Errata

Note: This Page 01, Issue 1, must be filed immediately in front of Page 1, Issue 3, dated 8 Mar 1966.

(The following amendments must be made to the regulation).

3. Page 29

   a. Para 71, line 6

      Delete: 'R114' Insert: 'R116'

   b. Para 71, line 8

      Delete: 'R144' Insert: 'R116'

4. Page 30, Para 74, line 8

      Delete: 'R116' Insert: 'R114'

EME/8c/1364/Tels

STATION, RADIO, C13

TECHNICAL HANDBOOK - TECHNICAL DESCRIPTION

Errata

Note: This Page 0, Issue 1, will be filed immediately in front of Page 1, Issue 3, dated 8th March 1966.

1. The following amendment will be made to the regulation.

2. Page 12, para 22, line 1

   Delete: 'UNF'

   Insert: 'UNC'

EME/8c/1364/Tels

STATION, RADIO, C13

(TRC13 Mk 1 and Mk 2, P.S.V. No 16, T.R.F. No 11)

TECHNICAL HANDBOOK - TECHNICAL DESCRIPTION

Note: This Issue 3, Pages 1-41 and 1001-1003 supersedes Issue 1, Pages 1-16, 19-20, 25-38 and 1001-1003 dated 10 Feb 61 and Issue 2, Pages 17-18, 21-24 dated 1 Nov 62. The regulation has been amended throughout.

This EMER must be read in conjunction with Tels H 162 Part 2 which contains figures and tables to which reference is made.

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INTRODUCTION

General

1. The Station, radio, C13 is designed to operate in A or B vehicle installations or as a ground station. Primarily, it replaces the WS 19 and 19HP in the regimental role where v.h.f. cannot be used. A secondary function of the station is its use by R. Sigs instead of the Transmitter, radio, C11 and Reception set, R210 when this combination is unsuitable due to size or power consumption. An intercommunication amplifier is included. Used with the Amplifier, r.f., No 7 the C13 gives an output of about 200W r.f. on phase modulated r.t. or c.w.

2. This regulation deals with the following items of the station:-

a. Transmitter-receiver C13, Mk 1 and Mk 2 (TRC13)

b. Power supply, vibratory, No 16 (12V and 24V) (P.S.V. No 16)

c. Tuner, radio, frequency, No 11 (T.R.F. No 11)

3. The harness items normally required to complete a vehicle installation are dealt with in Tels L 770 - L 779 and Tels L 780 - L 789 (Radio control harnesses, types A and B respectively). Each installation is also specifically described in the appropriate Communication Installation EMER for the type of vehicle and set used. (See Comms Inst A 000).

4. The TRC13 is an h.f. transmitter-receiver housed in one sealed box. It operates in the frequency band 1.5-12Mc/s and can be used on r.t. (amplitude or phase modulation) or c.w. Tuning procedure is similar to the TRC42 and employs an inbuilt crystal calibrator. It is possible, using this calibrator and the film scale calibrations, to adjust the set to any integral 2.5kc/s point in the frequency band without reference to any external frequency source.

5. The P.S.V. and T.R.F. are also sealed units, and, together with the C13, mount on the standard C42, C45 carrier, allowing the station to be easily demounted for ground station work. When demounted the set can be used with remote antennae through up to 50 ft of coaxial cable. The T.R.F. also is 'remote' in these conditions and is fitted to a remote antenna adaptor with tuning indication.

6. The T.R.F. No 11 matches the 70Ω output of the C13 to rod or wire antennae suitable for the frequency being used. (See user handbook for details, also para 112).

TRANSMITTER-RECEIVER C13 MK 1 AND MK 2

BRIEF DESCRIPTION

Controls etc

7. The controls, etc, on the front panel are shown in Fig 1 (TRC13 Mk 1) and Fig 22 (TRC13 Mk 2) and consist of:-

SYSTEM SWITCH (SB)

CURSOR ADJUST	In this position the receive frequency is set to the 100kc/s crystal calibrator harmonic nearest to the desired frequency by the MC/S and CHANNEL controls. The cursor is aligned to the CHANNEL (KC/S) film calibration. M1 is used for correct tuning indication.
CHANNEL ADJUST	As at CURSOR ADJUST but with a counter following the 100kc/s crystal calibrator to give checks down to 10kc/s. Adjusted by CHANNEL control.
TUNE RF	Used to align the m.o., p.a. and r.f. circuits to the exact frequency of the receiver (already calibrated on CURSOR ADJUST and CHANNEL ADJUST).
RT	The set is switched for use on telephony, a.m. or phase modulated (see SC).

