CHAPTER 1

TRANSMITTERS, Types T.1154, T.1154A, B, C, D, E, F, H, J, K, L, M, and N

INTRODUCTION

1. Transmitters of the T.1154 series are designed primarily for installation in aircraft, to provide air-to-ground or air-to-air communication by W/T, and in all but two versions by R/T as well. Series L, however, is intended for installation in high-speed launches, and series D and E were introduced for mobile ground stations. Normally all these transmitters are used with receivers of the R.1155 series (see Chapter 2 of this publication).

Frequency coverage

2. Altogether there have been thirteen production varieties of the T.1154, the principal differences between them concerning frequency coverage and the provision or absence of R/T facilities. Component variations in the drive and output units, modifications of the "click-stop" mechanism for rapid selection of pre-set frequencies, and the use of steel or aluminium cases account for further versions. Table 1 enumerates the different types of transmitter and their frequency ranges. The colours stated in the table are those of the tuning controls for the ranges concerned.

TABLE 1

Frequency coverage of transmitters T.1154

T.1154, *T.1154A, T.1154B, T.1154J, T.1154N				
	Range 1	(H.F.),	BLUE	10 Mc/s to 5·5 Mc/s
	Range 2	(H.F.),	RED	5·5 Mc/s to 3·0 Mc/s
	Range 3	(M.F.),	YELLOW	500 kc/s to 200 kc/s
T.1154C, T.1154F, T.1154H, T.1154K, T.1154M				
	Range 1	(H.F.),	BLUE	16·7 Mc/s to 8·7 Mc/s
	Range 2	(H.F.),	BLUE	8·7 Mc/s to 4·5 Mc/s
	Range 3	(H.F.),	RED	4·5 Mc/s to 2·35 Mc/s
	Range 4	(M.F.)	YELLOW	500 kc/s to 200 kc/s
T.1154D, *T.1154E				
	Range 1	(H.F.),	BLUE	8 Mc/s to 4·5 Mc/s
	Range 2	(H.F.),	RED	4·5 Mc/s to 2·5 Mc/s
	Range 3	(M.F.),	YELLOW	500 kc/s to 200 kc/s
T.1154L				
	Range 2	(H.F.),	RED	5·5 M/cs to 3 Mc/s
	Range 2A	(H.F.),	BLUE	3 M/cs to 1·5 Mc/s
	Range 3	(M.F.),	YELLOW	500 kc/s to 200 kc/s

**Note*.—Transmitters marked with an asterisk provide C.W. and M.C.W. only. All others are for C.W., M.C.W., and R/T.

3. In all transmitters with three frequency ranges there are separate sets of tuning controls for each range, identified by colours as in the foregoing table. Series C, F, H, K, and M, however, use the same set of controls, coloured blue, for the two higher H.F. ranges.

4. Certain types of T.1154 are now obsolete or obsolescent and ultimately the series will be narrowed to three standard types for all applications. The position in this respect is shown in Table 2, the final standard versions being identified with a dagger. In the same table is shown the type of case, aluminium or steel, and of "click-stop" mechanism.

Pre-set frequency selection

5. The click-stop mechanism is arranged so that the tuning controls click into and are rigidly held in the correct position for pre-set frequencies. With the Multi-click system all the chosen frequencies are selected in turn as the tuning dials are rotated, and the operator sees which one is engaged at any moment by means of lettered tabs coming into view behind an aperture. The mechanism can be released to allow free rotation of the dials when setting up frequencies which have not been pre-selected.

6. The Uni-click mechanism on the other hand allows one click-stop to be brought into use at a time, the stop required being selected by turning a selector knob to the appropriate position on a lettered dial. Both mechanisms are fully described in para. 84 to 92.

TABLE 2

Stores Ref.	*Type*	*Case Aluminium (A) or Steel (S)*	*Click-stop Mechanism*	*Remarks*
10D/97	T.1154	A	Multi	Obsolete
10D/99	A	A	Multi	Obsolete
10D/196	B	A	Multi	Obsolescent.—Restricted to use in Halifax (B) only, but suitable for use in all bombers.
10D/198	C	A	Multi	Obsolescent.—Coastal version. Superseded by T.1154F.
10D/730	D	A	Multi	Obsolescent.—Provided for mobile ground stations, but superseded by T.1154K.
10D/731	E	A	Multi	Same construction as T.1154D.
10D/893	F	A	Multi	Obsolescent.—Coastal version. Used in Halifax (G.R.) and Sunderland aircraft, and in trainers where the steel version is unacceptable.
10D/1180	†H	A	Uni	T.1154F with Uni-click mechanism. For Halifaxes and flying boats.
10D/1329	J	S	Multi	Obsolescent. Steel version of T.1154B for all bombers other than Halifaxes.
10D/1330	K	S	Multi	Obsolescent. Steel version of T.1154F. Will be superseded by T.1154M.
10D/1455	†L	S	Uni	For high-speed launches and certain trainers of Technical Training Command.
10D/1587	†M	S	Uni	As T.1154K with Uni-click stops.
10D/1588	N	S	Uni	Steel version of T.1154B with Uni-click stops.

