there should be a reading on the feed milliammeter mA indicating the presence of H.T. When the key is pressed the relay short circuits R_9 thus connecting the power amplifier control grids V_2, V_3 —H.T. *via* R_{10}, and switch section L to earth. The resistance R_{10} develops a negative bias due to the total current drain flowing through it from the H.T. supply. The negative bias is applied to the suppressor grids of the two power amplifiers to limit the anode feed due to mal-adjustment during the tuning operation. Simultaneously the grid of the master oscillator V_1 is keyed to earth *via* an anti-parasitic resistance R_{25} and also the grid leak R_{11}. The anode circuit of the tone generator valve V_4 is coupled *via* C_7 to the grid of that valve through switch section J, thus starting the generation of L/F oscillations. These are fed to the telephones *via* C_9 and the keying relay, the telephone circuit being made and broken by the action of this relay, thus providing sidetone. The tone generating valve V_4 is producing oscillations all the time, although sidetone is heard in the telephones only when the key is pressed. By the action of the keying relay, " listening through " is available when the key is released. In the TUNE position of the master switch therefore, low power C.W. transmission will occur. Short distance communications and any setting up adjustments of the transmitter should be made with the master switch in this position.

(iv) *C.W.* The L.T. energizing circuits of the two power units are maintained so that H.T. and L.T. continue to be supplied to transmitter and receiver. The resistance R_{10} is short circuited *via* switch section J, thus dispensing with its negative bias. In this way the anode volts on the power amplifiers V_2, V_3 are increased by the value of bias volts normally developed when R_{10} is in circuit. The suppressor grids have a positive bias which results in full power C.W. transmission. The sidetone circuits remain unaltered. It should be noted that as the generation of L/F oscillations is completely independent of transmission, sidetone strength or quality give no indication of transmission strength or quality. This is mentioned as in some aircraft equipments the sidetone circuits are directly associated with the transmitter output, in which case weak transmission results in weak sidetone. By the action of the keying relay " listening through " is available when the key is released.

(v) *M.C.W.* The short circuit is removed from R_{10} by switch section J, and a negative bias imposed on the suppressor grids of the power amplifiers V_2, V_3, which are connected to —H.T. *via* LFC_2, the output of the tone-generator. Thus when the key is pressed oscillations from the tone-generator are fed to the suppressor grids of the power amplifiers thus modulating their output at low frequency. The frequency of the tone-generator oscillations is approximately 1,200 cycles per second. The negative bias across R_{10} is of such a value to enable 100 per cent. modulation to be obtained without serious distortion of the wave form of the modulation frequency. By the action of the keying relay " listening through " is available when the key is released. There is no change in the sidetone circuits.

(vi) *R/T*. When a carbon type microphone is used it is connected in series with the microphone transformer T_1, and +L.T., dropping resistances R_{27}, R_{28} being so arranged that there is approximately 2 volts across the microphone itself. The coupling between grid and anode of the tone-generator valve V_4, *via* C_7 is removed, and the valve used as a modulator (switch section J). The resistance R_{10} remains in circuit for the same reason as stated under M.C.W. The key and a switch connected in parallel with it remain in circuit. To transmit speech it is therefore necessary to press the key or operate the switch. This switch is located in a convenient position for operation by the pilot. By the action of the keying relay R_9 is short circuited. After speech transmission it is necessary to release the key or to switch the parallel switch OFF in order to receive. This releases the keying relay which moves over to the RECEIVE position. As stated in paragraph 12 an electro-magnetic microphone may be used in conjunction with amplifier A.1134.

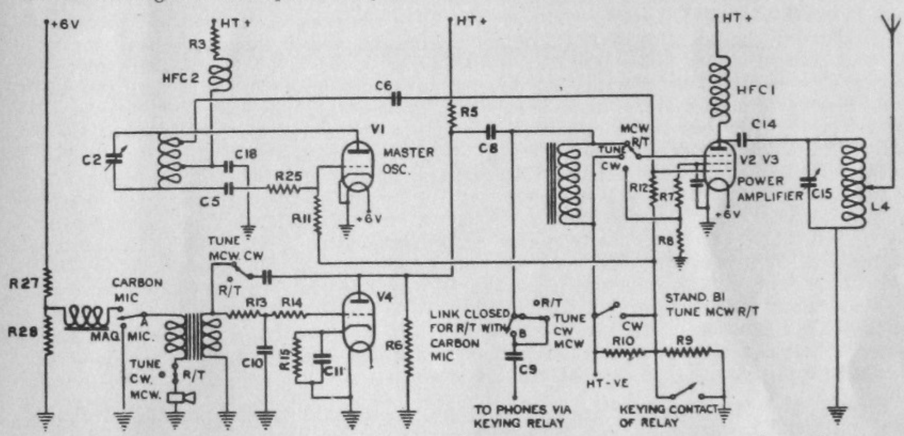


FIG. 3. Simplified diagram of Transmitter T.1154. Switching arrangements Range 1.

Frequency Range Switch S1, S2.

16. This consists of two ganged sections S1 and S2. S1 has four sets of contacts marked N, O, P and Q. These accomplish all necessary circuit changes in the master oscillator stage V_1, when switching from one range to another. Each frequency range has its own inductance and tuning condenser as follows :—

Range 1 (H/F)	Inductance L_1 Condenser C_2
Range 2 (H/F)	Inductance L_2 Condenser C_4
Range 3 (M/F)	Inductance L_3 Condenser C_{17}

The changes effected on each frequency range by switch section S1 are described in paragraphs 17, 18 and 19.

Range 1 (H/F).

17. The inductance L_1 and variable condenser C_2 are connected to the master oscillator V_1 by sections N, Q. Section P couples L_1 to the power amplifiers V_2, V_3 *via* C_6. Section O short circuits Range 2.

Range 2 (H/F).

18. The inductance L_2 and variable condenser C_4 are connected to the master oscillator V_1 by sections N, Q. Section P couples L_2 to the power amplifiers V_2, V_3 *via* C_6. Section O short circuits Range 1.

Range 3 (M/F).

19. The inductance L_3 and variable condenser C_{17} are connected to the master oscillator V_1 by sections N, Q. Section P couples L_3 to the power amplifiers V_2, V_3 *via* C_6. Section O short circuits Range 2. A bank of resistances R_1, R_2, is connected between earth and the main +H.T. line *via* section O and inductance L_2.

This is to counteract the greater efficiency of the master oscillator stage V_1, on Range 3, as compared with Ranges 1 or 2 The resistances R_1, R_2 acting as a parallel H.T. load prevent the H.T. volts rising to a dangerous value. An additional resistance R_{26}, is also switched into the grid circuit of the master oscillator V_1 by switch section Q. This is to prevent the generation of parasitic oscillations which may occur on this range.

20. Section S2 of the Frequency range switch consists of four sets of contacts. These accomplish all necessary circuit changes between the output of the power amplifiers V_2, V_3 and the aerial circuits, when switching from one range to another. The changes effected on each frequency range by S2 are described in paragraphs 21, 22 and 23.

Range 1 (H/F).

21. The main H.T. supply is fed *via* the feed milliammeter across a section of S2, and through the H/F choke HFC_1 to the anodes of the power amplifiers V_2, V_3. The output of the power amplifiers is fed *via* C_{14} across S2 to the tapped inductance L_4 this being tuned by a variable condenser C_{15}. A semi-circular commutator having two brushes is fitted to the spindle of condenser C_{15}. This commutator is so arranged that the condenser completes one half revolution with the brush contacts open, and the other half revolution with the brush contacts closed. When the brush contacts are closed part of inductance L_4 is short circuited. The angular setting of the commutator permits the condenser to sweep from maximum to minimum capacitance with the commutator brush contacts open, and likewise to sweep from minimum to maximum capacitance with the commutator brush contacts closed. As the opening and closing of the commutator contacts effects a change in inductance value of L_4, a greatly increased tuning range is achieved, giving the necessary tuning margin for coupling to a wide range of aerials. The aerial is connected from the H/F aerial plug, across the keying relay and switch S2, to a switch S3 which selects tappings on the inductance L_4. The tuned inductance L_5 of Range 2 is short circuited and earthed by the action of S2. An external aerial ammeter is provided. The reading of this instrument will probably vary a great deal, according to the transmission frequency, and it is only intended to give a rough indication of radiation.

Range 2 (H/F).

22. The main H.T. supply is fed *via* the feed milliammeter across a section of S2 and through the H/F choke to the anodes of the power amplifiers V_2, V_3. The output of the power amplifiers is fed *via* C_{14} across S2 to the tapped inductance L_5, this being tuned by a variable condenser C_{16}. A semi-circular commutator device similar to that described in paragraph 21 is fitted to the spindle of the variable condenser C_{16}. The aerial is connected from the H/F plug across the keying relay and switch S2, to a switch S4, which selects tappings on the inductance L_5. Any portion of L_6 of range 3 in circuit *via* the tapping switch is earthed by the action of S2. An external aerial ammeter is provided as described in paragraph 21.

Range 3 (M/F).

23. The main H.T. circuit is similar to that described in paragraphs 21 and 22. On Range 3 there are two switches, one of which is the Anode tap S_6, controlling the point on the inductance L_6 at which the anodes of the power amplifiers V_2, V_3 are connected. The other switch has two ganged sections S_6 and S_7. S_7 varies the amount of inductance L_6 in the aerial circuit, fine tuning being accomplished by means of a sliding core inside the tuning inductance L_6. Operation of S_7 takes place simultaneously and places into circuit with the feed milliammeter a varying shunt resistance, the effect of which is to increase the sensitivity of the milliammeter with an increase of aerial tap, and so provide a means for indirectly limiting the voltage applied to the aerial circuit. The feed, when using the TUNE, M.C.W., or R/T positions of the master switch, should never be allowed to reach a value greater than that indicated by the green line engraved on the milliammeter scale, or, when using the C.W. position of the master switch, a value greater than that indicated by the beginning of the red sector on the milliammeter scale. A constant value of shunt resistance is employed when the aerial taps are in positions 1-9 ; from positions 10-17 a steadily increasing value of shunt resistance is placed in circuit. This has the effect of increasing the sensitivity of the milliammeter, and in consequence necessitates a reduction of anode tap in order to reduce the milliammeter reading to the prescribed limits. An aerial ammeter reading from 0-3.5 amperes is connected in the earth end of the aerial inductance L_6 on this range. This instrument is mounted on the front panel of the transmitter.

Magnetic Relay Type 85.

24. This is a multi-contact relay operated by the 6 volt radio supply. When the key is pressed, the relay energizing coil circuits are completed, thus breaking all necessary receiver circuits and completing all necessary transmitter circuits. The relay therefore performs the functions of a send-receive switch operated by the morse key. In between keying the receiver is operative, this being known as "listening through." The relay has two banks of six fixed tungsten contacts. The moving contacts, of which there are seven, are made of gold-silver alloy, and travel between the two banks of fixed contacts. There are three energizing coils.

A coil.

25. This is in circuit as long as the transmitter is switched on (i.e., when the master switch is in the STAND-BI, TUNE, C.W., M.C.W., or R/T positions). When the master switch is in the STAND-BI position, A coil only is energized, and holds the relay in the RECEIVE position. For reception only, therefore, this position of the master switch should be used.

B coil.

26. When the master switch is in the TUNE, C.W., M.C.W., or R/T positions, B coil becomes energized on pressing the morse key, and performs the function of demagnetizing A coil, thus releasing the moving contacts from the RECEIVE position, and giving them an initial kick over in the direction of the TRANSMIT position of the relay.

C coil.

27. When the master switch is in the TUNE, C.W., M.C.W., or R/T positions, C coil is also energized on pressing the morse key, causing the moving contacts to snap over to the TRANSMIT position of the relay, where they are held as long as the key is pressed.

Action of Magnetic Relay Type 85.

28. When the master switch is in the STAND-BI position, A coil only is energized, and this causes the relay to move over to the RECEIVE position. The morse key is not in circuit. When the master switch is in the TUNE, C.W., M.C.W., or R/T positions, the morse key is switched into circuit. Pressing the morse key energizes both B and C coils. Winding B is connected so that its field neutralizes the field due to the holding coil A. To effect the demagnetizing process very rapidly it is necessary that the resistance and inductance of coil B must be very small. This would result in unduly high current dissipation in B coil, if the circuit were to remain closed for any length of time. For this reason, B coil is energized through an auxiliary pair of contacts on the relay.

29. When the morse key is pressed there is a rapid rise of current through B coil. At the instant when the nett field resulting from both A and B coils is zero, the relay commences to move under the combined action of the spring contacts. The auxiliary relay contacts open, thus cutting off the current through B coil. The sudden cessation of current in B coil causes a transient condition in A coil, which instantaneously reduces its current to zero. Thereafter the field of A coil is re-established at a rate determined by the high inductance of this winding. In effect, B coil de-magnetises the holding or RECEIVE magnet (A coil). The relay then commences to move, and although the de-magnetising coil is then disconnected, the field due to A coil is not fully re-established until the elapse of a period of time considerably greater than the transit time of the relay. As C coil is energized simultaneously with B coil (i.e., when morse key is pressed) it follows that the relay motion initiated by B coil will be completed by the attraction due to C coil. The fact that the A coil field is re-established does not sensibly affect the hold on power of the C coil, owing to the widely different air gaps. When the key is released the relay must rapidly return to the RECEIVE position, since the field due to A coil is already established, and the field due to C coil will collapse immediately the current is cut off, by the breaking of the morse key.

Aerial Selector Switching Unit Type J.

30. On the T.1154/R.1155 equipment, the trailing aerial is normally used for medium frequency transmission and reception, whilst the fixed aerial is used for high frequency transmission and reception. When making use of the R.1155 receiver as a direction finder the fixed aerial is used as a vertical aerial. For normal operation both aerials are connected *via* the aerial selector switch to the transmitter medium frequency and high frequency aerial terminals, thence *via* the keying relay, to either the transmitter output circuits or to the receiver. The correct aerial is selected by the frequency range switch on either transmitter or receiver (transmitter switch, S_1 S_2 receiver switch S*wxyz*). Thus if the transmitter frequency range switch is turned to Range 1 (H/F) the fixed aerial is connected to the appropriate transmitter circuits. Similarly, if the receiver frequency range switch is turned to say Range 4 (M/F), the trailing aerial is connected to the appropriate receiver circuits. Should either of the two aerials become defective, the remaining aerial may be

used for both M/F and H/F two-way communication, by suitable adjustment of the switches. In addition the switching unit, if correctly set, prevents transmission when using D/F or when the aerials are earthed due to static conditions.

31. The switching unit has five positions each of which are shown in Figs. 4, 5, 6, 7 and 8. For D/F the trailing aerial is disconnected. The fixed aerial is used for D/F sense purposes. When using visual D/F, headphone reception is also available if desired. The energizing circuit of the H.T. starter relay is broken by the secondary contacts, thus preventing transmission. The signal may first of all be tuned in on Omni or A.V.C. In this case a 25 mmf fixed condenser, located in the switch, is connected in series with the fixed aerial. This reduces the pick up from the fixed aerial so that any signal heard at reasonable strength on Omni or A.V.C. will definitely be strong enough for D/F purposes. When the receiver master switch is in the " BALANCE," VISUAL D/F, or FIGURE-OF-EIGHT positions, the aerial switching unit must be in either the D/F or EARTH position, in order to complete the receiver H.T. circuit. When the trailing aerial is defective the fixed aerial may be used for M/F transmission and reception. The fixed aerial is connected *via* the M/F terminal on the aerial switching unit to the M/F socket on the transmitter, and across the keying relay to either transmitter or receiver. The transmitter range switch must be turned to Range 3. The fixed aerial is connected to the receiver through the M/F aerial socket on the transmitter, across the keying relay to transmitter terminal 2A and thence to the receiver *via* a low loss Telecothene screened cable, where the aerial is connected through C_{100} to the medium frequency ranges. The aerial switching unit connects a loading condenser type 764 (capacity 70 mmf.), between fixed aerial and earth (i.e., in parallel with the fixed aerial and aerial tuning inductance). This condenser ensures that the necessary frequency coverage will be obtainable on all types of aerials likely to be encountered on aircraft. When both aerials are serviceable, the NORMAL position of the aerial switching unit is used. This position should be used when both aerials are serviceable. Medium frequency transmission and reception take place on the trailing aerial, whilst H/F transmission and reception take place on the fixed aerial. Once the aerial switching unit is set in the Normal position, the correct aerial is selected simultaneously with the desired frequency when the transmitter or receiver frequency range switches are operated. When the fixed aerial is defective the trailing aerial may be used for H/F transmission and reception. The trailing aerial is connected through the aerial switching unit to the H/F terminal in the aerial switch then to the H/F aerial socket on the transmitter, and across the keying relay to either transmitter or receiver. In the case of transmission, this aerial is not connected to the transmitting circuits unless the Range switch is set to either Range 1 or 2 (H/F ranges). In the case of the receiver, the aerial circuit is taken *via* the keying relay to transmitter terminal 1A, thence to receiver terminal 1 *via* a low loss Telecothene screened cable and through C_{102} inside the receiver, to the frequency range switch where it is selected for H/F Ranges 1 and 2. When heavy static conditions prevail the EARTH position of the aerial switching unit is used. Both the fixed and trailing aerials are directly earthed at the switch ; the starter relay circuit of the H.T. power unit is broken, thus preventing use of the transmitter.