CW	The set is switched for c.w. operation, the b.f.o. is operative on receive and the keying sidetone oscillator on send.
TUNE AE	The t.r.f. can be aligned for maximum rectified antenna current read on meter M1 (biased back in this switch position).

SENDER (SA)

TRIM AE	In this position the set is switched to low power send irrespective of system or pressel switches. The p.a. cathode current is metered and the p.a. anode trimmer (AE TRIMMER) is adjusted for correct tune. This position is spring-loaded so that after release the switch returns to LP.
LP	On send the set gives low power output (approximately 1.5W) due to a reduction of h.t. voltages in the p.s.v.
HP	On send the set gives an output of 5-20W according to frequency and system of operation.

AE (PLB)

A 70Ω coaxial r.f. output to, or input from, the T.R.F. No 11.

AE TRIMMER (C140)

This control, adjusted on TRIM AE, is a variable capacitor across the antenna tuned circuit (see SA).

RF (C114)

This controls the gang capacitor for the four r.f. tuned circuits (m.o. grid, m.o. anode, r.f. grid/p.a. anode and r.f. anode). A film scale calibrated in three bands geared to the gang gives tuning indication.

MC/S (SD)

This switch is set to display the Mc/s digit of the required frequency in the MC/S window and the correct r.f. band and oscillator and i.f. frequencies are automatically selected for that Mc/s band.

CHANNEL (C205, C202)

This control alters the v.f.o. and 1st i.f. frequencies to give the correct channel. This is indicated on the KC/S film scale which is calibrated 0-1000kc/s to cover the channels between each Mc/s step.

CURSOR

This is used to adjust the cursor line to the correct 100kc/s calibration mark on the film scale when aligned to the inbuilt crystal calibration at CURSOR ADJUST.

MODULATION (SC)

PHASE	At the RT position of the system switch, adjusts the set for transmission or reception of phase modulated signals. At this position the TRC13 can also be used to drive Amplifier, r.f., No 7 for r.t. communication.
NORMAL	At the RT position of the system switch, adjusts the set for transmission or reception of amplitude modulated signals.

SUPPLY

TRC13 Mk 1

This is merely an indicating label to show with which type of p.s.v. (12V or 24V) the set may be used. A switch within the set (SF on the r.f. chassis) controls this but cannot be altered without opening the set.

TRC13 Mk 2

This set can only be used with 24V P.S.V. Switch SF (12/24V) is not fitted on Mk 2 models