Aerial systems and switching

7. When installed in aircraft the transmitters work into the aircraft fixed aerial on the H.F. ranges and into the trailing aerial on M.F. The appropriate aerial is selected by the frequency range switching of the transmitter, but to provide for occasions when the normal aerial may not be available an external aerial selector switch type J (Stores Ref. 10F/126) is provided which can override the transmitter switch and connect the H.F. output circuit to the trailing aerial or the M.F. output circuit to the fixed aerial. Other positions of this switch are arranged to cut off the transmitter H.T. supply when the aerials are earthed, or when the associated receiver is being used for loop D/F.

8. In some early installations an aerial plugboard (Stores Ref. No. 10H/681) is provided in place of the aerial selector switch and the desired aerial is connected to the transmitter, on occasions when the automatic internal switching does not fulfil the requirements, by the interchange of plug and socket connections.

9. Either carbon-granule or electro-magnetic type microphones may be used for R/T with the transmitters equipped for telephony transmission, but when electro-magnetic microphones are used it is necessary to incorporate a suitable sub-modulating device such as the intercommunication (I/C) amplifier A.1134 (Stores Ref. 10U/11500) or A.1134A (Stores Ref. 10U/90) to provide the necessary microphone gain. The change from carbon to electro-magnetic operation entails a minor internal adjustment of the transmitter (see para. 28, 29). A detailed description of the amplifier A.1134 is given in Sect. 4, Chap. 2 of A.P.1186.

Power supplies

10. Power supplies for the airborne equipment are derived from the general aircraft electrical supply system of nominal 12-volt or 24-volt rating, through two rotary transformers with the necessary smoothing and filtering circuits. One of these units (referred to as the H.T. power unit) supplies 1200 volts H.T., and the other (the L.T. power unit) provides 6·3 volts L.T. The L.T. power unit is used, also, by the receiver installation, supplying H.T. and L.T. for the receiver, in addition to transmitter L.T.

† Denotes final standard version

11. When used in a ground installation the rotary transformers may be run from accumulators "floating" across a mains rectifier such as the power unit type 115 (Stores Ref. 10K/351), or the transmitter may be supplied direct from a.c. mains through a rectifier such as the power unit type 114 (Stores Ref. 10K/350), which is tapped to provide the correct voltage inputs.

12. The overall dimensions of a transmitter, in its case, are approximately 17½ in. by 16⅝ in. by 11¼ in. The weight of the instrument, complete with its suspension units and valves, is approximately 46 lb. 10 oz. The general appearance of a transmitter T.1154M is shown in fig. 1 and this illustration is representative of the remaining types except for the click-stop mechanism of the older versions.

GENERAL DESCRIPTION

13. Before considering the circuit arrangement of the transmitter it is necessary to understand the functions of the transmitter master switch (S_5, fig. 1). This has six (or in transmitters without R/T, five) positions, labelled as follows: OFF, STD.BI, TUNE, C.W., M.C.W., R/T. In the STD.BI position the input circuit of the L.T. power unit is completed and the transmitter valves are heated by the 6·3 volts output of that unit. When the switch is turned to TUNE, 6·3 volts from the L.T. power unit are applied to the starting relay of the H.T. machine, which on running produces 1,200 volts for the transmitter anodes. The circuit from the L.T. power unit to the H.T. starting relay passes through the aerial selector switch type J and is broken there when the switch is in the D/F or EARTH positions.

14. The remaining positions of the switch are shown in the basic circuit diagram, fig. 2. No frequency range switching is shown in this diagram, for the sake of simplicity. The annotations of the tuned circuit components are those for the BLUE range, but the general circuit is similar on all frequencies except for the aerial tuning arrangements on M.F., which are described later, and are shown inset.

Master oscillator circuit

15. It will be seen from fig. 2 that the transmitter consists of a master oscillator stage driving two pentode power amplifying valves in parallel. Only one of the P.A. valves is shown in the simplified diagram. The master oscillator valve, V_1, an indirectly-heated triode, has its tuned circuit, L_1 C_2, connected between grid and anode, and its H.T. supply is fed through a tapping point on the coil. This point is also in effect the cathode tap of the circuit, being at cathode potential from the point of view of R.F. by reason of its connection to earth *via* the condensers C_{18}, C_{19}. The circuit is therefore a series-fed Hartley oscillator. In this transmitter the cathodes are connected to chassis, which is however at a positive d.c. potential with respect to the H.T. negative line because of the voltage drop across the resistances R_9, R_{10} through which the whole H.T. current flows from the chassis back to its negative supply terminal.