32. As far as possible, the switching system of the equipment has been designed to select automatically the correct aerial, etc., for transmission or reception on any desired frequency within the coverage provided, but there are limitations to its use. For instance, if the aerial switching unit is placed in position 2 (M/F on fixed aerial), it may be found that H/F reception is available on Range 1 or 2 of the receiver although an aerial is not directly connected to these ranges under the foregoing circumstances. This is due to the extreme sensitivity of the R.1155 Receiver. Again, with the aerial switching unit in the " Earth " position, loop reception is available, and if the aerial wiring is of appreciable length in a

particular aircraft installation, some degree of omni reception may be present. It will therefore be understood that it is most important to grasp clearly the circuit changes brought about by the aerial switching unit in its various positions, and when using the equipment, to make a careful check that the switch is in the correct position for the service required.

Aerial Selector Plug Board.

33. On a limited number of installations it will be found that an aerial selector plug board is fitted instead of the aerial switching unit type J. The aerial selector plug board is shown in Fig. 9. Changing over the sockets on the centre pair of plugs makes it possible to obtain various combinations of aerial connections to the equipment, viz. :—

M/F transmission and reception on trailing aerial.
H/F transmission and reception on fixed aerial.

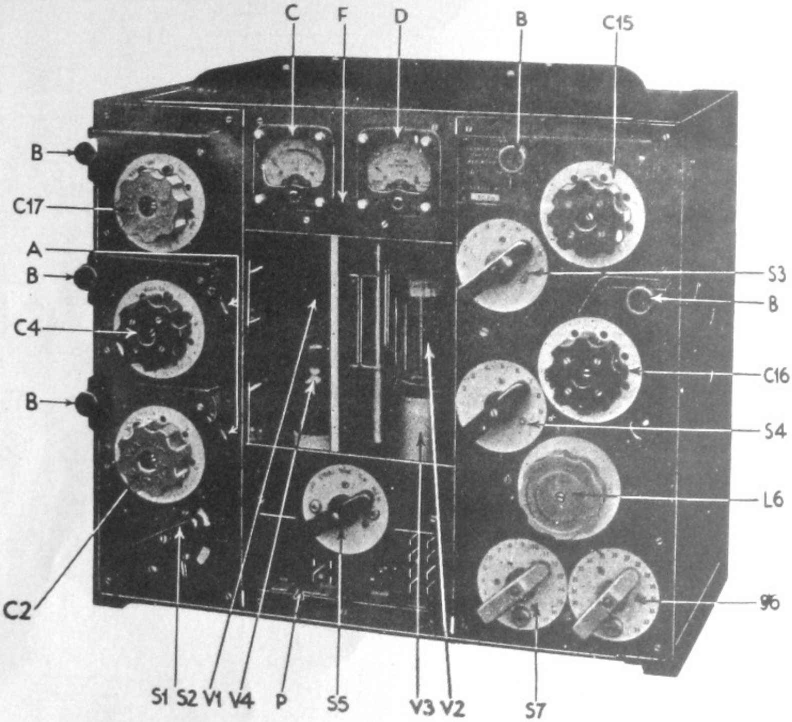


Fig. 10. Transmitter T.1154 front panel showing valves.

This is a normal position and is used when both aerials are serviceable. For D/F the fixed aerial must be connected to the H/F plug, and the trailing aerial disconnected and earthed. If either aerial becomes defective, then by re-arranging the plug and socket connections it is possible to use the remaining aerial for both M/F and H/F transmission and reception. If the fixed aerial should become defective the trailing aerial socket must be connected to the link marked H/F (top pair), in order to transmit or receive on H/F. If the trailing aerial should become defective the fixed aerial socket must be connected to

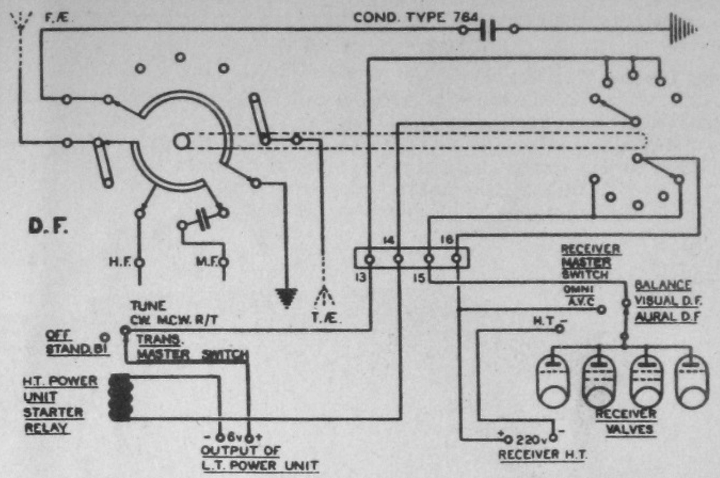


FIG. 4. Aerial Switching Unit Type J in D/F position.

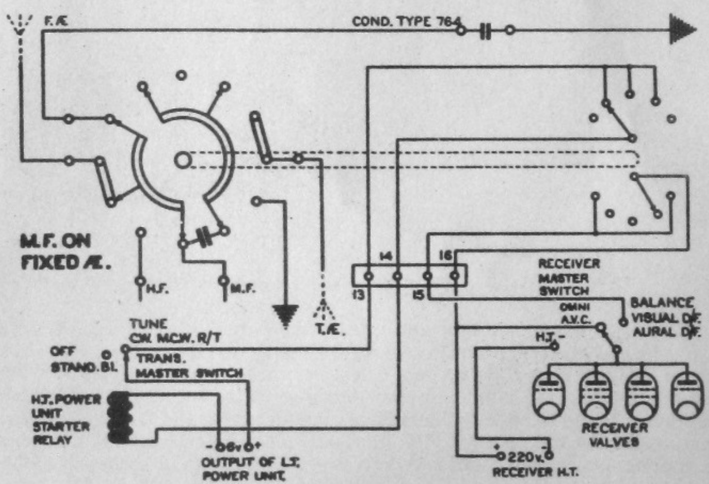


FIG. 5. Aerial Switching Unit Type J in M/F on FIXED AERIAL.

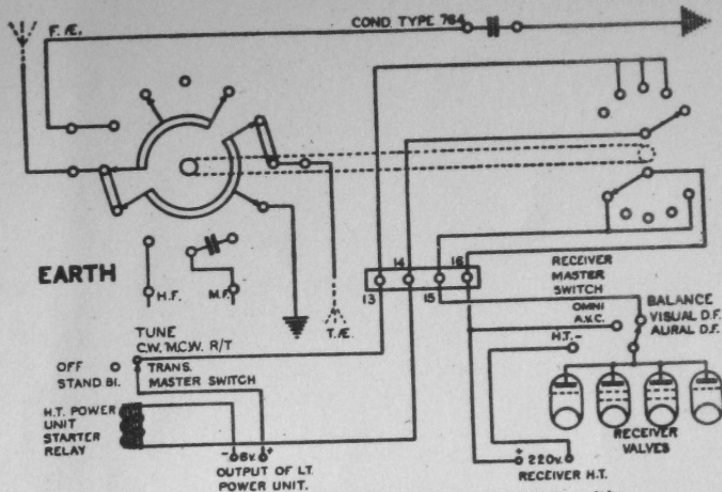


FIG. 8. Aerial Switching Unit Type J in EARTH position.

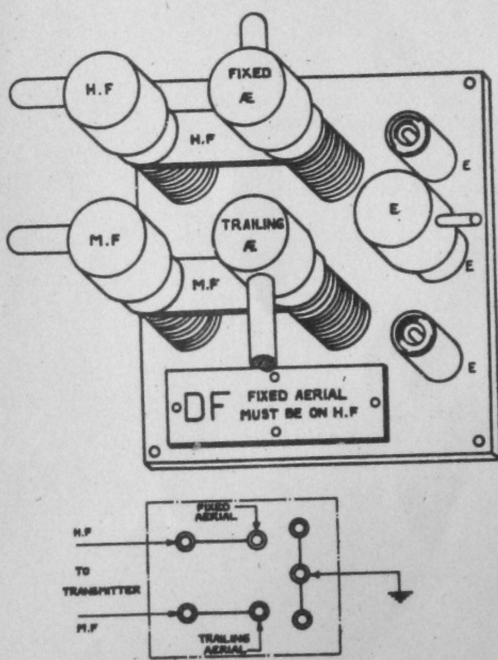


FIG. 9. Aerial Plug Board.

the link marked M/F (bottom pair). In conditions of heavy static both aerials may be earthed by plugging into the two outside earth plugs. In this case by setting the receiver master switch on figure-of-eight, loop reception only is available but no sense of bearing can be obtained as both aerials are earthed. Under these conditions the transmitter master switch must be set in the STAND-BI position, thus shutting down the H.T. power unit and making transmission impossible.

34. If the fixed aerial becomes defective sensing of D/F bearings must not be attempted on trailing aerial as this may cause an error of 180°. When the fixed aerial becomes defective therefore only figure-of-eight D/F reception is available.

CONSTRUCTIONAL DETAILS.

35. Fig. 10 shows the transmitter panel and its controls, meters, plugs, valves and fuses. The master switch (S_5) is located in the centre of the panel immediately below the valve compartment and has the following switching positions :—

(i) OFF
(ii) STAND-BI
(iii) TUNE
(iv) C.W.
(v) M.C.W.
(vi) R/T.

Circuit changes effected by this switch are fully described in paragraph 15. The frequency range switch (S_1, S_2) is located at the left hand bottom corner of the panel and has three positions, Range 1, 2 and 3.

Range 1 (H/F).

36. There are three controls in this range all coloured BLUE. The master oscillator tuning condenser (C_2) is located at the left hand bottom corner of the panel and is provided with click stops causing the dial to click into eight different positions which may be pre-set to coincide with any eight frequencies within the limits of the range. These eight click-stops are labelled A, B, C, D, E, F, G and H. A tap switch (S_3) is located immediately to the right of the valve compartment and has the function of connecting the aerial to any of nine tappings on Range 1 output circuit inductance L_4. An output tuning condenser (C_{15}) is located at the top right hand corner of the panel and is also provided with eight click-stops, these being engraved A—H, in the same way as the master oscillator tuning on this Range. This condenser tunes inductance L_4.

Range 2 (H/F).

37. There are three controls in this range all coloured RED. The master oscillator tuning condenser (C_4) is located on the left centre of the panel and is similar to Range 1 master oscillator tuning condenser. The click-stops are labelled J, K, L, M, N, P, Q and R. A tap switch (S_4) is located immediately on the right of the valve compartment and below Range 1 tap switch. This has the function of connecting the aerial to any one of nine tappings on the output circuit inductance L_5. The output tuning condenser (C_{16}) is located on the right hand centre of the panel and is also provided with eight click-stops these being labelled J—R in the same way as the master oscillator tuning on this Range. This condenser tunes inductance L_5.

Range 3 (M/F).

38. There are four controls in this Range all coloured YELLOW. The master oscillator tuning condenser (C_{17}) is located at the top left hand corner of the panel and is similar to the master oscillator tuning condensers on Ranges 1 and 2. The click-stops are labelled S, T, U, V, W, X, Y and Z. The aerial tap switch (S_7) is located at the bottom of the panel immediately to the right of the master switch. This control has 17 positions numbered 1-17 and varies the amount of aerial tuning inductance L_6 in use. The output tuning control (L_6) is located immediately below the output tuning of Range 2. It consists of a sliding core inside the aerial tuning inductance L_6. There are no click-stops provided on this control as the change in frequency between taps is small compared with Ranges 1 and 2. The anode tap switch (S_6) is located at the right hand bottom corner of the panel and has 17 positions numbered **18-34**. This, as its name indicates, shifts the position at which the output of the power amplifier is connected to the aerial tuning inductance L_6.

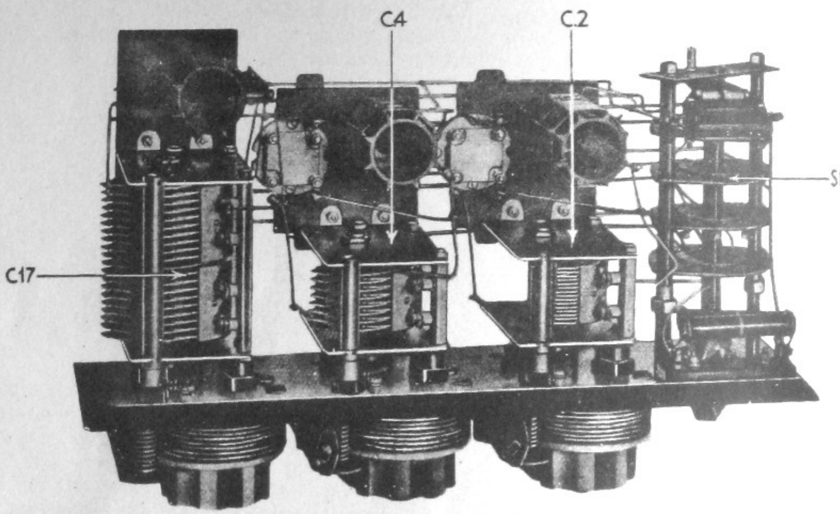


FIG. 11. Transmitter T.1154 master oscillator panel.

Secondary Controls.

39. The master oscillator controls on the two H/F Ranges 1 and 2 are provided with a vernier adjustment (A). This is capable of varying any pre-set frequency plus or minus 0.1 per cent. A release is provided for the click-stops on each master oscillator dial (B) and on the two H/F output tuning dials. This enables the dials to be rotated without engaging the click-stops so that any frequency within the limits of the particular range can be selected. A friction drive is brought into use when the click-stops are released thus preventing the dials from vibrating off their setting. At the top of the panel immediately above the valve compartment is a feed milliammeter (C). This instrument reads from 0—300 milliamps. It shows the current taken by the anodes of the power amplifiers V_2, V_3. An aerial ammeter (D) is located at the top of the panel on the right of the feed milliammeter. It reads from 0—3.5 amps but is only in circuit on the M/F Range 3. An external aerial ammeter is provided for the H/F Ranges 1 and 2. There are four power plugs (P) on the

front panel located immediately below the master switch. From left to right they are as follows :—

(i) Receiver Power supply
(ii) Key and telephones
(iii) H.T. (1,200 volts)
(iv) Main power supply.