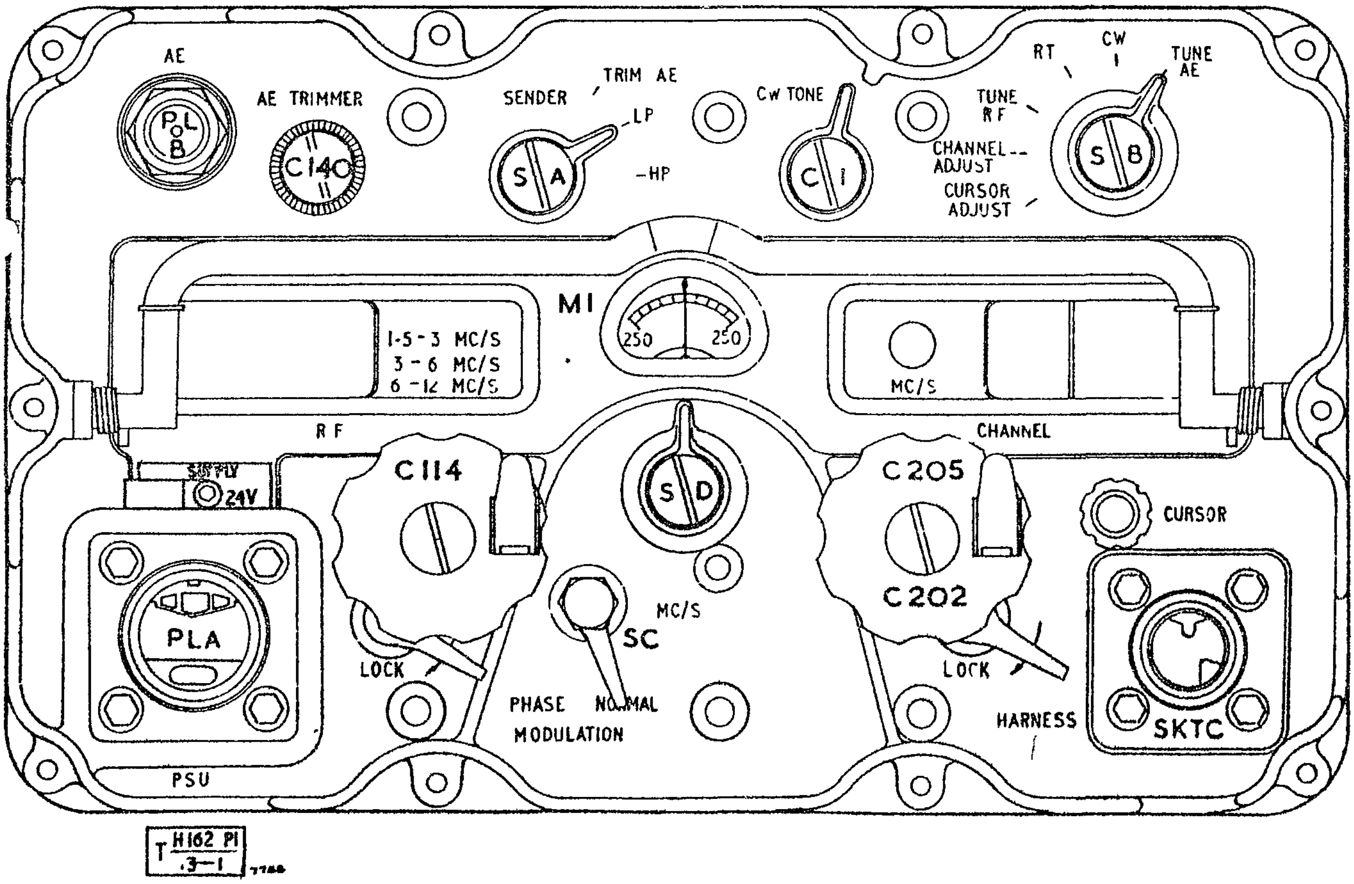

Fig 1 – Front panel controls etc (TRC13 Mk 1)

P.S.V. (PLA)

An 18-way Mk 4B plug used to connect the C13 to its p.s.v.

HARNESS (SKTC)

A 12-way Mk 4B socket with the standard outputs for connection to Harness A or B in installation.

LOCK

Two controls which lock the drives to the RF and CHANNEL controls and the film scales.

CW TONE (C1)

Adjusts the b.f.o. frequency for c.w. reception.

Principles of operation

8. Three block diagrams of the TRC13 are shown in Fig 2001, 2002 and 2003 to illustrate the operation on calibrate, receive and transmit. A table of frequency relationships is shown on each block diagram and is repeated in Table 1 for reference.

Calibrate

9. Fig 2001 shows the block diagram in the three calibrate positions of the system switch. A crystal calibrator V401, V402, is connected into the grid circuit of r.f. amplifier V107 via the antenna circuit. At CURSOR ADJUST, harmonics of 100kc/s throughout the h.f. band are generated and passed through the complete receiver circuits connected as for reception of r.t. phase modulated signals. The discriminator V313, V314, which will give outputs at 100kc/s intervals, is connected to a centre zero meter. The set is tuned for zero output at the nearest 100kc/s point to the required frequency and the movable cursor is adjusted to the correct calibration mark on the v.f.o. (KC/S) film scale. When switched to CHANNEL ADJUST, the 100kc/s is counted down by 10:1 to give signals at every 10kc/s throughout the band. Tuning to the nearest 10kc/s can then be achieved by again tuning for zero discriminator output. The system switch is set to TUNE RF since the r.f. dials have as yet been only approximately tuned. In this switch position the crystal calibration signal is disconnected and an alternative signal is fed to the second mixer V207. This signal is the resultant frequency produced by mixing the master oscillator (sender) frequency with the crystal controlled 1st local oscillator in the sender or a.f.c. mixer V206. The m.o. tuned circuits, and the r.f. and antenna tuned circuits ganged to them, can now be adjusted to the correct frequency by adjusting for zero discriminator output from the already calibrated receiver circuits.