P.A. and output circuits

16. The M.O. stage is connected to the directly-heated pentode power amplifier valves V_2, V_3 through the coupling condenser C_6. On the BLUE range the P.A. tuned circuit is the coil L_4 with the condenser C_{15} in parallel. The aerial is coupled directly to this circuit through a variable tapping controlled by the switch S_3 (fig. 1) on the front panel. Similar arrangements, using a separate set of components, apply on the RED range of all transmitters except those of series C, F, H, K, and M. In these versions the end of the aerial coil remote from the P.A. valve anodes is not normally earthed, although provision is made for earthing it, through two series condensers, in the circumstances described in para. 55. The P.A. circuit is shunt-fed through the H.F. choke HFC_1. A feed meter, M_1 is provided, and it should be noted that it reads only the current taken by the power amplifier valves. The input fuse F_1 carries the H.T. current to all valves in the transmitter.

17. On the YELLOW range the aerial itself provides the tuned circuit capacitance. The amount of inductance in the circuit is varied in steps by means of a tapped coil, a varying portion of which is short-circuited as the tapping is altered. The coil has a sliding iron-dust core for fine variations of inductance by permeability tuning. The anodes of V_2, V_3 are connected to the aerial coil through a variable tapping, which enables the valve loading to be adjusted to the best advantage. These arrangements are shown in the inset of fig. 2, and it will be seen that the P.A. circuit is shunt-fed as on the H.F. ranges. An aerial ammeter, M_2, is connected between L_6 and earth, to give an indication of aerial current.

Sidetone and modulator valve

18. The indirectly-heated triode valve V_4 acts either as a 1,200 cycle (approx.) oscillator to provide keying sidetone, or sidetone together with modulation of the transmitter output on M.C.W.; or as a modulator for R/T, when speech sidetone is also available from this valve provided a carbon microphone is in use. The modulating voltages are applied to the suppressor grids of the P.A. valves. Approximately 70 per cent. modulation is effected.