The H.T. fuse (F) is immediately below the two meters. This fuse is of the glass tubular type and is rated at 750 milliamperes. The fuse is protected and held in position by an insulated cap which screws on to the panel. Microphone sockets are provided for connecting

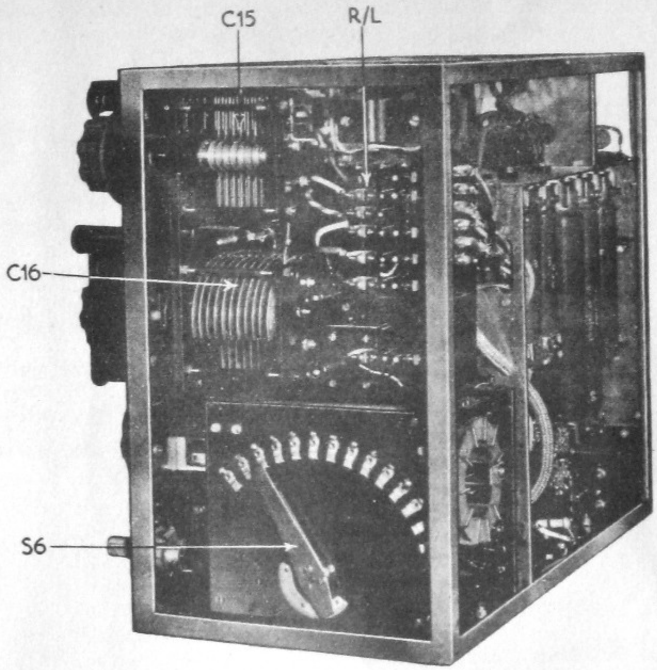


FIG. 12. Transmitter T.1154 side view of chassis showing the keying relay R/L.

up a carbon type microphone when using R/T. When using an electro-magnetic microphone in conjunction with amplifier A.1134, the output of the amplifier is connected to the transmitter *via* these two sockets described above.

40. Several views of the transmitter are given (Figs. 10—13). The panel is robustly constructed being made up of a number of units thus facilitating repair or replacement. The complete chassis is quickly detachable from its containing box, this latter being mounted on special Firestone rubber suspension units to afford protection from mechanical shocks and vibration. This minimises the possibility of the master oscillator stage frequency being modulated by mechanical vibrations which is of special importance when considering

H/F transmission stability. All cable connections to the transmitter are terminated in plugs and sockets which are both non-reversible and non-interchangeable. Wherever possible supply cables are of the metal braided type, this braiding being earthed in order to reduce the possibility of electrical interference being picked up from an external source and thus passed on to the receiver circuits *via* internal wiring of the equipment. The master oscillator circuits have been carefully screened from those of the power amplifiers in order to maintain transmission stability and constancy of calibration of the master oscillator stage tuning.

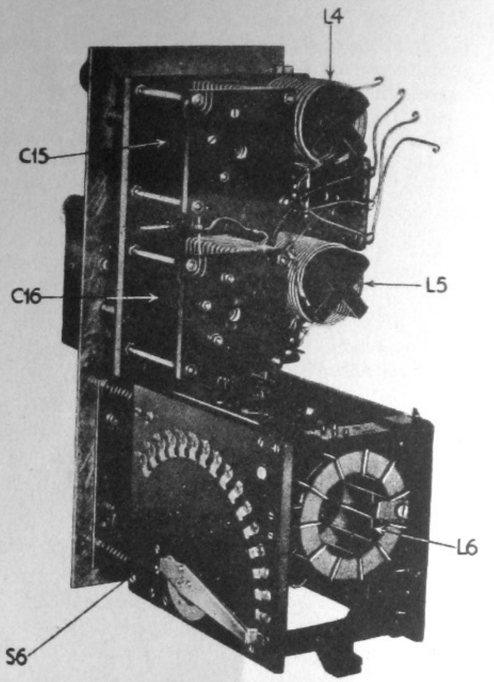


FIG. 13. Transmitter T.1154 output panel.

Aerial Selector Switching Unit Type J.

41. This unit is constructed throughout of high insulation material capable of withstanding H/F voltages up to 6,000 volts even at high altitudes. Two sets of contacts are carried on a square sectioned shaft, this being operated by one handle. The unit has five switching positions indicated by engraving on the cover. At the back of the unit are the main contacts which switch the aerial circuits. The secondary contacts which switch various L.T. and receiver H.T. circuits are housed underneath the front cover. All cable connections to this unit are terminated in plugs and sockets.

Aerial Selector Plug Board.

42. Fig. 9 shows the aerial selector plug board, which consists of a metal base with seven shrouded plugs mounted on it. On the right hand side are three plugs all of which are connected together and engraved E (Earth). A connection to earth is taken from the

centre plug. In the centre of the unit are two shrouded plugs mounted on bakelite pillars. Connecting cables from both fixed and trailing aerials are terminated in sockets which fit on either of the above two plugs. On the left hand side of the unit are two more shrouded plugs also mounted on bakelite pillars. The cables from the M/F and H/F aerial sockets on the transmitter are terminated by sockets which fit on to these plugs. The two pairs of plugs mounted on the bakelite pillars are linked across, one pair being labelled H/F and the other M/F.

VALVES AND POWER SUPPLIES.

43. The valves used in the transmitter are of two types. In the master oscillator V_1, and modulator V_4, the valve employed is type ML6. This is a non-metallised indirectly heated triode having a heater current of 0.7 amperes at 6 volts. The maximum H.T. voltage is 250 and the anode dissipation 5 watts. This valve has a standard 5 pin base. In the power amplifier stages V_2, V_3 two valves type PT.15 are employed. The PT.15 is a pentode valve having a filament current of 1.30 amperes at a nominal 6 volts. The maximum anode voltage is 1,250 and maximum screen voltage 300. The maximum anode dissipation is 40 watts and maximum screen dissipation 10 watts. The valve has a standard 5 pin ceramic base, the anode connection being brought out at the top of the envelope.

44. The L.T. power input to the transmitter is 45 watts on full load. This is distributed as follows :—

Transmitter valve heaters	6v.	4.0 amps	(24 watts)
H.T. power unit starting relay	6v.	1.0 amps	(6 watts)
Keying relay type 85 with key pressed	6v.	2.5 amps	(15 watts)

Power Units

45. Two motor generators are employed for each installation ; one supplying H.T. for the transmitter, the other H.T. for the receiver and L.T. for both transmitter and receiver. These are known as the H.T. power units and the L.T. power units respectively.

L.T. Power Units.

46. There are two models of this unit which have the following characteristics :—

Power Unit type 34 (Stores Ref. : 10K/19).

Input	10.3v.	D.C. Nominal 12v.
Outputs	7v.	13 amps D.C.
	217v.	110 m/a D.C.

This unit comprises the following electrical components :—

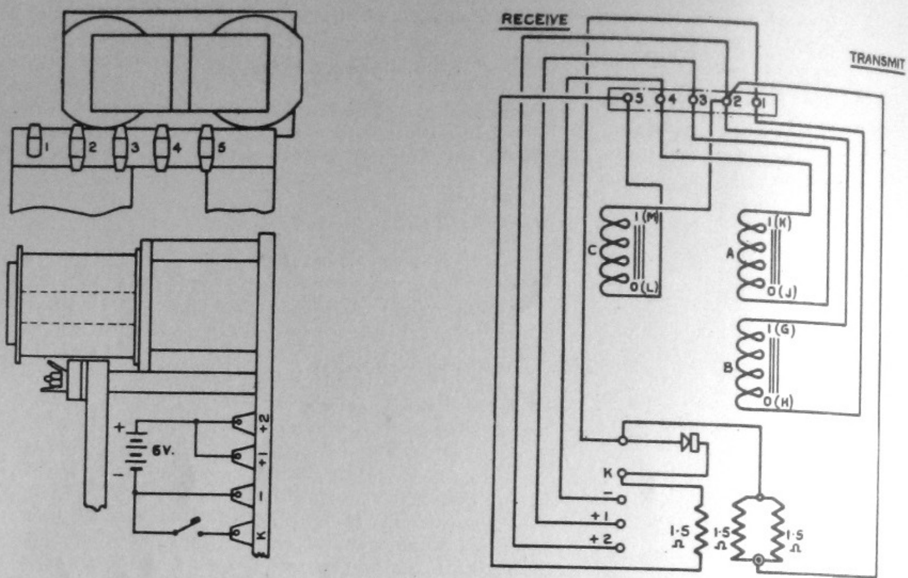
(i) Motor generator type 30
(ii) Two-step starter
(iii) L/F and H/F filter circuits
(iv) Plugs and sockets.

Power Unit type 35 (Stores Ref. : 10K/20).

Input	18.5v.	D.C. Nominal 24v.
Outputs	7v.	13 amps D.C.
	217v.	110 m/a D.C.

This unit comprises the following electrical components :—

(i) Motor generator type 31
(ii) Two-step starter
(iii) L/F and H/F filter circuits
(iv) Plugs and sockets.



INSTRUCTIONS FOR ADJUSTMENT.

INDIVIDUAL COIL TESTS.

Coil A	Terminals 3 & 4
Coil B	,, 1 & 2
Coil C Direct.	,, 2 & 5
Coil C with series resistance	,, 2 & K

KEYING TEST.

Connect battery and key as indicated.

Operating Coils for 6v Operation.

Resistance Coil	A	between Terminals	3 & 4	=	12.045Ω±	0.6Ω
,, ,,	B	,, ,,	1 & 2	=	1.525Ω±	0.1Ω
,, ,,	C	,, ,,	2 & 5	=	2.1 Ω±	0.1Ω

Fig. 18. DIAGRAM OF CONNECTIONS. MAGNETIC RELAY Type 85.

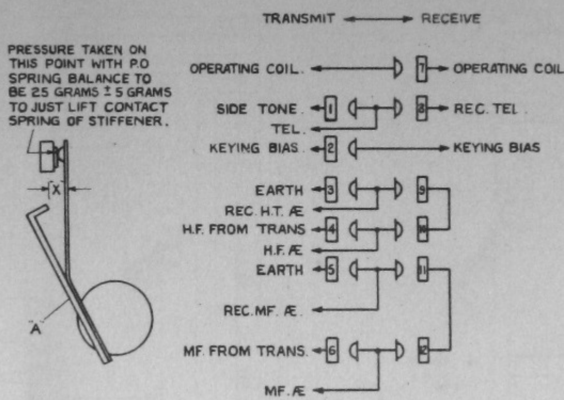


Fig. 19. Magnetic Relay Type 85.

Contact No.	Gap " X."
1	0.048 in. (18G)
2	0.028 in. (22G)
3	0.048 in. (18G)
4	0.048 in. (18G)
5	0.048 in. (18G)
6	0.048 in. (18G)
7	0.064 in. (16G)
8	0.028 in. (22G)
9	0.048 in. (18G)
10	0.048 in. (18G)
11	0.048 in. (18G)
12	0.048 in. (18G)

Note :—Adjustments are to be made by setting the screw contacts Nos. 1—12 to the required positions as indicated. On no account must the stiffener strips " A " be bent to facilitate adjustment. A suitable type of gauge can be made from a 3 in. length of piano wire of correct diameter ; bend the wire at 90 degrees at $\frac{5}{16}$ in. from one end.

Bearings. The relay spindle should roll freely from side to side under its own weight when the relay is tilted.

Magnet Structure. In either of the closed positions a small air gap of 0.001 in. to 0.005 in. should remain between the armature plate and the central leg of the yoke.

Insulation. The insulation should withstand a 500 volt megger test between the windings and frame and give a resistance of greater than 10^6 ohms.

Operational Tests. The overall characteristics of the relay may be checked by measuring the minimum voltage which, applied to each coil in turn, will just cause the relay to close.

Coil.	Terminals.	Max. Value Permissible to Cause Relay to Close.
A.	3 & 4	4 volts
B.	1 & 2	2.2 volts
C.	2 & 5	1.85 volts
C (with series resistance)	2 & K	3.2 volts

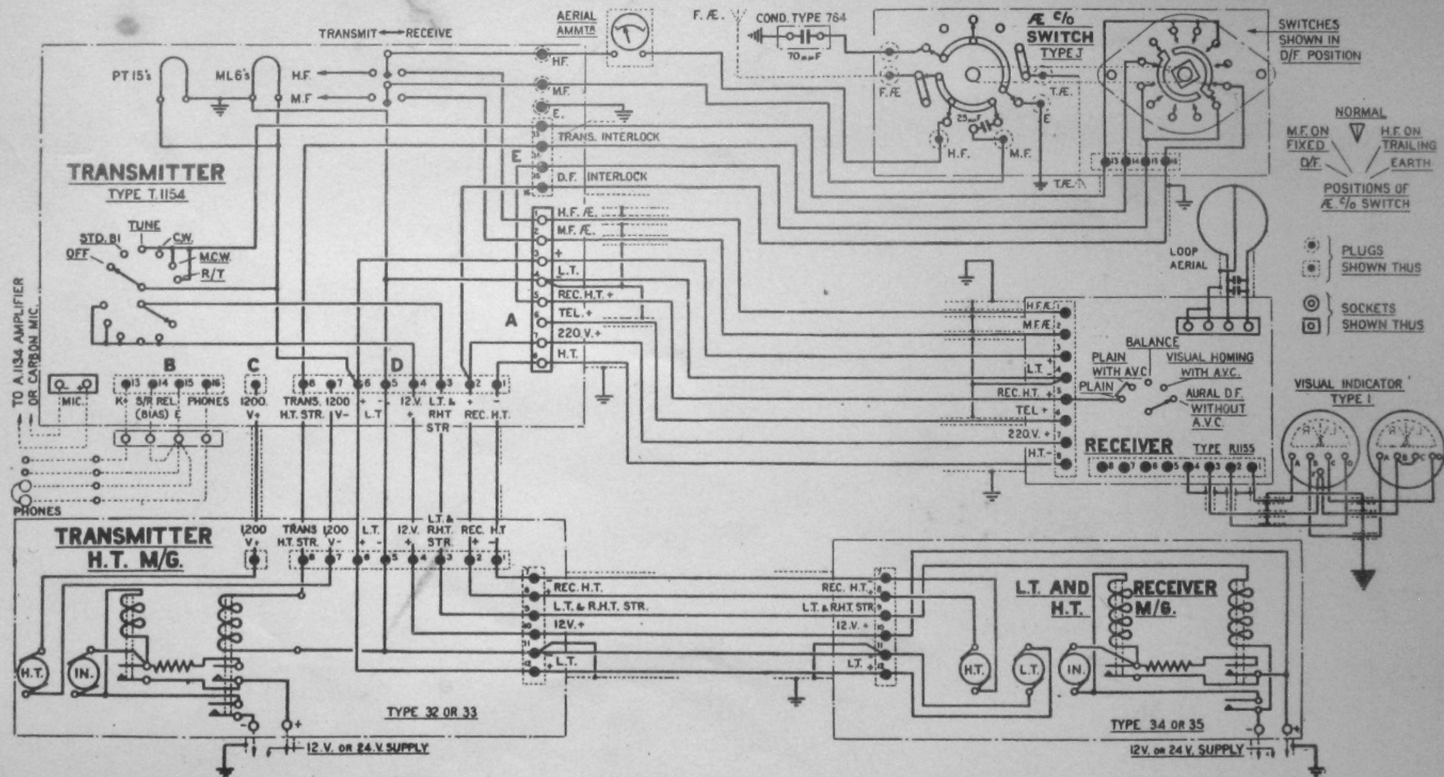


FIG. 20. Main Equipment Diagram T.1154/R.1155.

Pin No.	Socket A to Receiver.	Plug B to phones and key.	Plug C to power supply.	Plug D to power supply.	Plug E to aerial switch Trans. and Rec. interlock.
1	High Freq. Aerial	—	+ 1,200 v. H.T.	— 220 v.	—
2	Medium Freq. Aerial	—	—	+ 220 v.	—
3	+L.T.	—	—	Starter Fils. & Rec. H.T. M/c	—
4	—L.T.	—	—	Battery + 12 v.	—
5	+ 220 v. Receiver H.T.	—	—	— L.T.	—
6	Phones	—	—	+ L.T.	—
7	+ 220 v.	—	—	— 1,200 v.	—
8	— 220 v.	—	—	Starter 1,200 v. M/c	—
13	—	Key	—	—	+ L.T.
14	—	Relay Key Contact	—	—	+ L.T. to starting relay 1,200 v. M/c
15	—	Earth	—	—	+ 220 v. receiver H.T.
16	—	Phones	—	—	+ 220 v.

ANODE FEED METER.

F.S.D. 0—100 M/A. Calibrated 0—300 M/A.