Receive

10. Consider the receive position (Fig 2002) to explain Table 1. The C13 is a single-superheterodyne receiver on frequencies from 1.5-3Mc/s. The 1st i.f. is variable in two bands (1-2Mc/s and 2-3Mc/s). Thus on frequencies up to 3Mc/s the set can be regarded as a normal two band superhet with the 1st mixer as an r.f. amplifier and an additional r.f. stage V107. The variable frequency oscillator (V208) (v.f.o. or local oscillator) operates between 1.5 and 2.5Mc/s either above or below the signal frequency. The output from the 2nd mixer V207 is at 500kc/s

and is amplified by two stages (V301, V302). On a.m. the signal is detected by V305, and coupled to a.f. amplifiers V311 and V316 via noise limiter V306 and quieter V309. On phase modulation the 500kc/s 2nd i.f. is fed to two limiters V307, V310 and then to the discriminator, V313, V314. The discriminator output is then coupled to the 'quieter' V309 and a.f. amplifiers as on a.m.

11. Above 3Mc/s the wider sweep of frequencies required from a single variable local oscillator would mean sacrificing the stability obtained by using the restricted range in the v.f.o. (1.5-2.5Mc/s), so a double-superhet with a crystal-controlled 1st local oscillator (V205B) is used from 3-12Mc/s. Referring to Table 1 it will be seen that, when the signal and selected crystal frequencies are mixed in V205A the resultant 1st i.f. input to 2nd mixer V207 always lies within the range 1-3Mc/s. The signal frequency range on any MC/S switch position (Table 1, column 1), each 1st i.f. band (1-2 or 2-3Mc/s) and the v.f.o. sweep (1.5-2.5Mc/s) all cover exactly 1Mc/s. It is, therefore, possible to calibrate the KC/S film scale, geared to the v.f.o. and the 1st i.f., from 0-1000kc/s and to select the correct 1st i.f. band to be always 500kc/s either above or below the v.f.o. so giving a second i.f. of 500kc/s. To achieve this with a limited number of crystal frequencies it is sometimes necessary to have the v.f.o. and the 1st i.f. decreasing in frequency as the signal frequency increases. This would mean that the KC/S film scale reading would have to be subtracted from the number of Mc/s indicated instead of added, a difficulty obviated by printing the film starting from either end and obscuring the unwanted half by a shutter. Fig 2 shows a section of a KC/S film scale and the last column of Table 1 shows the shutter position for each MC/S switch position.

Sig. freq. (Mc/s)	MC/S switch position	R.F. band (Mc/s)	Crystal freq. (Mc/s)	First i.f. (Mc/s)	V.F.O. freq. (Mc/s)	Second i.f. (kc/s)	KC/S shutter position
1.5-2	1	1.5-3	-	1.5-2	2-2.5	500	Up
2-3	2	1.5-3	-	2-3	1.5-2.5	500	Up
3-4	3	3-6	5	2-1	2.5-1.5	500	Down
4-5	4	3-6	7	3-2	2.5-1.5	500	Down
5-6	5	3-6	7	2-1	2.5-1.5	500	Down
6-7	6	6-12	8	2-1	2.5-1.5	500	Down
7-8	7	6-12	9	2-1	2.5-1.5	500	Down
8-9	8	6-12	7	1-2	1.5-2.5	500	Up
9-10	9	6-12	7	2-3	1.5-2.5	500	Up
10-11	10	6-12	8	2-3	1.5-2.5	500	Up
11-12	11	6-12	9	2-3	1.5-2.5	500	Up