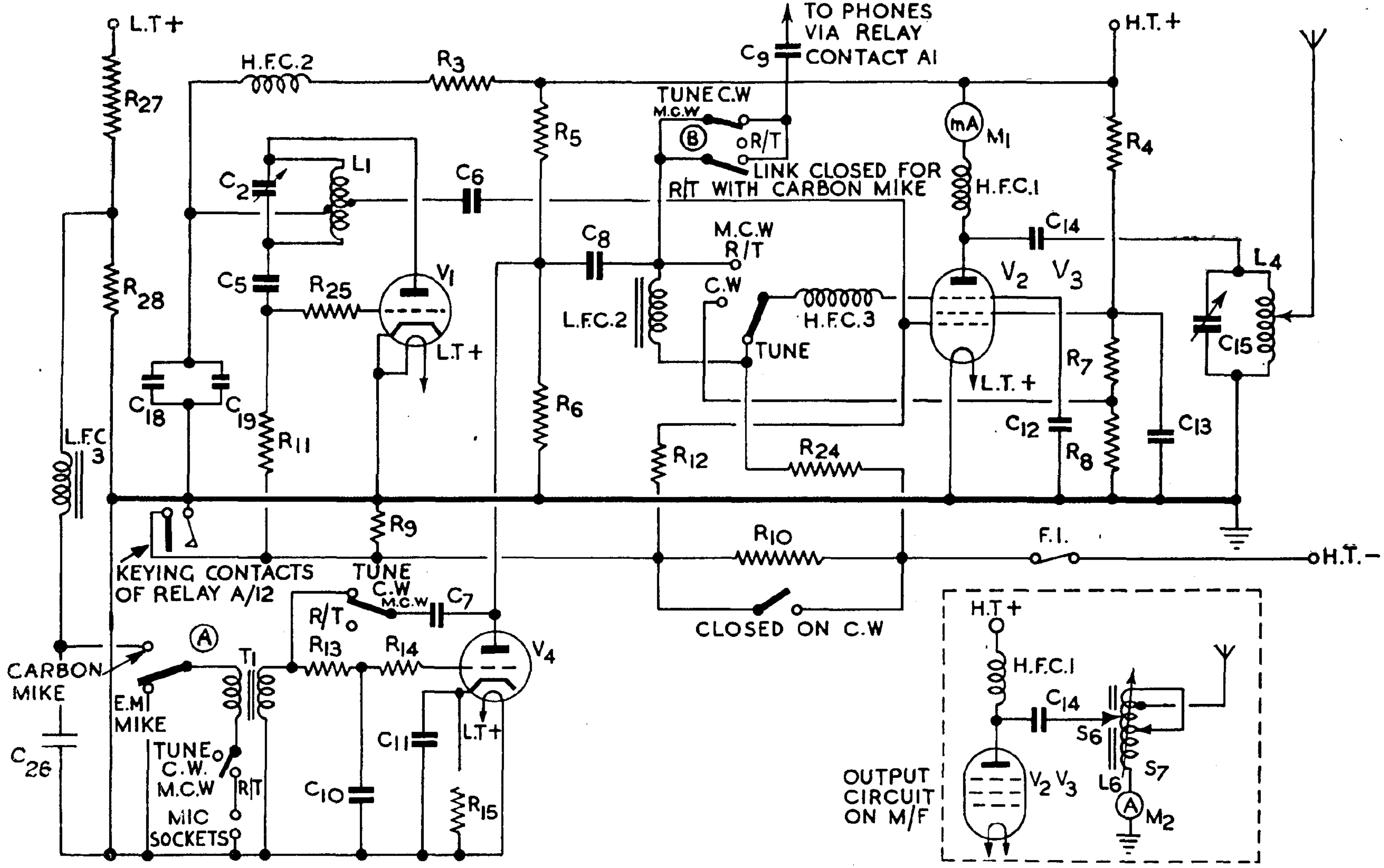


FIG. 2.—SIMPLIFIED CIRCUIT DIAGRAM, T.1154

"Tune" position of master switch

19. When the transmitter master switch is on TUNE and the key is up, the keying contacts of REL. A/12 are open, and the flow of H.T. current through the resistances R_9, R_{10} renders the control grids of the master oscillator and P.A. valves so negative with respect to their cathodes that no oscillation takes place, and the P.A. stage passes no current. With the key down the relay contacts close, short-circuiting R_9, so that the bias is removed from the control grids and the circuit oscillates. However, with the master switch at TUNE the resistance R_{10} is still in circuit and the suppressor grids of V_2, V_3 are negative to cathode on account of the voltage drop across that resistance, the bias being of the order of 45 volts. This is sufficient to prevent excessive feed to the P.A. valves caused by misadjustment when tuning, and permits short-range communication to be carried on. It should be noted that the suppressor grids are at filament potential to R.F. on account of condenser C_{12}. The power output on TUNE is approximately one quarter of that on C.W.

20. When the transmitter is oscillating the M.O. valve V_1 receives automatic bias from the grid leak and condenser combination C_5, R_{11}, the resistance R_9 being short-circuited as explained above, and the grid leak keyed to earth, *via* the keying relay contacts. The grid-stopper resistance R_{25} suppresses parasitic oscillations.

21. A resistance R_3 in the H.T. positive line serves to reduce the anode voltage of the oscillator valve. When the key is up, the increased bias reduces the anode current, giving less voltage drop in R_3 and a higher anode voltage to V_1, which helps this valve to commence to oscillate when the key is pressed. The increase of anode current then gives more drop in R_3 and the anode current then drops to the normal working value.

"C.W." position of master switch

22. On turning the master switch to C.W. the suppressor grids of V_2, V_3 are joined to a point on the potentiometer formed by the resistances R_4, R_7, and R_8 connected across the H.T. supply and acquire a positive potential, although still at earth potential to R.F. by virtue of the by-pass condenser C_{12}. At the same time the resistance R_{10} is short-circuited. The positive potential on the suppressor grids is approximately 20 volts and provides full-power conditions of working. The control grids of V_2, V_3 receive automatic bias from the grid leak and condenser R_{12}, C_6.

23. It will be noted that the screen grids of V_2 and V_3 are also supplied from a tapping on the potentiometer formed by R_4, R_7, and R_8. They are at earth potential to R.F. by reason of C_{13}.

Listening through

24. While the master switch is in the TUNE, M.C.W., or C.W. position the valve V_4 acts as an A.F. oscillator, anode-to-grid feedback being provided by the condenser C_7. The A.F. voltages across LFC_2 are fed to the operator's telephones through contacts on the keying relay which are closed when the key is down. When the key is raised these contacts break and another relay contact connects the telephones to the output of the receiver. In this way the operator is provided with "listening through" facilities, being able to hear a station calling him in the intervals of his keying.

25. It must be appreciated that the note heard when the key is pressed is due entirely to the valve V_4, which can be regarded in these circumstances as a valve buzzer, and gives no indication that the M.O. and P.A. stages are functioning correctly.

M.C.W. and R/T

26. With the master switch at M.C.W., V_4 continues to act as an A.F. oscillator, but now the voltages across LFC_2 are applied also to the P.A. suppressor grids *via* HFC_3 to modulate the output. At the same time the short-circuit is removed from R_{10} and the suppressor grids again receive a negative bias, which is varied by the modulating voltages.

27. On turning the master switch to R/T the anode-to-grid circuit of V_4 *via* C_7 is broken so that the valve ceases to oscillate and acts as an A.F. amplifier. The primary circuit of the microphone transformer is made, and the speech frequencies applied to the grid of V_4 appear amplified across LFC_2 and are passed to the suppressor grids of V_2, V_3, which again have a negative bias due to the voltage drop across R_{10}.

Use of carbon or E.-M. microphones

28. Two sockets on the transmitter panel allow for a modulating source to be connected. A plate inside the transmitter (but accessible from the back, as shown in fig. 11) engraved CARBON on one side and ELECTRO-MAGNETIC on the other can be turned round so that either label is showing

being held in position by six fixing screws. When the word CARBON is visible, link connections incorporated in the plate tap off a portion (2 volts) of the L.T. voltage from the junction of R_{27} and R_{28} for energising the microphone, and connect the operator's telephones in parallel with the input to the P.A. suppressor grids to provide him with sidetone.