Range.	Meter Shunt Resistance Switch. Positions.	F.S.D.
1	—	0—300 M/A
2	—	0—300 M/A
3	1—9	0—300 M/A
3	10—11	0—255 M/A
3	12—13	0—210 M/A
3	14—15	0—165 M/A
3	16—17	0—120 M/A

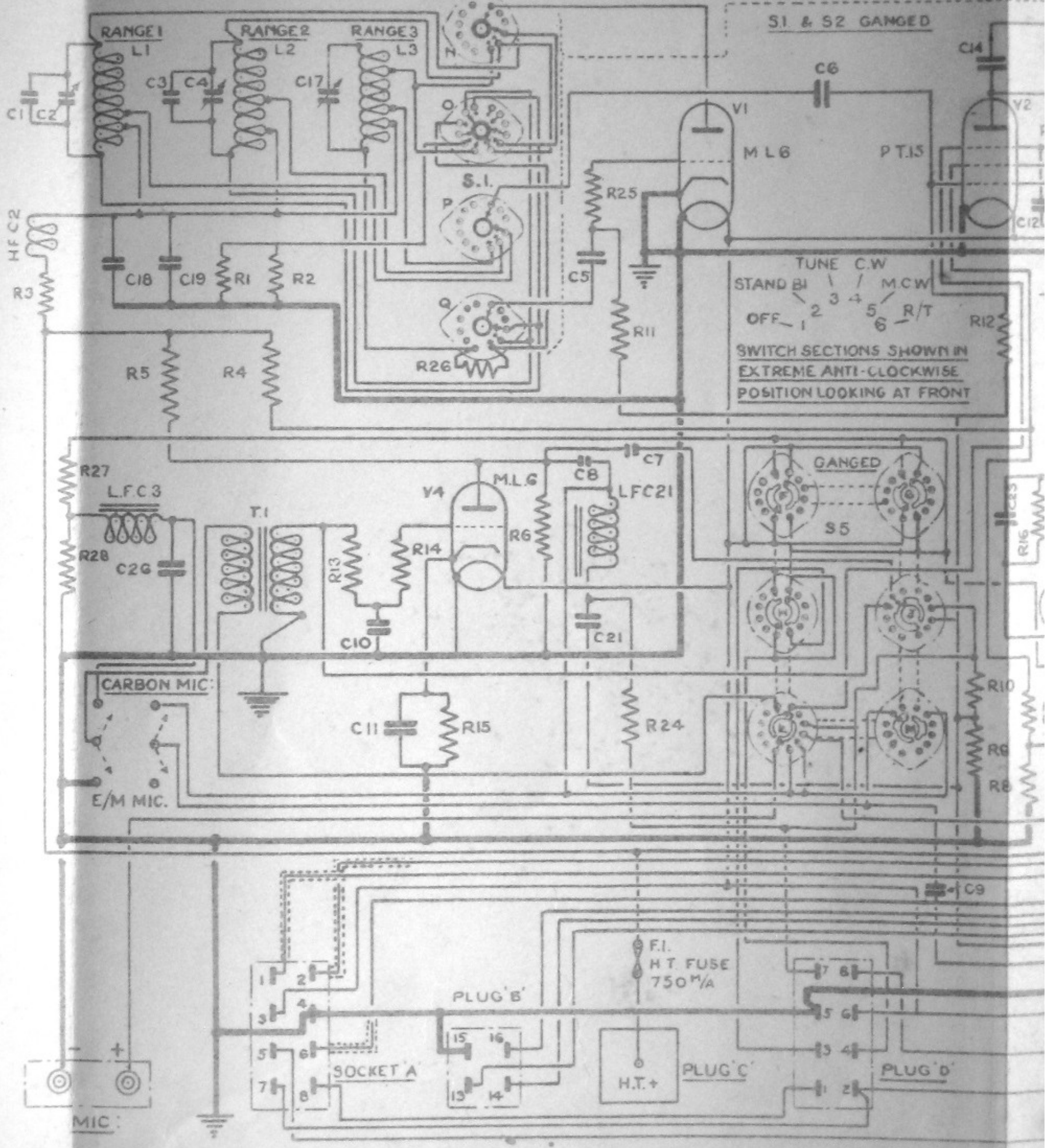
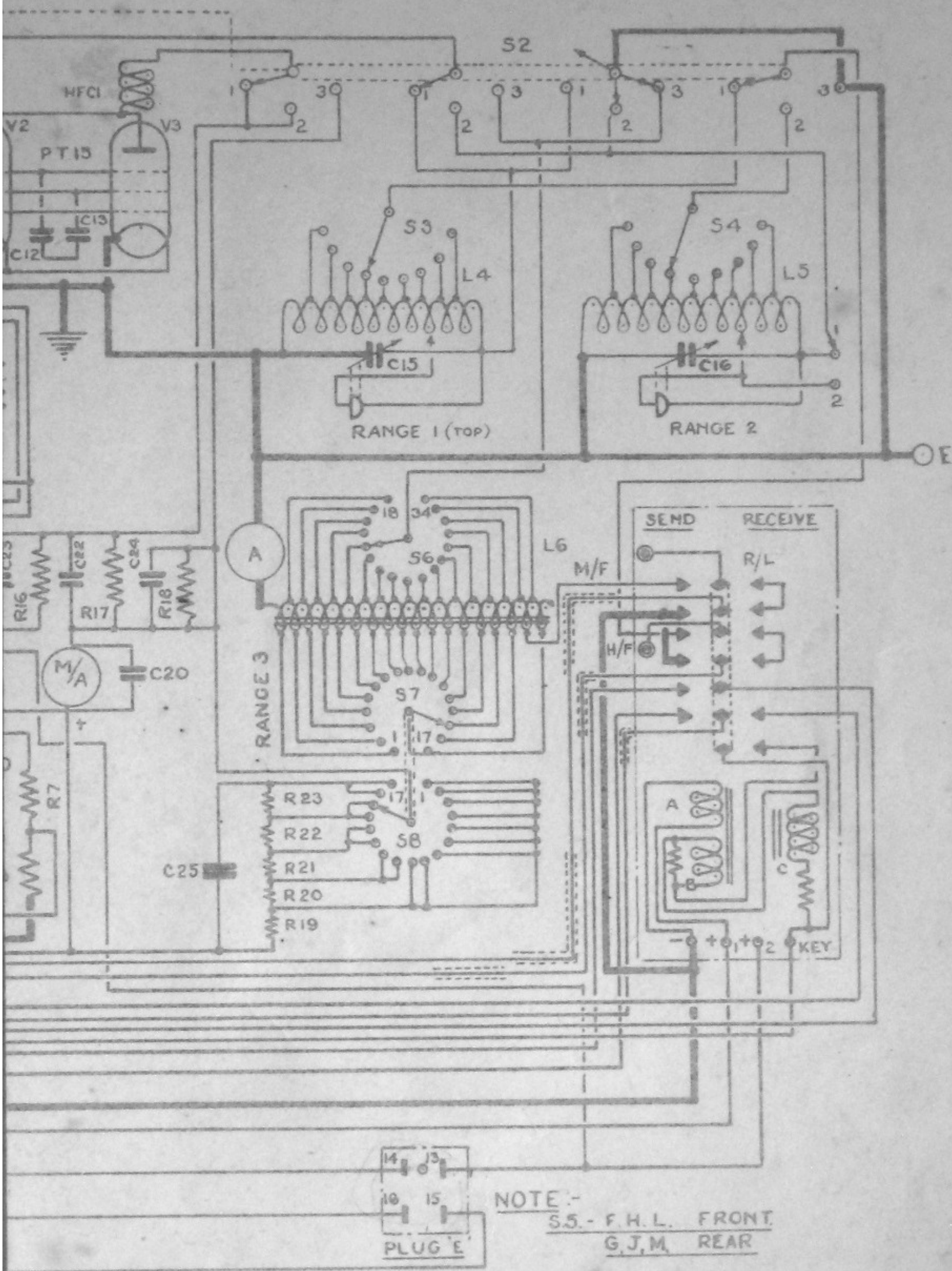


Fig. 21 Main Diagrams of Connecti



nections, T.1154.

RECEIVER TYPE R.1155.

(Stores Ref. : 10D/98).

INTRODUCTION.

1. The receiver R.1155 is designed for use in aircraft, and is used with the Transmitters type T.1154 and T.1154A. It provides for the reception of modulated and unmodulated signals and when connected to a suitable loop aerial can be used as a direction finder. The addition of a visual indicator makes it possible to obtain bearings or to "home" on a Radio Station by the visual method. The receiver is of the superheterodyne type and employs a total of ten valves. The frequency bands covered are 18 Mc/s—3 Mc/s (16.6 metres—100 metres), 1,500 kc/s—75 kc/s (200 metres—4,000 metres), with a gap between 600 kc/s—500 kc/s (500 metres—600 metres). Direction finding facilities are available within the frequency bands 1,500 kc/s—75 kc/s. Provision is also made for direction finding within the frequency band 7.5 Mc/s—3 Mc/s. A large tuning scale is provided and the selection of frequencies is carried out by the operation of a five positioned range switch.

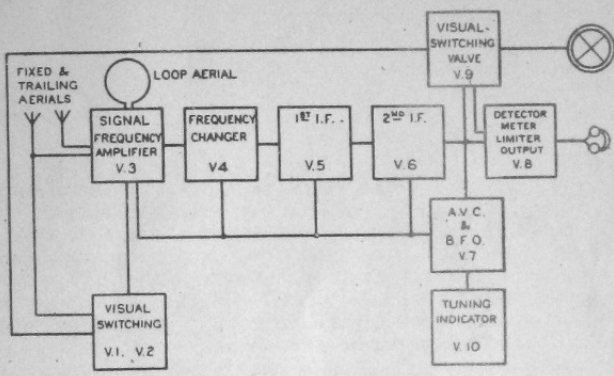


FIG. 1. Schematic diagram of Receiver R.1155.

2. The power for the receiver is obtained from a motor generator which provides both L.T. and H.T. This unit is described in paragraphs 46 and 47 of the section dealing with transmitter type T.1154. The overall dimensions of the receiver in its case are approximately $16\frac{5}{8}$ in. × $9\frac{3}{8}$ × $11\frac{3}{8}$ in. The weight of the receiver complete with valves and suspension units is approximately 27 lbs.

GENERAL DESCRIPTION.

3. The circuit arrangements of the receiver are described with reference to Fig. 10, but the principal features will be more easily understood with the aid of simplified theoretical diagrams Figs. 1—6. The same notation is employed in all diagrams. The D/F circuit arrangements incorporating valves V_1, V_2, V_9, are described in paragraphs 6—16.

Aerials.

4. Both fixed and trailing aerials are connected to the receiver, *via* the aerial switching unit type J, and Transmitter T.1154 (paragraphs 30—34 Transmitter T.1154). The correct aerials for H/F or M/F or D/F reception, are selected by the frequency range switch, and for normal use are as below :—

Ranges 1 and 2 (18.5—3 Mc/s).	Fixed aerial.
Ranges 3, 4 and 5 (1,500—75 kc/s).	Trailing aerial.
Ranges 2, 3, 4 and 5 (when using D/F).	Fixed aerial.

Provision is made for working all frequency ranges on either fixed or trailing aerials, but this is controlled by the aerial switching unit type J.

Communication Circuits (Master switch on " Omni " or A.V.C.).

5. The following description deals with the receiver as a communication unit only.

(i) *H/F Stage* (V_3). This is the first valve of the communication receiver, V_1 and V_2 being utilised in the D/F circuits. The function of V_3 is to amplify the signal received by the aerial before it is passed on to the frequency changer (V_4). This signal frequency stage has a tuned grid circuit with A.V.C. or manual volume control. The circuit is tuned by a section of the ganged condenser C_{84}, and the anode circuit is coupled to the grid circuit of the frequency changer V_4 by a transformer.

(ii) *Frequency Changer Stage* (V_4). This valve combines the function of 1st detector and local oscillator. Local oscillations are generated by the triode section of V_4, which are at all times greater than the incoming signal by 560 kc/s. By electronic mixing and rectification within the valve, a frequency of 560 kc/s (i.e., the resonant frequency of the I/F amplifier) is obtained in the anode circuit. The latter comprises an inductance and capacity C_{86}, which forms the primary of the first intermediate frequency coupling unit.

(iii) *Intermediate Frequency Trap Circuit.* On medium frequency ranges a special circuit, formed by an inductance and capacity C_{67}, is used to eliminate the possibility of instability due to I/F feedback at the signal frequency stage. It will be understood that should the impedance of the tuned grid circuit become appreciable at or near the I/F, feedback may occur either due to direct influence of the stray field in the circuit itself, or by the amplification of the valve V_3. The circuit employed is arranged to cause the impedance of the grid circuit of V_4 to fall very sharply at the intermediate frequency, thereby preventing both the above forms of feedback.

(iv) *Oscillator Section of* V_4. A tuned anode circuit with tapped inductances is loosely coupled with the grid circuit inductance. To reduce frequency drift on the H/F ranges, two chokes are connected in the anode circuit which resonate just beyond the low frequency end of the bands. The combination of these chokes operating above their resonant frequency and the small condensers C_{78} and C_{79}, enables the correct degree of coupling between the anode and tuned circuits to be maintained throughout the frequency band. Thus the frequency drift due to changes in valve constants whilst heating up, etc., or due to the replacement of a valve, has considerably less effect on the tuned circuit, with consequent retention of accuracy of calibration.

(v) *Intermediate Frequency Amplifiers* V_5 *and* V_6. There are two stages of I/F amplification employing band-pass coupling units. The band-pass coupling is effected by very small fixed capacities C_{97}, C_{98} and C_{101}, there being practically no inductive coupling. The coupling units comprise dust-iron cored inductances which are adjusted to the intermediate frequency of 560 kc/s by means of variable cores. There is no adjustable capacity across the inductances. The I/F selectivity is approximately 4—5 kc/s (total band-width) for 6 dbs. attenuation. Both I/F stages have either A.V.C. or manual gain control, according to the position of the master switch.

(vi) *Gain control of communication receiver with master switch in "omni" position.* The gain of valves V_3 to V_6 is controlled by the application of varying amounts of bias to their grids, and is manually effected by the potentiometer $R_{8(1)}$. The full L/F input is applied to the grid of the output valve and, in this position of the master switch, the A.V.C. system is inoperative. The following circuit changes are effected :—The manual volume control potentiometer $R_{8(1)}$ is connected across a resistance in series with H.T. negative. The diode end of the resistance network R_{10}, R_{11} and R_{12} is disconnected from the A.V.C. diode (V_7) and connected to the slider of the manual volume control ($R_{8(1)}$). The diode which is used for A.V.C. purposes is left connected through R_9 to a point 3.6 volts negative along the H.T. negative series resistance. A total of about 30 volts is developed across the H.T. negative resistance, and this voltage therefore appears across the ends of the manual volume control potentiometer $R_{8(1)}$. From the slider any negative voltage from minus 3.6 volts to minus 30 volts can be applied to the end of the A.V.C. load resistance (originally connected to the diode) and in turn, bias can be applied to the controlled valves, the same proportion for each valve being obtained by the retention of the resistances R_{10}, R_{11} and R_{12}. Whilst in the "Omni" position, the grid of the output valve is taken direct to the top of the L/F volume control and the variable slider is out of circuit, thereby applying the full L/F volts to the output valve.

(vii) *Gain control of communication receiver with master switch in A.V.C. position.* The gain of valves V_3 to V_6 is controlled automatically by the strength of the received signal, but manual control of L/F from the speech diode V_8 to the output valve is also provided, this being effected by the variable potentiometer $R_{8(2)}$. In order to simplify the controls on the front panel, the potentiometer used for applying varying amounts of bias to the valves V_3 to V_6 (i.e., $R_{8(1)}$) is ganged to the L/F volume control potentiometer $R_{8(2)}$, both these potentiometers being operated by a single knob marked "Volume Control." From the foregoing it should be appreciated that $R_{8(1)}$ is in circuit when the operational switch is in the "Omni" position, whilst $R_{8(2)}$—the L/F control—is in circuit when the master switch is in the A.V.C. position. The received signal is applied to the grid of V_3 and after the frequency changing is amplified at the I/F by valves V_5 and V_6. From a tapping in the primary of the last I.F. transformer both diode sections of V_7 are connected for A.V.C. purposes. Rectified current from them flows through the series choke and master switch to a resistance network comprised of R_{10}, R_{11} and R_{12} across which volts are developed for supplying negative bias for automatic control of the valves V_3 to V_6 inclusive. The voltage obtained as bias may vary from 0-30 volts. In order to provide the correct proportion of bias volts to each valve, the grids of the valves V_4 and V_5 receive full A.V.C. bias volts, V_3 receives half A.V.C. volts and V_6 one-tenth. The reason for the choice of different bias volts is to provide a good signal-to-noise ratio. The A.V.C. is delayed about 13 volts, this being achieved by making the cathode of V_7 positive with respect to its diodes, by resistances R_{14} and R_{15}. This delay assists in giving an A.V.C. characteristic which for a change in input signal of 80 dbs. results in a change in output of approximately 8 dbs. Since none of the A.V.C. controlled valves are automatically biased by cathode resistors, the resistance network R_{10}, R_{11} and R_{12}, from which the A.V.C. voltage is derived, is returned to a point 3.6 volts negative with respect to the grids. This point is taken from a resistance in series with H.T. negative, and it maintains a standing bias on all controlled valves during no-signal periods. On Ranges 1 and 2 (H/F) the bias is reduced to 2.5 volts approximately, in order that the amplification over the full five ranges may be reasonably constant.