Table 1 - Frequency relationship

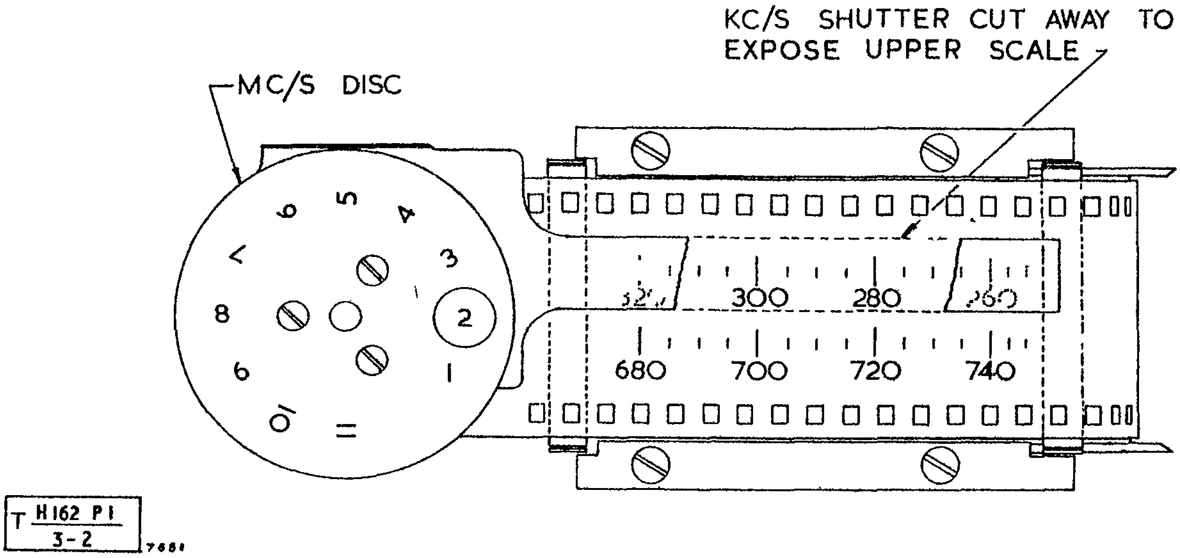

Fig 2 - Portion of KC/S film scale

12. Two examples of tuning procedure are given to illustrate the system:-

a. In the case of a frequency between 1.5 and 3Mc/s, say 2.715:-

(1) The MC/S switch is set to 2. Table 1 shows that this will select the low r.f. band (1.5-3Mc/s) by the Ledex relay controlled r.f. switch (see para 30 for details of Ledex relay). The crystal oscillator V205B will be inoperative. The high 1st i.f. band (2-3Mc/s) is selected and the shutter will show the lower scale since the v.f.o. is increasing for increase in frequency.

(2) The system switch is set to CURSOR ADJUST and the CHANNEL control adjusted to the zero output point nearest the 700kc/s mark on the KC/S CHANNEL film scale. This ensures that the v.f.o. is operating at 2.2Mc/s and the 1st i.f. is tuned to 2.7Mc/s. The cursor is adjusted to the 700kc/s mark on the film scale.

(3) The system switch is set to CHANNEL ADJUST and the CHANNEL control adjusted to the zero output reading 10kc/s above the 2.7Mc/s mark, ie the first zero in this case. The CHANNEL control is then set to the 5kc/s film scale calibration point above this, ie 715kc/s. The v.f.o. will then be operating at 2.215Mc/s and the 1st i.f. tuned to 2.715Mc/s giving the correct 2nd i.f. of 500kc/s. The CHANNEL control is then locked.

(4) The system switch is then set to TUNE RF and the RF control adjusted for zero output on the meter. The sender frequency of the master oscillator, the p.a. circuit and the r.f. amplifier tuned circuit are all ganged and will be adjusted to the required frequency, ie to produce 2.715Mc/s 1st i.f. to give zero receiver discriminator output.

(5) To ensure that the p.a. anode circuit is absolutely on tune the SENDER switch is set to TRIM AE and the p.a. trimmer capacitor (AE TRIMMER) adjusted for maximum meter reading.

b. For a frequency of 6.410Mc/s the procedure is as follows:-

(1) The MC/S switch is set to 6, which selects the high r.f. band (6-12Mc/s) by Ledex relay, the 8Mc/s crystal for the 1st local oscillator, the low 1st i.f. (1-2Mc/s) and the KC/S shutter will switch down. This exposes the top KC/S scale since the 1st i.f. and v.f.o. decrease for an increase in signal frequency.