29. When the plate is turned so that the word ELECTRO-MAGNETIC is showing, the microphone energising circuit is broken, as is also the link feeding sidetone to the telephones (see points A and B, fig. 2). In these circumstances it is the output of a sub-modulating amplifier (see para. 9) which is connected to the microphone sockets on the transmitter, and sidetone is provided from the amplifier.

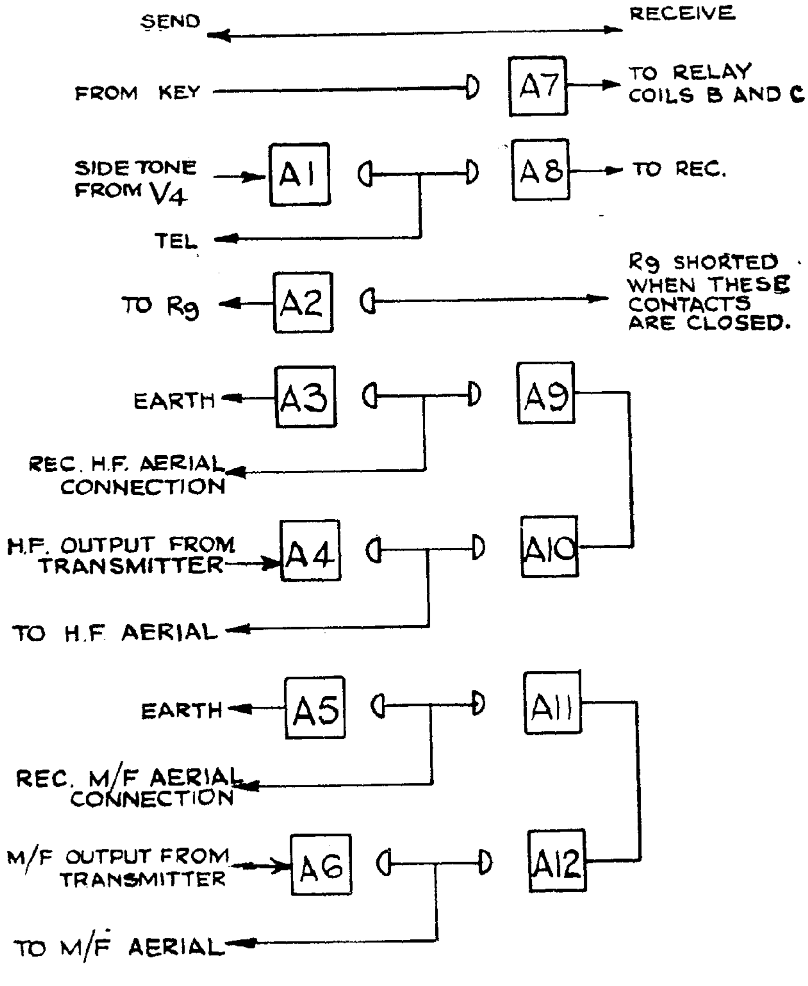


FIG. 3.—KEYING RELAY CONTACTS

Magnetic relay type 85 (keying relay)

30 Where mention has been made in the foregoing description of a relay in connection with keying and sidetone, it has referred to the magnetic relay type 85. This is a multi-contact relay with a row of moving contacts which move from side to side during keying to complete circuits through two rows of fixed contacts known respectively as the SEND and the RECEIVE contacts. It will be seen from fig. 3 that when at SEND, in addition to short-circuiting R_9 through the contacts A_2, and connecting the telephones to the output of the valve V_4 *via* A1, the relay completes aerial connections to the transmitter *via* A_4 or A_6. The particular aerial connected depends upon the position of the frequency range switch or the aerial selector switch type J. Both aerial connections from the receiver are earthed at contacts A_3 and A_5.

31. On moving to RECEIVE the relay removes the short-circuit from R_9, thus stopping oscillation, and connects the telephones and the aerial in use to the receiver.

Action of relay

32. The relay is operated by the 6-volt supply from the L.T. generator and is common to all versions of the transmitter. It can operate at a speed equivalent to more than 25 words a minute.

33. The relay incorporates three coils A, B, and C. The coil A is in circuit so long as the transmitter is switched on, that is, with the master-switch S_5 at any of the positions STD.BI, TUNE, C.W., M.C.W. or R/T. With S_5 in the STD.BI position the coil A only is energized and holds the relay in the RECEIVE position. The key is not in circuit. The coils can be seen in fig. 4, 5 and 6.

34. When the switch S_5 is in the TUNE, C.W., M.C.W., or R/T position the key is switched into circuit. Depression of the key energizes both B and C coils of the relay, the connection of the winding B being so arranged that its field neutralizes the field due to the holding coil A. At the instant when the nett field resulting from both coil A and coil B is zero the relay commences to move under the combined action of the spring contacts and coil C. The auxiliary contacts of the relay open, thus cutting off the current through the coil B. This sudden cessation of current in coil B causes a transient condition in the coil A which instantly reduces its current to zero. Thereafter the field of coil A is re-established, but not fully until after the elapse of a period considerably greater than the transit time of the relay. As coil C is energised simultaneously with coil B when the key is pressed, it follows that the relay motion initiated by coil B will be completed by the attraction of coil C.