(viii) *Beat Frequency Oscillator* (*Triode V_7*). In addition to providing the A.V.C. the MHLD6 valve V_7 also acts as a beat frequency oscillator, the triode section of the valve being used for this purpose. The oscillator circuit is tuned to half the I/F (i.e., 280 kc/s). A Colpitts circuit is employed for generating oscillations, H/T being fed *via* R_{17}, R_{18}, and the inductance to the anode of V_7. The tuning portion of the L/C circuit is formed by C_{14} and C_{15}. C_{13} is a variable condenser which may be adjusted to the required beat frequency from the front panel by means of a screwdriver. The beat frequency oscillations are fed through the diode load condenser to the diode V_8, at which point heterodyning takes place.

Special Note.—It will be found when working the receiver that indications of a carrier wave are obtained at 280 kc/s. This is due to the B.F.O. fundamental frequency, and should not be confused with a signal coming from an external source.

(ix) *Second Detector, Limiter and Output V_8.* One diode of V_8 functions as a second detector, its input being obtained from the secondary of the last I/F transformer. The rectified voltage developed across R_{21} is fed through C_8 and C_9 to the potentiometer $R_{8(2)}$, which functions as a volume control when using A.V.C. Across $R_{8(2)}$ is connected an L/F filter circuit comprising an inductance and capacities C_8, C_9 and C_{10}. This circuit effectively prevents all frequencies below 300 cycles from getting to the volume control and hence to the output stage. The purpose of this L/F filter circuit is to remove a proportion of the aircraft electrical and ignition noise and also to minimise the effect of acoustic noises and vibration. This filter may be switched in or out of circuit as desired, by a switch on the top left hand corner of the panel. The use of one diode of V_8 as a limiter is described in the section dealing with the visual D/F (paragraph 13). The triode section of V_8 functions as the output valve. The voltage developed across the volume control potentiometer $R_{8(2)}$ is fed *via* the slider to the triode section of V_8, in the anode circuit of which is connected the output transformer. A working output of approximately 100 milliwatts is obtained.

(x) *Tuning Indicator V_{10}.* The tuning indicator is arranged to give a varying shadow angle on a fluorescent target, as an indication of correct tuning. The angle of light is dependent on the voltage developed across R_9, a resistance connected in parallel with the A.V.C. load. The valve itself consists of a conical shaped anode which is coated with fluorescent material, this becoming luminous when subjected to electronic bombardment. The cathode protrudes through a centre hole in the anode and when the H.T. is applied to the anode of the valve it becomes luminous. Adjacent to, but slightly off centre from, the anode is located a wire which is in the direct path of the electron stream. This wire is connected to the anode of a triode section of the valve. The anode of this triode is connected to H.T. positive through a one megohm resistor R_{13}. The grid is fed from volts developed across R_9. It will be seen that there is a difference of potential between the fluorescent anode and the triode anode. This will tend to make the electron stream diverge from the more direct path to the fluorescent anode, and when the largest difference of potential exists between these two anodes, a large shadow will be noted on the fluorescent anode, i.e., less of the eye portion of the indicator will be coloured green. When a large signal is received the control grid will become more negative with consequent reduction in anode current to the triode anode, thus reducing the voltage across R_{13}. This in turn causes a small difference of potential between the two anodes and therefore the electron stream will take the most direct path across the valve, causing the greater part of the fluorescent anode to be illuminated.

Direction Finding Circuits.

6. The following description deals with the receiver as a direction finder. The following operations can be performed with this receiver when coupled to a suitable D/F loop and a visual indicator of the twin needle type :—

(i) the taking of bearings visually. Sensing of bearings can also be carried out visually.

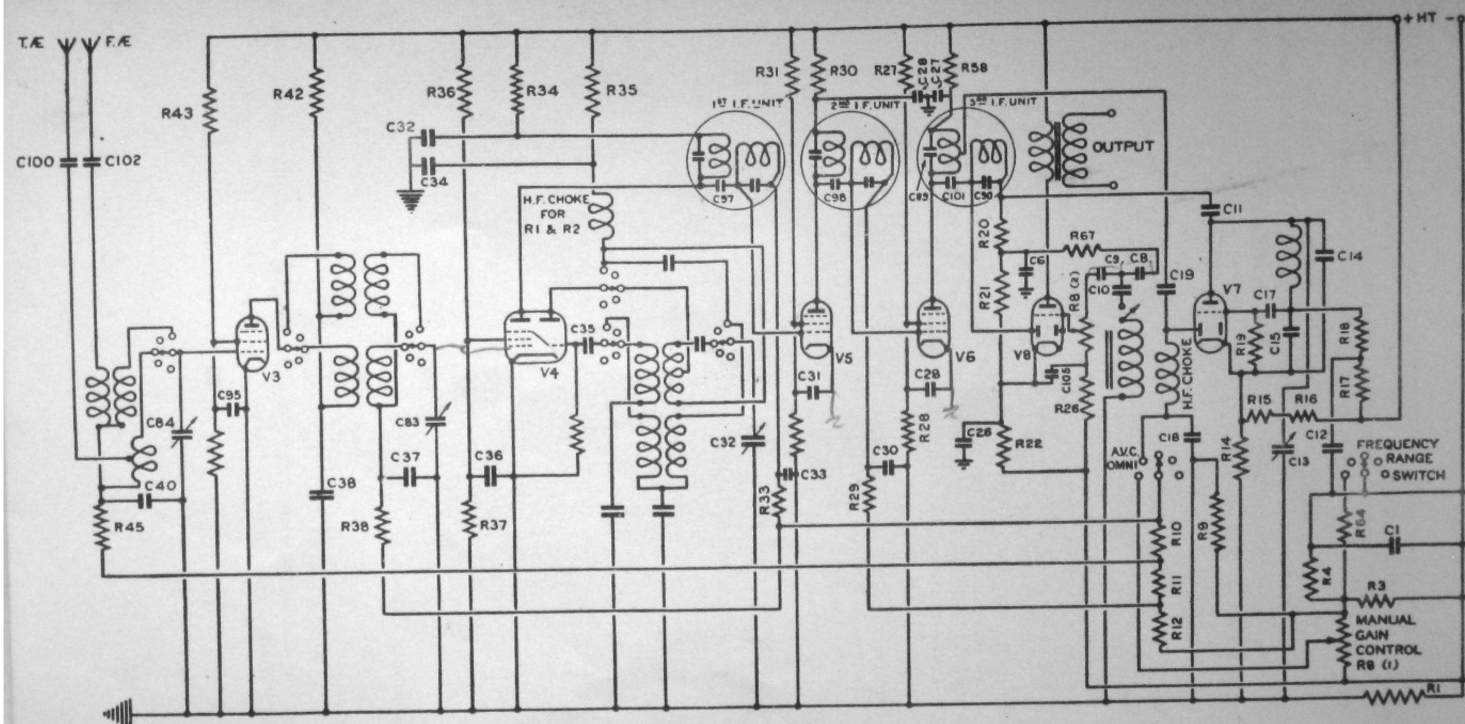


FIG. 2. Simplified Diagram of Communication Circuits R.1155.

(ii) homing by the visual method, in which the loop is set in the athwartship position, and the aircraft flown on a course which brings the point of intersection of the needles on to the centre line of the scale.

(iii) the taking of bearings aurally, using the Figure-of-Eight method. Sensing of bearings can also be carried out aurally.

Visual D/F.

7. In addition to the communication circuits previously described the receiver type R.1155 also incorporates a visual direction finder, in which all switching is accomplished by electronic means. Two triode hexode valves switch the vertical aerial with relation to the loop, at a predetermined frequency. A double triode valve, known as the meter switching valve, switches the rectified output to the indicating meter. These two switching operations are synchronised. A further valve, known as the limiter, automatically controls the input to the indicating meter. In order to explain the action of the visual circuits, each switching operation is described separately.

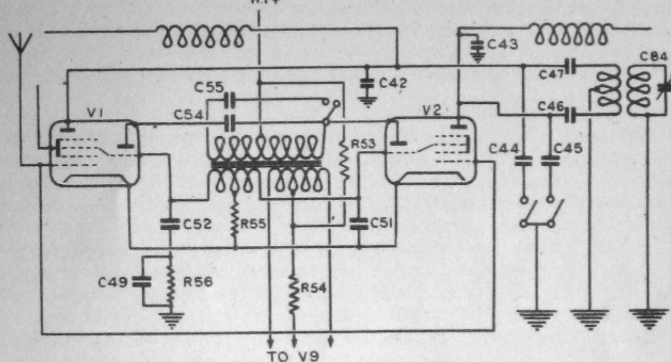


FIG. 3. L/F Oscillator Switching Circuit.

Low Frequency Switching Oscillator Circuit

8. The receiver operates on what is known as the "switched heart" principle, in which both the input and output switching is carried out electronically. The valves which perform the switching are in turn operated by means of a L/F oscillator. Fig. 3 shows the input switch valves and the L/F oscillator. V_1 and V_2 are dual function valves of the triode hexode type, in which the triode portions are connected to form a push-pull L/F oscillator. Thus when the oscillator grid of V_1 is positive, the oscillator grid of V_2 is negative. The hexode portions of these valves have their input grids connected together, and the vertical aerial is fed to this point. The anodes are connected differentially to the loop circuit. Thus if V_1 is amplifying and V_2 is not amplifying, anode current flows in one sense with respect to the loop circuit whilst if V_1 is not amplifying and V_2 is amplifying the anode current is in the opposite sense. Due to the action of R_{55}, during negative half cycles the oscillator grid of each valve has the full secondary voltage applied to it. Each hexode valve is therefore rendered inoperative for a longer time during each negative half cycle than would otherwise be the case, resulting in a sharp cut off. During positive half cycles the oscillator grid is held at a uniform and slightly positive value. The hexode valve gain therefore remains practically constant. The condensers C_{51} and C_{52} are of such a value that they are not sufficiently large to build up an appreciable negative charge due

to the rectifying action of the grids. The function of these condensers is to by-pass to earth any H/F voltage which might appear on the grids. In order to provide simultaneous switching of the receiver output circuits a double triode valve is used as shown in Fig. 5. The anodes of the valve act as diode anodes, and the L/F switching voltage from the secondary of the oscillator transformer is fed to the two grids of this double triode valve V_9. The resistance R_{54} performs a similar function to that of R_{55}, and therefore the diode valves are paralysed alternately as the grids pass through negative half cycles. The condensers C_{23} and C_{24} act as H/F by-pass condensers.

Provision of two L/F Oscillator Frequencies.

9. In this receiver the vertical aerial voltage is switched by the action of valves V_1 and V_2, and consequently there is always some interruption of the signal at the time of phase reversal. Thus the signal has a "wobble" on it, which, although least noticeable when the axis of the loop points in the direction of the incoming signal, is still present. Experiment has shown that for speech reception, interference with intelligibility is negligible when the switching frequency is 30 cycles per second. For telegraphy reception, however, 30 cycles per second is too low a frequency, and therefore a switch is provided which, when closed connects C_{54} and C_{55} (Fig. 3) in parallel so adjusting the oscillator frequency to approximately 30 cycles per second. When the switch is open, C_{54} alone is in circuit and the oscillator frequency is then approximately 80 cycles per second.

Meter Deflection Sensitivity (High-Low).

10. The sharpness of bearing in this type of receiver depends upon the amplitude of the vertical aerial voltage with respect to that of the loop voltage. By varying the amount of vertical voltage with respect to loop voltage it is therefore possible to adjust the sharpness of bearing so that a high degree of sensitivity to change of direction is obtained when taking bearings, and a lower degree of sharpness is available when using the receiver for "homing" purposes. The accuracy of indication as a direction finder depends upon the fact that V_1 and V_2, and their associated circuits are balanced electrically, so as to give equal gain during their respective half cycles of operation. For this reason it is highly undesirable to attempt to vary the amount of vertical voltage fed to the loop circuit by varying the gain of these valves. Also it is undesirable to vary the vertical voltage by reducing the input to the grids of V_1 and V_2 as this would reduce the signal level with respect to valve noise. The vertical aerial voltage has therefore been reduced by incorporating two condensers C_{44} and C_{45}, which may be switched into circuit between the hexode anodes (V_1, V_2) and earth. When the switch is closed and the two condensers C_{44} and C_{45} are in circuit maximum deflection of the visual indicator occurs when the loop is offset by a small amount. When taking bearings by the visual method therefore, this switch should be closed. When the switch is open and the two condensers C_{44} and C_{45} are out of circuit maximum deflection of the visual indicator does not occur until the loop is offset by a considerably greater number of degrees. Thus when using the visual indicator for "homing" this switch should be open.

Differential Indicating Meter Circuit.

11. With the single needle indicating instrument normally used with visual D/F receivers, a null signal is indicated when the needle is in the central position. In this condition no current is flowing through the meter. The disadvantage of this type of instrument lies in the fact that there is no way of determining visually whether the needle is giving an "on course" indication or whether the signal previously received has ceased. The twin needle instrument overcomes this disadvantage since an "on course" signal is indicated by the intersection of the two needles on the centre line of the scale. Thus the position of the point of intersection will depend upon the amount of current passed through the circuits associated with each needle. In the present case arrangements have

been provided whereby the presence of an " on course " signal automatically insures that the point of intersection of the two needles lies on the working part of the scale. No signal is indicated by the complete collapse of the two needles. Fig. 4 shows a simplified circuit arrangement of the twin needle indicator circuits. A rectified output is fed from the diode D to a simple switch having two positions. The operation of this switch must be synchronised with the input switching arrangement of V_1 and V_2, and it may be either an electronic or mechanical device. With the switch in position 1 the rectified output flows through R_{25} and causes C_3 to accumulate a charge. Current can also flow down R_{24} *via* the indicating meter providing there is no opposing charge in condenser C_5. For the moment the combination C_4 and R_{23} should be neglected. With the switch in position 2, the condenser C_5 will accumulate a charge in a similar manner and as before current will tend to flow through the indicating meter but in a reverse direction. Thus if the applied voltage from the diode D is the same for both positions of the switch the condensers C_3 and C_5 will charge up to equal voltages and no current will flow through the meter. It follows that the potential between VW and between XY are equal. Thus the potential at the point P is also equal to that at both V and X. It will be seen that the combination C_4 and R_{23} has been introduced between the Point P and WY. This will increase the diode load and cause an equal drop of potential at points V and X, and polarizing currents of equal value will flow from V through one meter winding and R_{23} to W, also from X

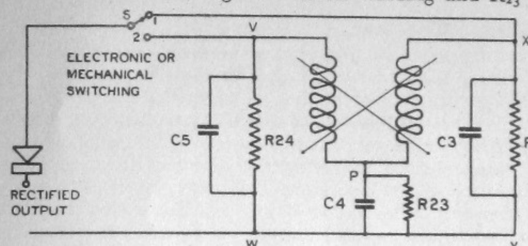


FIG. 4. Simplified Visual Meter Switching Circuit.

through the other meter winding and R_{23} to Y. This will cause both needles to rise to an equal height. The value of these two polarizing currents depends upon the value of R_{23}, and therefore variation of this resistance varies the height to which the needles will rise. If the loop is offset the voltages across C_3 and C_5 become unequal, thus causing one needle to rise and the other needle to fall. This shifts the point of intersection of the needles to one side of the centre line of the scale. The potential at the point P however, remains practically constant and therefore polarizing currents continue to flow in addition to differential current. Suppose that the loop be offset in such a manner that the voltage developed across C_5 is greater than that across C_3. Then differential current will flow from C_5 to C_3 through both meter windings and also polarizing current will flow from C_5 through one meter winding and R_{23}. Polarizing current also flows from C_3 through the other meter winding and R_{23}. It will be seen that one of these polarizing currents will therefore assist the differential current flowing from C_5 to C_3. The sum of these two currents will drive one needle upwards. The polarizing current flowing through the other meter winding will be in the opposite direction to the differential current and the resultant which will be the difference of the two currents will drive the second needle downwards. R_{23} is a variable resistance in order that the needles may be adjusted to a convenient height on the meter scale.. With minimum resistance in circuit the polarizing current will be maximum and the needles will rise to a point well up the scale. With all resistance in circuit the polarizing current will be reduced to a minimum and the needles will therefore intersect at a point near the lower end of the scale.