35. When the key is released the relay returns rapidly to the RECEIVE position since the field of coil A is already re-established, and the current through coil C ceases as soon as the key contacts open.

Transmitters T.1154C, F, H, K, M

36. A complete circuit diagram of a transmitter providing C.W., M.C.W., and R/T communication on four frequency ranges (T.1154C, F, H, K, and M) is given in fig. 4. The transmitter master switch S_5 consists of six sections, identified on the diagram with the letters F, G, H, J, L, and M. In the OFF position of this switch, both the rotary transformer power units are idle and the equipment is inoperative.

37. In the STD.BI position a circuit is completed for the aircraft 12 or 24-volt supply from contact 4 of the Jones plug D on the front of the transmitter, through switch section H of S_5, back to contact 3 of plug D and thence to the L.T. power unit. It will be seen that the circuit through switch section H is made in all positions of S_5 except OFF.

38. The 6-volt output of the L.T. power unit is brought into the transmitter at contact 6 of plug D and divides as follows:—

(i) To coil A of the magnetic relay type 85, which goes over to RECEIVE.

(ii) To heaters of V_1 and V_4 and to the filaments of V_2, V_3. Resistances R_{30}, R_{31} are included in the filament circuit of the P.A. valves to reduce the current they take when the transmitter is at STD.BI. In some transmitters a single ·75-ohm resistance is used in place of R_{30} and R_{31}.

(iii) To contact 3 of Socket A for supply to the receiver.

In the TUNE position of S_5 the following processes occur:—

(iv) Limiting resistances R_{30}, R_{31} are short-circuited by sections F and G.

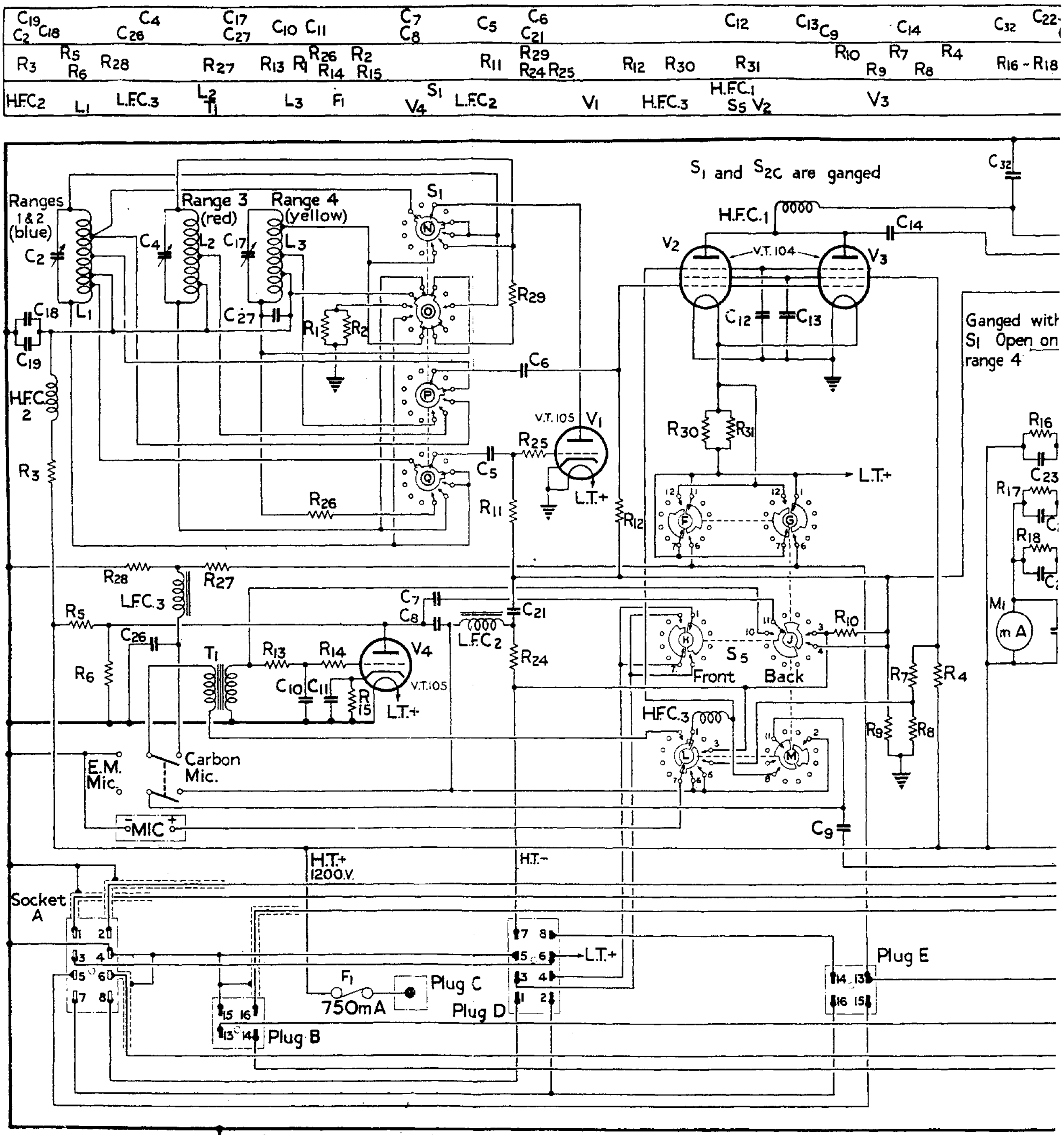
(v) The 6-volt supply is switched by sections F and G as follows:—