Effect of A.V.C.

12. The arrangement shown in Fig. 4 and previously explained, besides increasing the sensitivity of the meter due to differential action also causes one needle to rise as the other falls so that, providing the value of R_{23} is correct an ideal intersection of both needles results. This is important as otherwise due to the action of the A.V.C. system, when the loop is rotated from the " on course " position, one needle of the indicator would remain steady and the other would move downwards. Referring to Fig. 3 it should be appreciated that V_1 and V_2 always affect the same diode of V_9. Thus when the loop is rotated off course suppose that V_1 supplies a larger signal voltage to diode A (V_9) than V_2 supplies to diode B (V_9), the A.V.C. system would hold the larger signal, but would not control the weaker signal due to V_2. Thus one needle would remain in its original position and the second needle would fall.

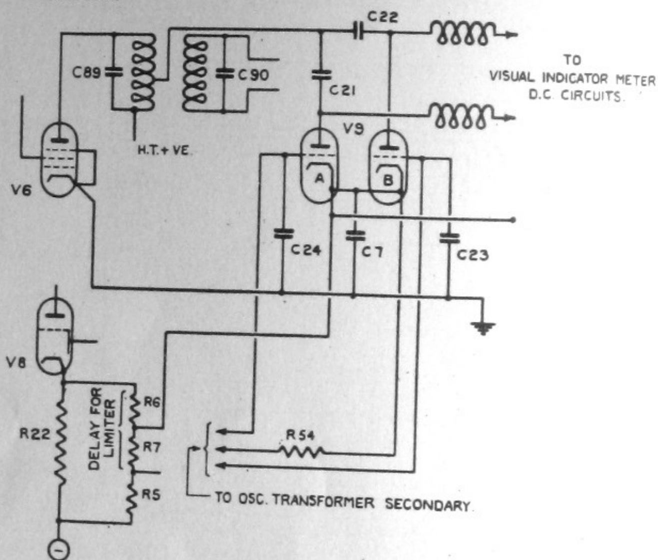


Fig. 5. Visual Meter Switching Circuit.

Application of above circuits to R.1155.

13. Referring to Fig. 5 the double triode valve V_9 combines the action of the diode D and switch S in Fig. 4. The grids of V_9 are operated from the L/F switching oscillator as described in para. 8. The anodes of V_9 may be considered as diodes whose operation is controlled by the bias applied to their grids. When one grid is biased slightly positive, causing one diode to be operative, the other grid is biased strongly negative, causing the second diode to become inoperative. Thus the diodes will operate alternately, and in synchronism with the input switching valves V_1 and V_2. The condensers C_{21} and C_{22} feed I.F. to V_9 and the D.C. switched output from this valve flows through chokes into the meter indicating circuit. Delay bias is applied between the cathodes and anodes of the double diode V_9, thus preventing them from delivering a current and raising the meter needles due to noise output of the receiver in the absence of a signal. The condenser C_{20} feeds a diode limiter V_8, the D.C. output of which flows *via* a choke and R_{23}. Any current that is fed in at this point therefore tends to drive both needles downwards without interfering with the differential action of the circuit. The normal A.V.C. action of the receiver

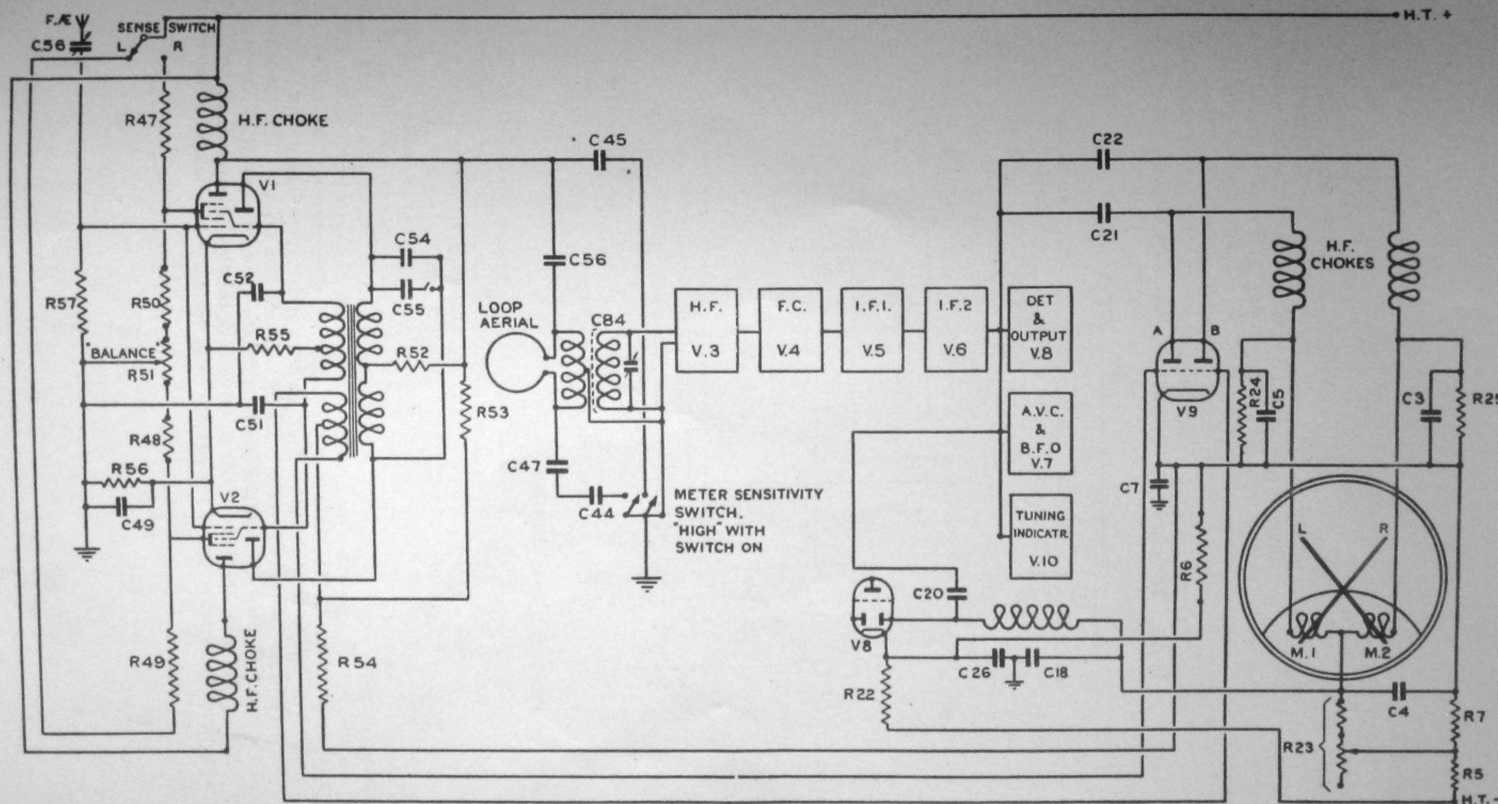


FIG. 6. Simplified Diagram of Visual D/F Circuits R.1155.

is not sufficient to keep the intersection of the needles on the scale for the range of signal variation which may occur. The limiter arrangement in Fig. 5 is so adjusted to make it impossible for the point of intersection of the needles to move off the scale providing the adjustment of R_{23} is correct. This limiter circuit will deal with input changes up to 80 dbs. The limiter delay voltage is supplied across R_6 and R_7 in series, and is adjusted to be approximately 4v. Thus the limiter does not come into action until the peak voltage applied to the common points C_{20}, C_{21} and C_{22} exceed the delay volts. The resistor R_{53} feeds a small positive bias potential to the grids of V_9. The effect of this is to lower the working impedance of the anode circuit and so greatly increase the sensitivity. It also reduces the effect of any difference of impedance between the two sections of the diode circuits V_9.

Balance.

14. The accuracy of indication depends upon the balance of the two input switching valves V_1, V_2, and all associated circuits throughout the visual D/F receiver. Balance is accomplished by means of a potentiometer R_{51} which is connected between the screens of valves V_1 and V_2 and earth. In the balance position of the receiver master switch the loop aerial is disconnected and earthed. A dummy loop consisting of a suitably matched inductance and condenser C_{99} is connected in place of the loop proper. This dummy loop does not pick up any signals and any sideways deflection of the indicator needles is therefore due to lack of circuit symmetry. In order to remove this lack of symmetry the point of intersection of the indicator needles should be adjusted to coincide with the centre scale line, by means of the potentiometer R_{51}.

Visual Sense.

15. If it is desired to use the visual indicator for homing, first the receiver must be tuned into the selected station, using the " Omni " or A.V.C. position of the master switch. Next the balance operation should be carried out. Setting the loop at 0 degrees (i.e., athwartship), the visual indicator may now be switched into circuit. Should the needles intersect at a point to the right of the fixed central line on the meter scale, it will be necessary to turn the aircraft in order to set it on course; which is indicated by the needles intersecting on the centre line of the indicator. There may be occasions when it is not known whether the homing transmitter lies ahead or astern of the aircraft, in which case it is necessary to use the sense arrangements as follows. After putting the aircraft on such a course that the needles intersect on the centre line, turn the aircraft a few degrees to the right: if the station is ahead the needles will intersect on the left: if the station is astern the needles will intersect on the right. This sense determination may, if desired, be carried out by rotating the loop from zero to, say 10 degrees instead of rotating the whole aircraft. The sense will then be indicated in the same manner. Care must be taken to restore the loop to zero after determination of sense. The above assumes that the loop connections are correct, as should these be reversed, 180 degrees error will be introduced. After installation of new apparatus, when making an initial test flight the above procedure may be adopted for determining whether the loop connections are actually correct. In this case, of course, it is necessary to make the check on a station whose position relative to the aircraft is known.

Figure-of-Eight Aural D/F.

16. When using this method of D/F, the vertical aerial is disconnected, the loop itself being the sole source of signal pick-up. The L/F oscillator incorporated in V_1 and V_2, and also the meter switching circuits of V_9 are inoperative. The A.V.C. system is out of circuit, volume control being effected manually. After tuning in the selected station, the loop is rotated to a point where a minimum signal occurs, this depending upon the well

known properties of the simple loop aerial. There are two such points for any given station, which occur 180 degrees apart. The selection of the correct minimum signal, indicating the true bearing, is done by applying vertical aerial voltage to the loop circuit. This is accomplished by a switch labelled L-R, which has three positions. The switch is spring loaded so that when released it returns to the central position. Moving the switch either to left or right, puts H.T. on to the screens of one or the other of the hexode portions of V_1 or V_2, thus coupling the vertical aerial through to the loop circuit.

CONSTRUCTIONAL DETAILS.

17. The receiver panel is quickly detachable from its containing box, the latter being mounted on special Firestone rubber suspension units, to afford protection from vibration shocks, etc. All cable connections to the receiver are terminated in plugs and

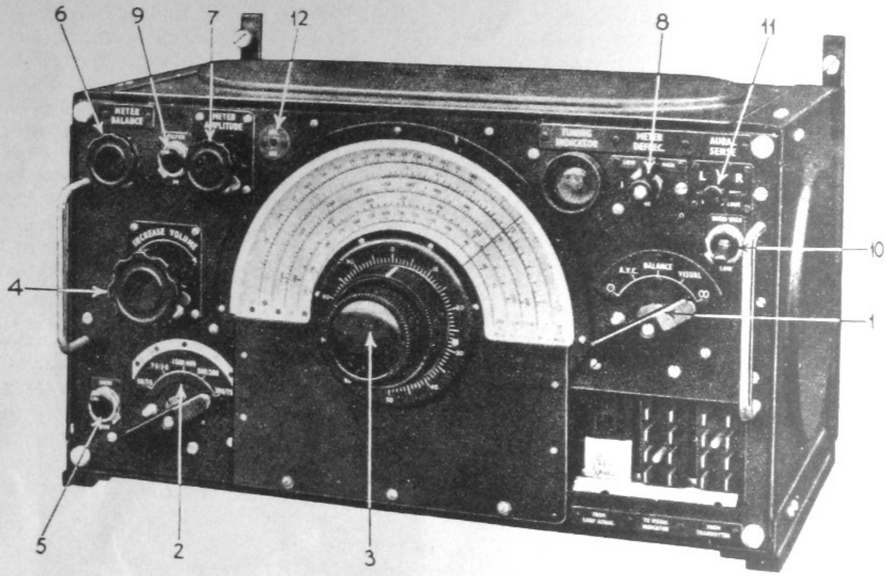


FIG. 7. Receiver R.1155 front panel.

sockets which are non-reversible and non-interchangeable. Cables are as far as possible metal braided, this metal braiding being earthed in order to minimise interference from external sources being picked up and passed on to the receiver circuits. The receiver containing box and panel are of metal construction, and are earthed to the main bonding system of the aircraft. Fig. 7 shows the receiver panel and its controls.

Controls.

18. *Master Selector Switch.* (1) This is positioned on the right hand side of the tuning dial, and has five positions :—

(i) " **Omni** " or " All round " reception. The gain of the H/F, Frequency changer and I/F stages (V_3, V_4, V_5 and V_6 respectively) are controlled manually by a potentiometer $R_{8(1)}$, the A.V.C. being out of circuit.

(ii) **A.V.C.** This gives automatic volume control, with the manual control of the L/F input to the output stage by means of the potentiometer $R_{8(2)}$.

(iii) **Balance** (for Visual D/F). This is for the purpose of matching the circuits and valves associated with the visual indicator.

(iv) **Visual D/F.** The twin needle indicator and associated circuits including valves V_1, V_2 and V_9 are switched into circuit. In this position A.V.C. is in use.

(v) **Figure-of-Eight** (Aural D/F). Bearings are taken on aural nulls, using the handswitch for sense determination. The H/F gain is manually controlled, the A.V.C. being disconnected.

Frequency Range Switch. (2) This is positioned on the lower left hand side of the tuning scale, and selects five frequency ranges, viz. :—

Range 1.	18.5 Mc/s	—	7.5 Mc/s	H/F		
„ 2.	7.5 Mc/s	—	3.0 Mc/s	H/F	}	
„ 3.	1,500 kc/s	—	600 kc/s	M/F	}	D/F
„ 4.	500 kc/s	—	200 kc/s	M/F	}	
„ 5.	200 kc/s	—	75 kc/s	M/F	}	

The operations carried out by the frequency range switch in its various positions may be set out briefly as follows. The trailing aerial is used for all M/F ranges, the fixed aerial being used for the two H/F ranges and also for sense purposes on D/F. When the aerial selector switch is in the D/F position, the fixed aerial may also be used for all round reception. The grid and anode inductances for the signal frequency stage are selected for the correct range. The grid and oscillator inductances of the frequency changer V_4 are selected for each range. The standing grid bias for the signal frequency, frequency changer and I.F. stages is decreased when on the H/F ranges in order to maintain constant amplification on all ranges.

Tuning. (3). This control is coupled to a three gang condenser, which is used for tuning on each frequency range. The condensers involved are indicated on the main diagram of connections by C_{82}, C_{83} and C_{84}. The tuning scale is of the large semi-circular type, being traversed by a single pointer. Direct and vernier tuning are provided.

The tuning scale is arranged as below :—

18.5 Mc/s	Black ...	10 Mc/s	Blue ...	7.5 Mc/s
7.5 Mc/s	Blue ...	5.5 Mc/s	Red ...	3.0 Mc/s
1,500 kc/s		Black —		600 kc/s
500 kc/s		Yellow —		200 kc/s
200 kc/s		Black —		75 kc/s

The colouring of the calibrated scales is arranged to line up with the range colouring on the transmitter.

Volume Control. (4). This is located immediately on the left of the tuning dial. It consists of two potentiometers mounted on the same spindle. These potentiometers are indicated on the main diagram of connections as follows :—$R_{8(1)}$ $R_{8(2)}$. Potentiometer $R_{8(1)}$ is in circuit when the receiver operational switch is in either the Omni or Figure-of-Eight positions. Potentiometer $R_{8(2)}$ is in circuit when the receiver master switch is in the A.V.C., BALANCE, or VISUAL D/F positions.

Heterodyne. (5). This is a small on-off switch positioned in the bottom left hand corner of the panel, its function being to switch on or off the beat frequency oscillator (triode section V_7).

Meter Balance. (6). This is located at the top left hand corner of the panel and is in circuit when the master switch is in either the BALANCE or VISUAL positions (Fig. 10, R_{51}).

Meter Amplitude. (7). This is on the right of the meter balance control and is for the purpose of adjusting the needles of the visual indicator to a convenient point on the meter scale (Fig. 10, R_{23}).

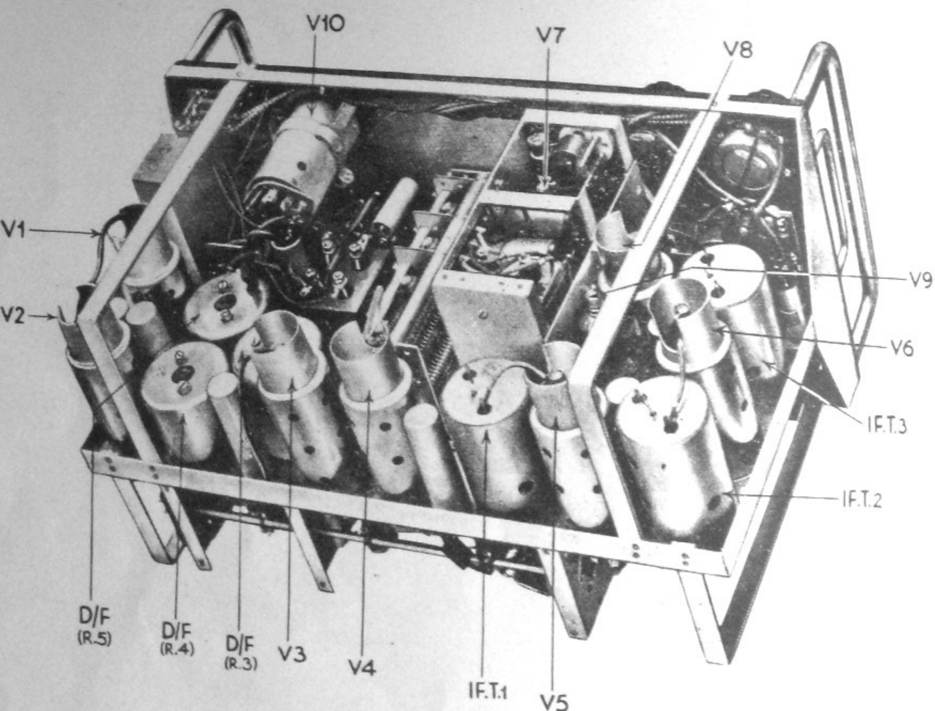


FIG. 8. Receiver R.1155 chassis with valves in position.

Meter Deflection Sensitivity Switch. (8). This is a two position switch located to the right of the tuning indicator. Its function is to provide comparatively low sensitivity of the visual indicator for homing purposes, or high sensitivity of the visual indicator when taking bearings by the visual method.

Filter Switch. (9). This is an on-off switch between the meter balance and meter amplitude controls, so that the L/F filter may be switched off if desired.

Meter Frequency Switch. (10). This is a two position switch immediately below the Aural sense switch. This switch has the function of altering the switching frequency of the two valves V_1 and V_2, and associated circuits from 30 to 80 cycles per second.

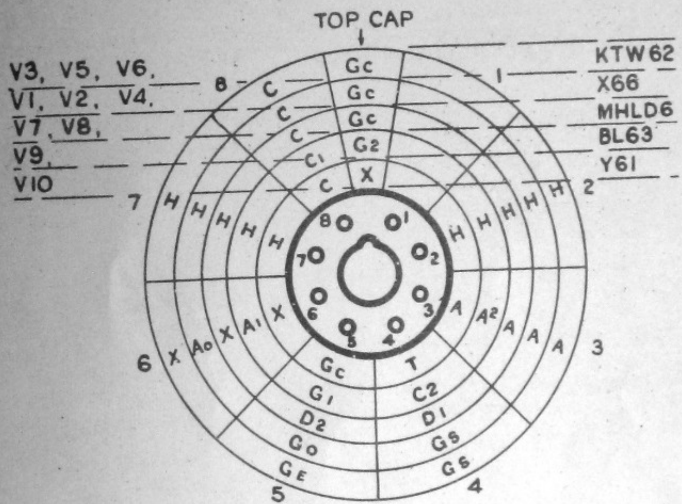
Aural Sense Switch. (11). This switch has three positions, and is located at the top right hand corner of the panel. The switch is spring loaded so that it returns to its central position. On the left it is marked L and on the right R. This is for sense determination when using Aural D/F.

Heterodyne Pre-set Adjustment. (12). This is a small semi-variable condenser, with screwdriver adjustment which varies the beat frequency. The condenser is shown on the diagram of connections by C_{13}.

VALVES AND POWER SUPPLIES.

Valves.

19. V_1 and V_2, known as the visual D/F switching valves, and V_4, the frequency changer are triode hexode valves type X.66. V_3 the H.F. stage, V_5 and V_6 the I.F. stages



KEY.

H	Heaters	AO	Oscillator Anode	GE	Suppressor Shields
C, C1, C2	Cathodes	GO	Oscillator Grid	T	Target
GC, G1, G2	Control Grids	D1, D2	Diodes	X	Pin omitted
A, A1, A2	Anodes	GS	Screened Grids		

FIG. 9. Octal Valve viewed from underside.

employ aligned grid tetrode variable mu valves type KTW.62. V_7, combining the function of A.V.C. and beat frequency oscillator, and V_8 combining the functions of speech diode. Visual meter limiter and output are double diode valves type MHLD.6. V_9, the visual meter switching valve is a double triode valve type BL.63. V_{10}, the tuning indicator, is a special valve type Y.61 or Y.63.

Power Supply.

20. Both H.T. and L.T. are derived from a power unit driven off the aircraft electrical supply and described in paras. 46, 47 and 48, Transmitter T.1154 section.

PRECAUTIONS AND MAINTENANCE.

R.1155.

21. When ground testing the above equipment the following procedure should be adopted. The aerial selector switch type J should be set in the NORMAL position. The receiver frequency range switch should be turned to either range 1 or 2. The receiver master switch may be set in either the OMNI or A.V.C. position. When the transmitter master switch is turned to STAND-BI, the L.T. power unit should run up, and in a few seconds the transmitter valves should glow faintly. The telephones may be plugged in, and reception checked. To receive on the M/F ranges 3, 4 and 5, the aerial switching unit type J must be set in the position engraved M/F ON FIXED AERIAL. If a check of D/F reception is made, the aircraft should be well clear of metal obstructions such as hangars, before verifying sense of bearings. To carry out such a test, the aerial switching unit type J must be switched to the position engraved D/F. With the aerial switching unit in this position or in the Earth position, the H.T. power unit should remain inoperative in all positions of the transmitter master switch.

22. On installations fitted with the aerial plug board (instead of aerial switching unit type J), the fixed aerial socket must be connected to the H/F plug in order to receive on the H/F ranges 1 and 2. In order to Receive on the M/F Ranges 3, 4 or 5, the fixed aerial socket must be connected to the M/F plug. When using visual D/F, it should be remembered that the aerial plug board does not break the H.T. power unit relay circuit in any position, and therefore the transmitter master switch must be kept in the STAND-BI position.

23. When the aircraft nominal supply is 12 volts, the minimum permissible voltage with the L.T. power unit running is 10.5 volts. When the aircraft supply is 24 volts, the minimum permissible voltage with the L.T. power unit running is 21 volts. A high resistance voltmeter should be used to check these figures. The minimum filament voltage permissible for normal functioning of the receiver is 5.7. If reception fails, or signals are weak when the filament voltage is between 5.7 and 6 volts, the frequency changer valve V_4 (type X.66) should be replaced. Full instructions for using the receiver will be found in a separate publication entitled " Working Instructions."

LIST OF RESISTANCES.

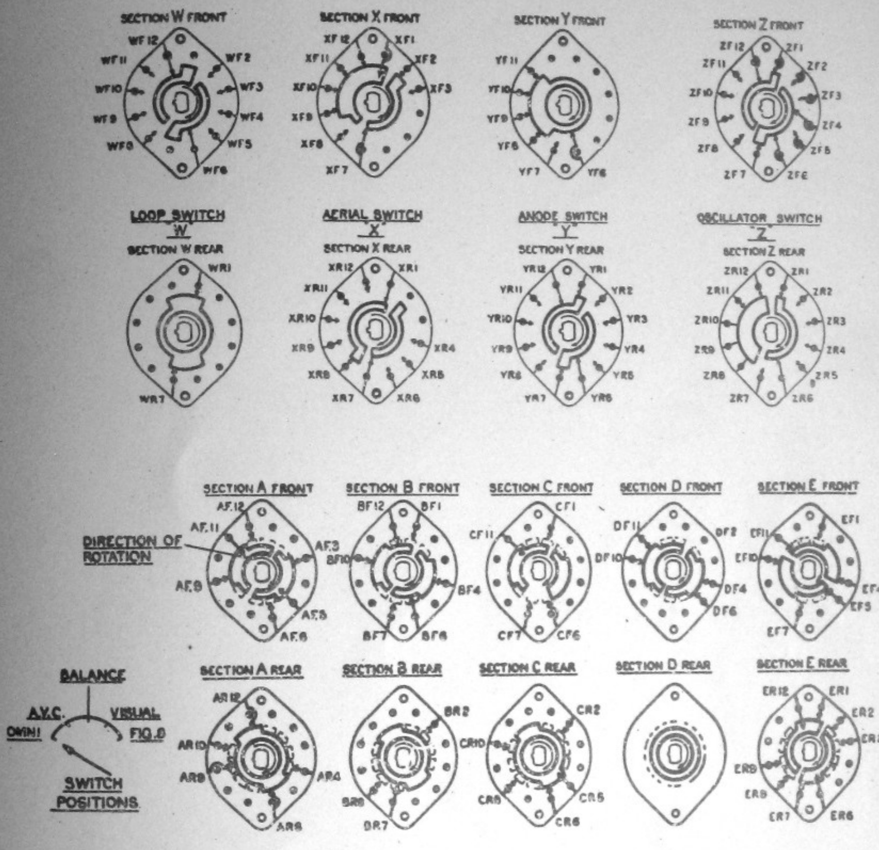
Ref.	Value.	Ref.	Value.
R1	2,000 ohms	R35	22,000 ohms
R2	1,200 ,,	R36	27,000 ,,
R3	1,200 ,,	R37	22,000 ,,
R4	120 ,,	R38	100,000 ,,
R5	1,000 ,,	R39	56,000 ,,
R6	1,500 ,,	R40	1,500 ,,
R7	270 ,,	R41	1,500 ,,
R8 (1, 2)	50,000 ; 500,000 dual pot	R42	2,200 ,,
R9	2,000,000 ohms	R43	27,000 ,,
R10	150,000 ,,	R44	22,000 ,,
R11	150,000 ,,	R45	100,000 ,,
R12	27,000 ,,	R46	1,500 ,,
R13	1,000,000 ,,	R47	27,000 ,,
R14	1,000 ,,	R48	6,800 ,,
R15	30,000 ,,	R49	27,000 ,,
R16	27,000 ,,	R50	6,800 ,,
R17	1,500 ,,	R51	20,000 ,, wire-wound pot.
R18	10,000 ,,	R52	6,800 ,,
R19	56,000 ,,	R53	560,000 ,,
R20	56,000 ,,	R54	56,000 ,,
R21	470,000 ,,	R55	56,000 ,,
R22	1,000 ,,	R56	240 ,,
R23	20,000 pot. (6,000 ω min.)	R57	560,000 ,,
R24	22,000 ohms	R58	2,200 ,,
R25	22,000 ,,	R59	220,000 ,,
R26	100,000 ,,	R60	220,000 ,,
R27	27,000 ,,	R61	1,200 ,,
R28	22,000 ,,	R62	2.2 megohms
R29	100,000 ,,	R63	2.2 ,,
R30	2,200 ,,	R64	100 ohms
R31	27,000 ,,	R65	10,000 ,,
R32	22,000 ,,	R66	10,000 ,,
R33	100,000 ,,	R67	22,000 ,,
R34	2,200 ,,	R68	56,000 ,,
		R69	100 ,,

LIST OF CAPACITIES IN MICROFARADS, UNLESS STATED.

Ref.	Value.	Ref.	Value.
C1	2.5	C13	60 picofarads
C2	2 x 0.1	C14	1,600 ,,
C3	2.5	C15	4,550 ,,
C4	1.0	C16	0.5
C5	2.5	C17	0.0001
C6	0.0001	C18	0.005
C7	0.005	C19	0.001
C8	0.001	C20	0.005
C9	0.001	C21	0.005
C10	0.004	C22	0.005
C11	0.0001	C23	0.005
C12	0.1	C24	0.005

C25	0.001		
C26	0.1		
C27	0.1		
C28	0.1		
C29	0.1		
C30	0.1		
C31	0.1		
C32	0.1		
C33	0.1		
C34	0.1		
C35	0.0002		
C36	0.1		
C37	0.1		
C38	0.1		
C39	0.1		
C40	0.1		
C41	0.1		
C42	25	picofarads	
C43	25	,,	
C44	240	,,	
C45	240	,,	
C46	80	,,	
C47	80	,,	
C48	200	,,	
C49	0.1		
C50	0.1		
C51	0.1		
C52	0.1		
C53	0.1		
C54	0.04		
C55	0.5		
C56	8–105	picofarads	max.
C57	4— 40	,,	,,
C58	4— 40	,,	,,
C59	4— 40	,,	,,
C60	4— 40	,,	,,
C61	4— 40	,,	,,
C62	4— 40	,,	,,
C63	4— 40	,,	,,
C64	4— 40	,,	,,
C65	4— 40	,,	,,
C66	4— 40	,,	,,