(*a*) To contact 13 of plug E, whence it is taken *via* the aerial selector switch type J (provided this is in one of the positions other than D/F or EARTH), back to contact 14 of plug E and thence via contact 8 of plug D to the starting relay of the H.T. power unit. The 1,200-volt output of this power unit is supplied to the transmitter at plug C.

(*b*) The 6-volt circuit is also taken from contact 13 of plug E, *via* relay coil B, and relay contact A_7 to contact 13 of plug B, but no current flows while the key is up. It will be seen that while the keying relay A/12 is at RECEIVE, relay coils B and C are short-circuited by relay contacts A_7.

39. When the key is pressed the 6-volt circuit through relay coil B is completed to earth via the key and as explained in para. 34 the flux from coil A, which has been holding the relay at RECEIVE, is neutralised, so that the relay begins to move under the pressure of the spring contacts. As soon as it does so relay contact A_7 breaks and the 6-volt circuit is diverted through coil C, holding the relay over at SEND. Relay contacts A_2 now short-circuit R_9 through pin 14 of plug B so that

This leaf issued in reprint, September 1947

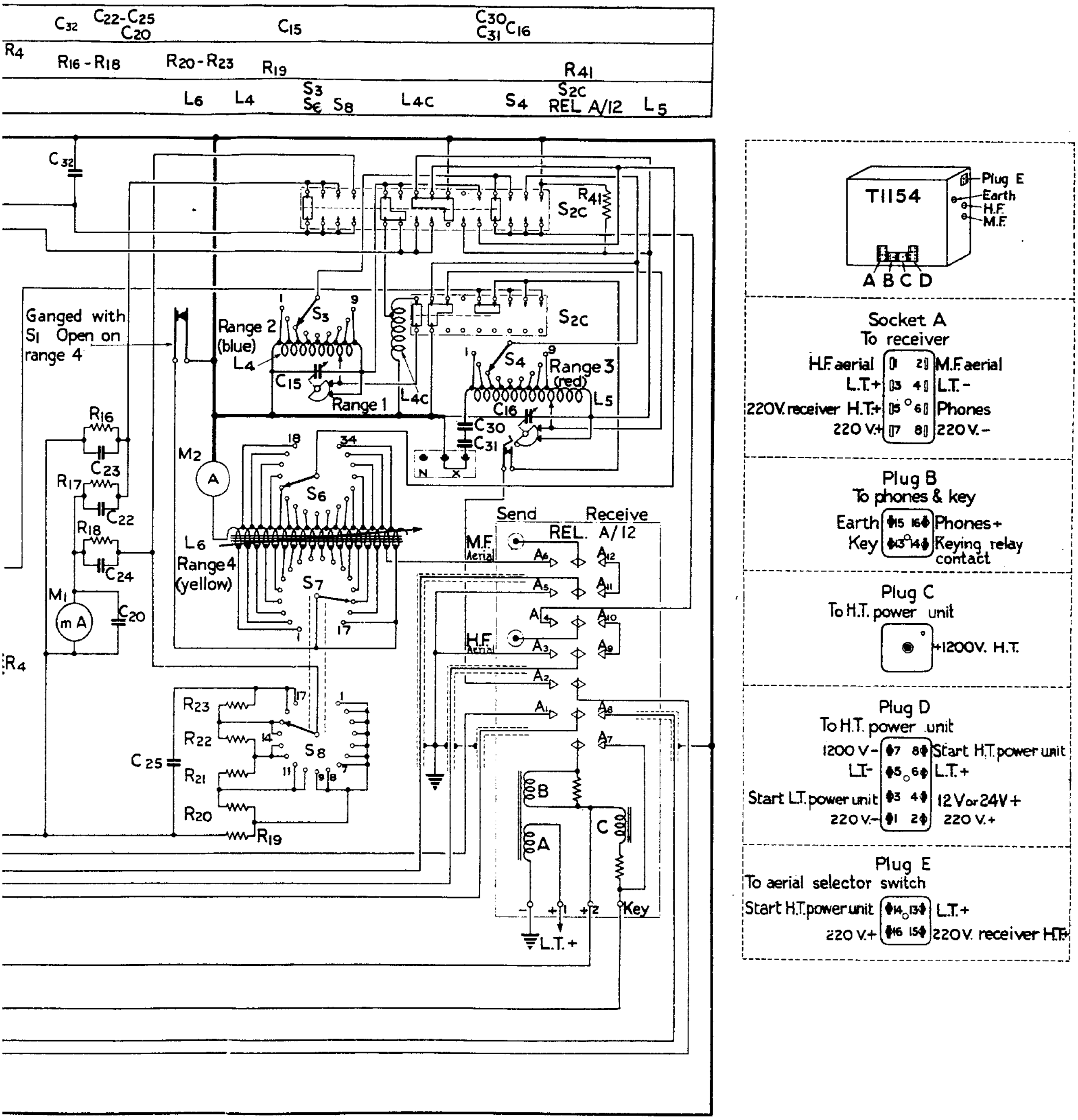


Note: S1 and S5 shown in extreme anti-clockwise position
Socket & plugs as viewed from front of transmitter.

FIG. 4

CIRCUIT OF

To face para. 36



...UIT OF T. 1154 C, F, H, K, & M

FIG. 4

REPRINT PP5014 M42902/73M/C 12/47 1600 C & P Gp. 959(4)

the bias is removed from the control grids. The telephones are connected to the output of V_4, via contact 16 of plug B, relay contact A_1 and section M of S_5, enabling the operator to hear the sidetone note. V_4 is in an oscillating condition the whole time the master switch is at TUNE, since its grid is returned to the filament end of R_9.

40. It will be noted that the total H.T. current is still flowing through R_{10}; the suppressor grids of the P.A. valves are connected through HFC_3 and switch section L to the end of R_{10} which is negative with respect to the end to which the control grids are connected via S_5J, and so a bias on the suppressor grids is maintained.

41. When the master switch is turned to C.W. the suppressor grids are connected via S_5L to the junction of R_7 and R_8, whence they receive a positive bias, and R_{10} is short-circuited by S_5J.

42. On turning the master switch to M.C.W., section L of S_5 applies the A.F. oscillations of V_4, via C_8, to the suppressor grids of V_2 and V_3. The short-circuit is removed from R_{10} by switch section J so that the negative bias is re-established.

43. Similar conditions obtain on R/T, except that section J of S_5 disconnects the condenser C_7 between anode and grid of V_4 so that the valve ceases to oscillate and acts as an amplifier, and at the same time the microphone (or output of the external amplifier) is connected to the primary of T_1 via section L.