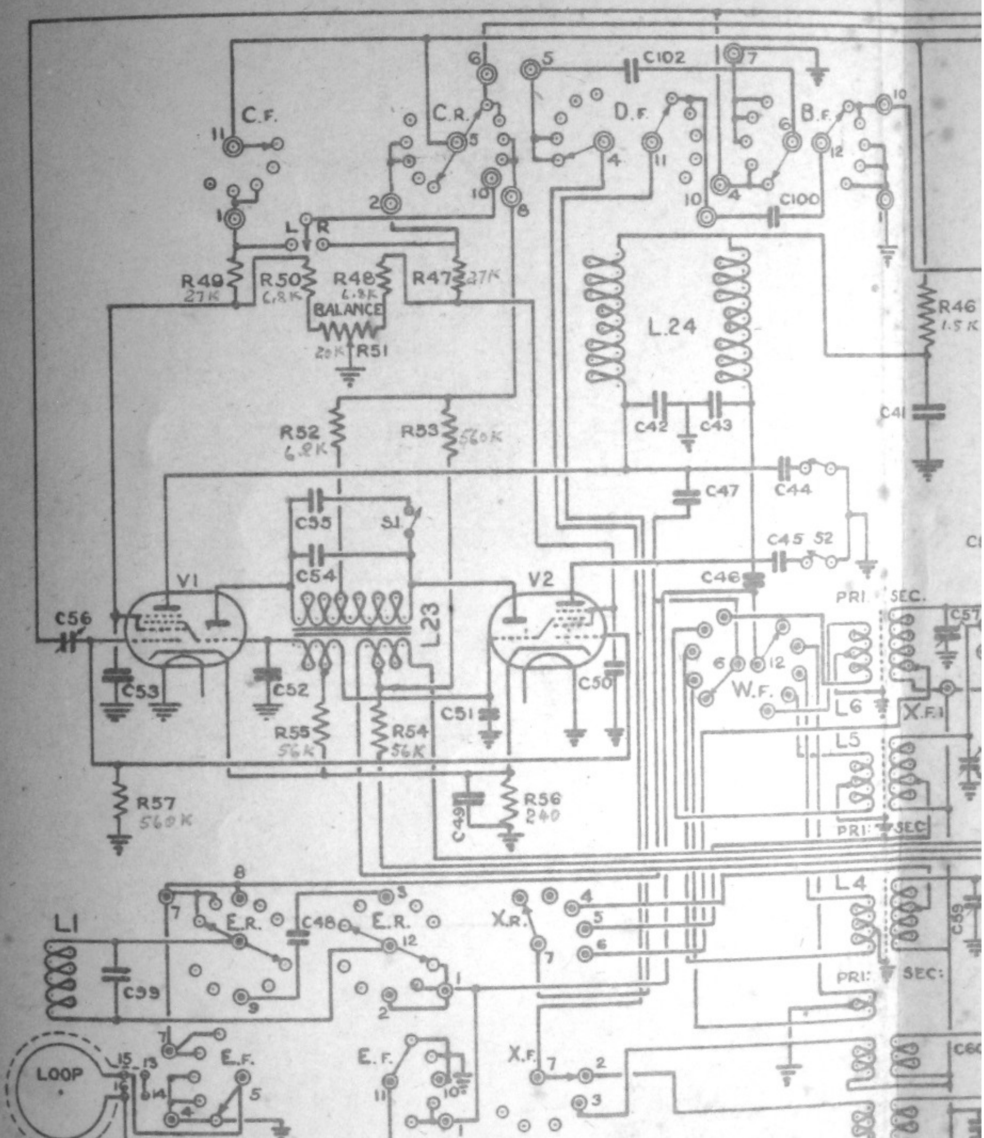
C67	2,000	picofarads	
C68	4—40	picofarads	max.
C69	4—40	,,	,,
C70	4—40	,,	,,
C71	5—40	,,	,,
C72	5—40	,,	,,
C73	93	picofarads	
C74	255	,,	
C75	537	,,	
C76	1,670	,,	
C77	6,170	,,	
C78	20	,,	
C79	15	,,	
C80	10	,,	
C81	15 cms		
C82 / C83 / C84	Tuning gang		
C85	300	picofarads	
C86	300	,,	
C87	300	,,	
C88	300	,,	
C89	600	,,	
C90	300	,,	
C91	40	,,	
C92	2.5		
C93	4.0		
C94	1.0		
C95	0.5		
C96	0.02		
C97	2	picofarads	
C98	2	,,	
C99	100	,,	
C100	200	,,	
C101	4	,,	
C102	0.001		
C103	0.005		
C104	75	picofarads	
C105	0.1		
C106	65	picofarads	
C107	0.1		
C108	0.0002		
C110	40 pico fds		



IMPORTANT NOTE :

In the theoretical circuit contacts shown thus :—⊙ which have a reference number, are shown in many cases connected to groups of contacts marked thus :—O. The latter are not to be found on the switch sections, having been eliminated by suitable shaping of the rotor blades, but are inserted to show clearly the function of the switch. In the case of frequency range switches, reference numbers are not shown on the theoretical circuit on all contacts, only the rotor contacts being numbered, but the contacts may be found by reference to switch diagram sections W, X, Y, Z.

All switches are shown in extreme counter-clockwise position.



LOOP PLUG CONNECTIONS 13, 14, 15, 16.

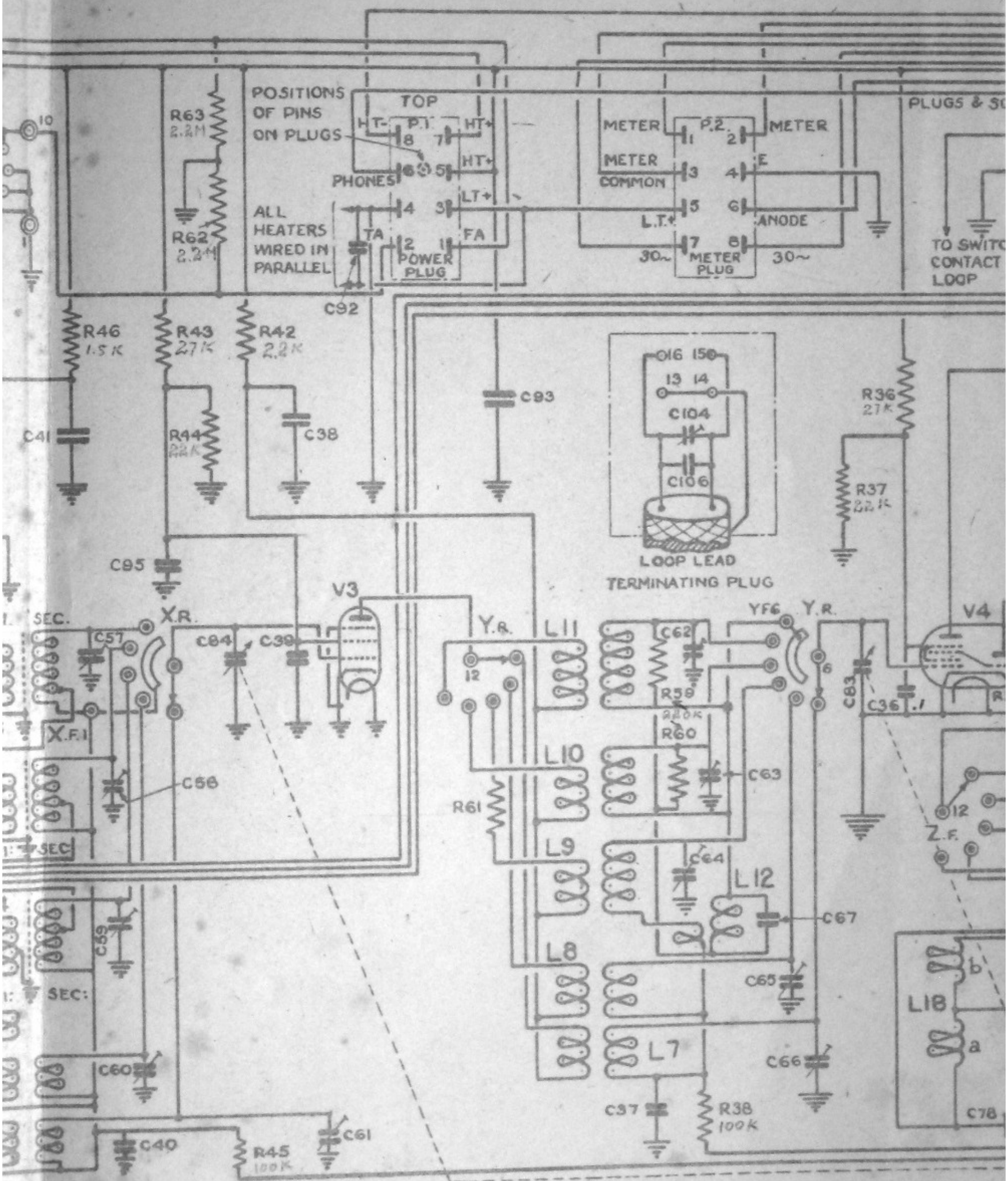
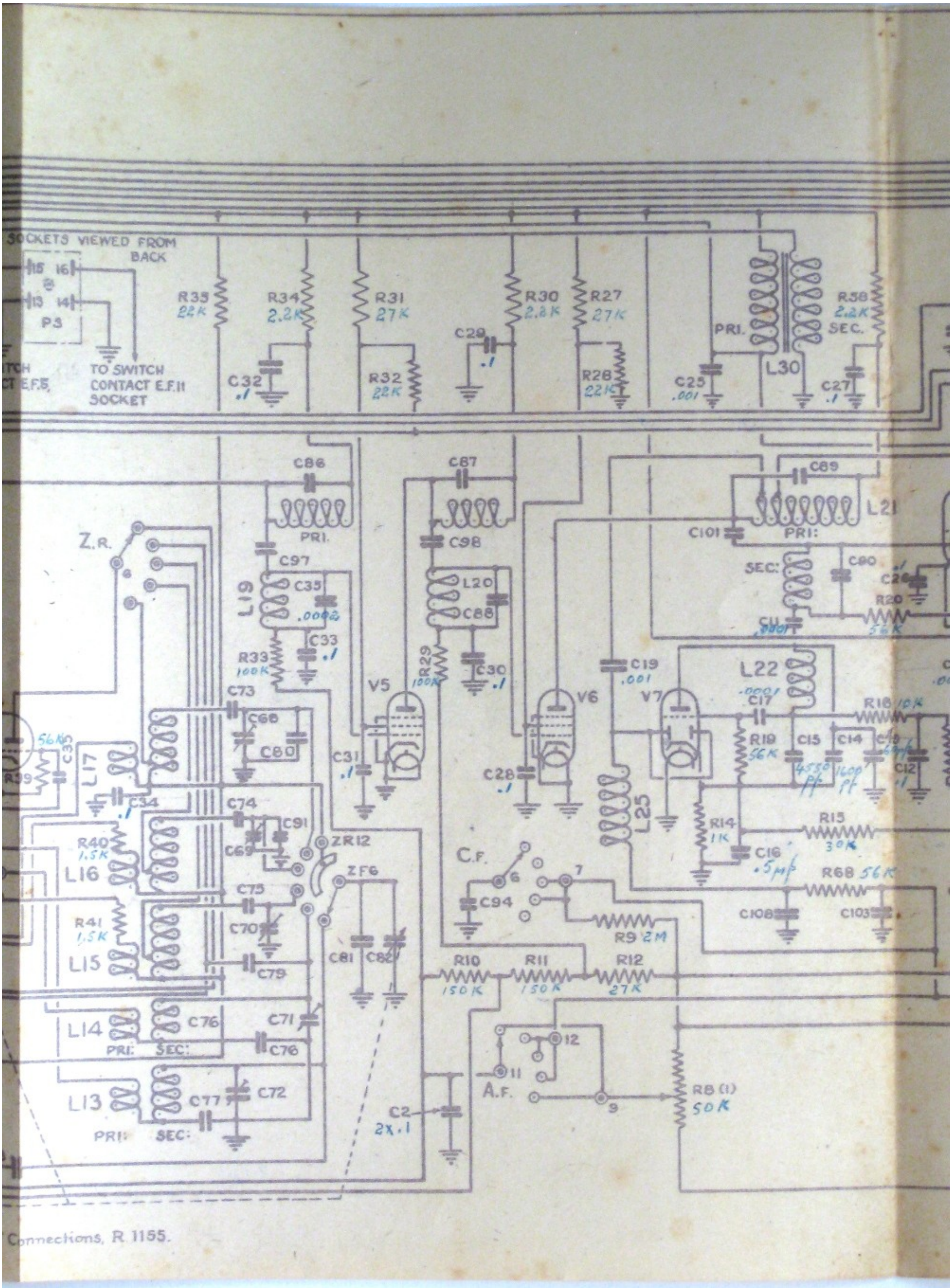
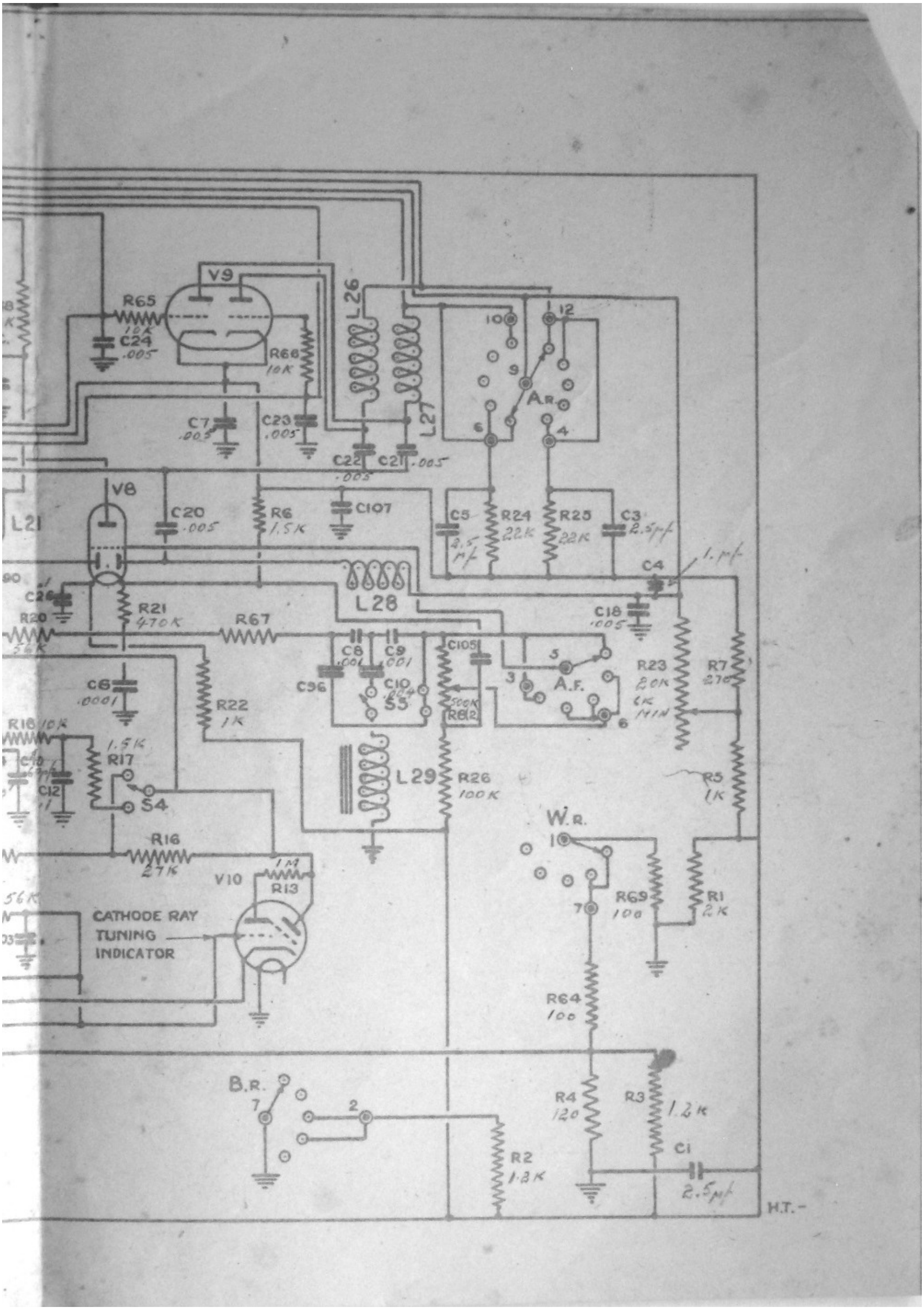


Fig 10 Main Diagrams of C



Connections, R. 1155.



V9
R65
10K
C24
.005
R66
10K
L26
L27
C7
.005
C23
.005
C22
.005
C21
.005
10
12
9
A.R.
6
4
V8
L21
C20
.005
R6
1.5K
C107
C5
2.5 mf
R24
22K
R25
22K
C3
2.5mf
C4
1.mf
L28
C26
R20
56K
R21
470K
R67
C18
.005
C8
.001
C9
.001
C105
5
3
A.F.
6
R23
20K
R7
270
C6
.0001
R22
1K
C96
C10
S5
500K
R8
R18
10K
R17
1.5K
S4
C12
L29
R26
100K
R5
1K
W.R.
1
7
R16
27K
V10
1M
R13
R69
100
R1
2K
CATHODE RAY
TUNING
INDICATOR
56K
R64
100
B.R.
7
2
R4
120
R3
1.2K
C1
2.5mf
R2
1.2K
H.T.-

[illegible]