44. With S_5 at R/T the key is still in circuit and must be depressed for transmission to take place; alternatively a shorting switch connected across the key can be installed in a convenient position for the pilot. The key must be released, or the switch opened, to allow the keying relay to return to RECEIVE before reception can take place. The power output (when fully modulated) is approximately ¼ of that on C.W. This applies to both R/T and M.C.W. and is the result of suppressor modulation, *not* of class C operation.

Frequency range switch

45. The ganged switches S_1, S_{2C} select the appropriate M.O. and P.A. tuning circuits for the different frequency ranges. The same coils and condensers are used for both BLUE ranges, so section N of S_1, short-circuits a portion of L_1 on Range 1 and S_{2C} connects L_{4C} in parallel with the P.A. coil L_4 to reduce the total inductance. On Range 2 the whole of L_1 is used and L_{4C} is switched out of circuit.

46. Resistances R_1, R_2 are connected between H.T.+ and earth on Range 4 (M.F.) by section O of S_1 in order to provide a parallel H.T. load and so limit the anode voltage on V_1, as the efficiency of the M.O. stage is considerably higher on the medium frequencies. In some transmitters a single vitreous resistance is used in place of the two resistors.

47. It will be seen that on Range 4 the anodes of V_2, V_3 are connected by S_{2C} to the anode tapping switch S_6, which enables any one of seventeen points of connection to the P.A. coil L_6 to be selected. On this range also S_{2C} connects across the P.A. feed meter, M_1, the system of variable shunts provided by resistances R_{19} to R_{23}.

Variable meter shunt

48. This transmitter is set up by adjusting the output circuit until the meter M_1 reads to a fixed point on its scale. The actual input represented by this reading is higher than is desirable on the M/F range, and consequently on these frequencies the meter is made to read higher by means of additional shunts, so that when its reading is reduced to the prescribed point on the scale, the input is in fact lower than it appears to be. In this way the value of R.F. voltage on the medium frequencies is kept within limits by the operator as part of his tuning procedure. The R.F. voltage depends upon the inductance in the aerial circuit and the current through it. The object of the shunt is to prevent the voltage developed exceeding 6,000, above which the insulation of fairleads, cables, etc., might begin to break down.

49. The value of shunt is selected by the switch S_8, which is ganged with the M.F. aerial coarse tuning switch S_7 and so arranged that the shunt resistance is increased concurrently with an increase in aerial inductance by switching in resistances R_{20} to R_{23} as S_7 is moved from tap 10 to tap 17. These are added in series with R_{19}, which is across the meter in all positions of S_7. The full scale deflection of the meter for the different values of aerial tap is shown in the following table:—

Aerial tap	*Full scale deflection (mA)*
1– 9	300
10–11	255
12–13	210
14–15	165
16–17	120