(2) On CURSOR ADJUST and CHANNEL ADJUST, as in the previous case, the v.f.o. is tuned to the calibrator to give the correct scale frequency; in this case 410kc/s. The 1st i.f. will be tuned to 1.590Mc/s and the v.f.o. will oscillate at 2.090Mc/s.

(3) The TUNE RF and TRIM AE procedure is exactly similar to the previous case.

Transmit

13. Fig 2003 shows the system on transmit. Consider first the master oscillator, power amplifier and a.f.c. circuits which are identical on NORMAL or PHASE modulation (SC). The master oscillator V104 output, set to the required frequency on TUNE RF (para 12.a.(4)) is amplified by power amplifier V106. In the anode circuit of V106 is the antenna tuned circuit with one section of the r.f. gang capacitor and the variable AE TRIMMER capacitor across it. This is adjusted to ensure a correct 70Ω match to the T.R.F. No 11. In the t.r.f. (not shown on block diagram) a current transformer and rectifier are used to give a d.c. current feed-back to the set meter. The system switch is set to TUNE AE and the meter M1 is biased back from its normal centre zero position. The rectified antenna current is used to give an 'on tune' indication of the T.R.F. No 11.

14. Part of the m.o. V104 output is fed to a.f.c. mixer V206. Here the signal is mixed with the crystal oscillator output and the resultant is fed to the second mixer V207 whose grid circuit is tuned to the appropriate 1st i.f. frequency. In the second mixer V207 this i.f. is mixed with the v.f.o. frequency to give 500kc/s output when the m.o. is on tune. This 500kc/s is coupled to stages V307, V310 which amplify and limit the signal before passing to discriminator V313, V314. This stage will give zero d.c. output when the m.o. is on the correct frequency. If, however, the m.o. frequency alters (the crystal oscillator and v.f.o. are very stable), the second i.f. will vary above or below 500kc/s giving a positive or negative d.c. output. This is fed (in the correct polarity to bring the m.o. back on frequency) to reactance valve V101 connected across the m.o. tuned grid circuit.

15. On RT, NORMAL (amplitude modulation) the microphone input is amplified by stages V311A, V316 and fed to modulator V103. The output of this stage is coupled as screen and grid modulation to the p.a. stage V106 and to a.m.c. rectifier V102. The d.c. output from V102 is used to bias a.f. amplifier V311A so controlling the modulation level.

16. On RT, PHASE (phase modulation) the microphone input is amplified by V311A and V316, as before, then passed to the grid of reactance valve V101. By feeding the a.f. via a network, whose response is proportional to the modulating frequency, the effect on the m.o. is to produce phase modulation. A.M.C. on RT, PHASE is obtained from the a.f.c. loop. The modulated signal passes through V206, V207, V307, V310 stages and is demodulated by V313, V314. The d.c. component (if any) of the signal controls the reference m.o. frequency by normal a.f.c. action while the a.f. component is fed to V103, amplified, rectified by V102 and used as bias on the a.f. amplifier V311A to provide a.m.c.

17. On RT (both NORMAL and PHASE) simulated sidetone is obtained from the second modulation amplifier V316. On c.w. a neon oscillator V105 is used to generate a note of about 1kc/s which is coupled into the sidetone circuit as an aid to keying.

Power supplies

18. The TRC13 Mk 1 and Mk 2 are normally supplied from 24V d.c., P.S.V. No 16. A 12V version of the p.s.v. has been designed for use with TRC13 Mk 1 ONLY but will be much less common.

19. Table 2 gives the input volts and maximum current drains on three typical conditions of use for the 24V p.s.v.

Condition	Current for 27V input (amps)
Standby (receive) and intercomm	2.3
Send low power c.w. and intercomm	3.75
Send high power c.w. and intercomm	6.3

Table 2 - Input current, 24V d.c. p.s.v.

20. Fig 2510 and 2511 show the interconnections between the 24V p.s.v. and the TRC13 Mk 1 and Mk 2 with some of the voltage distribution. Fig 2532 gives a circuit diagram of the 24V p.s.v. and a detailed description is given in para 103-111.

Construction

21. The construction of the TRC13 is illustrated in Fig 3 and 4. The set divides logically into three main parts:-

a. Front panel and web

b. R.F. (sender) chassis

c. Mixer and i.f. chassis

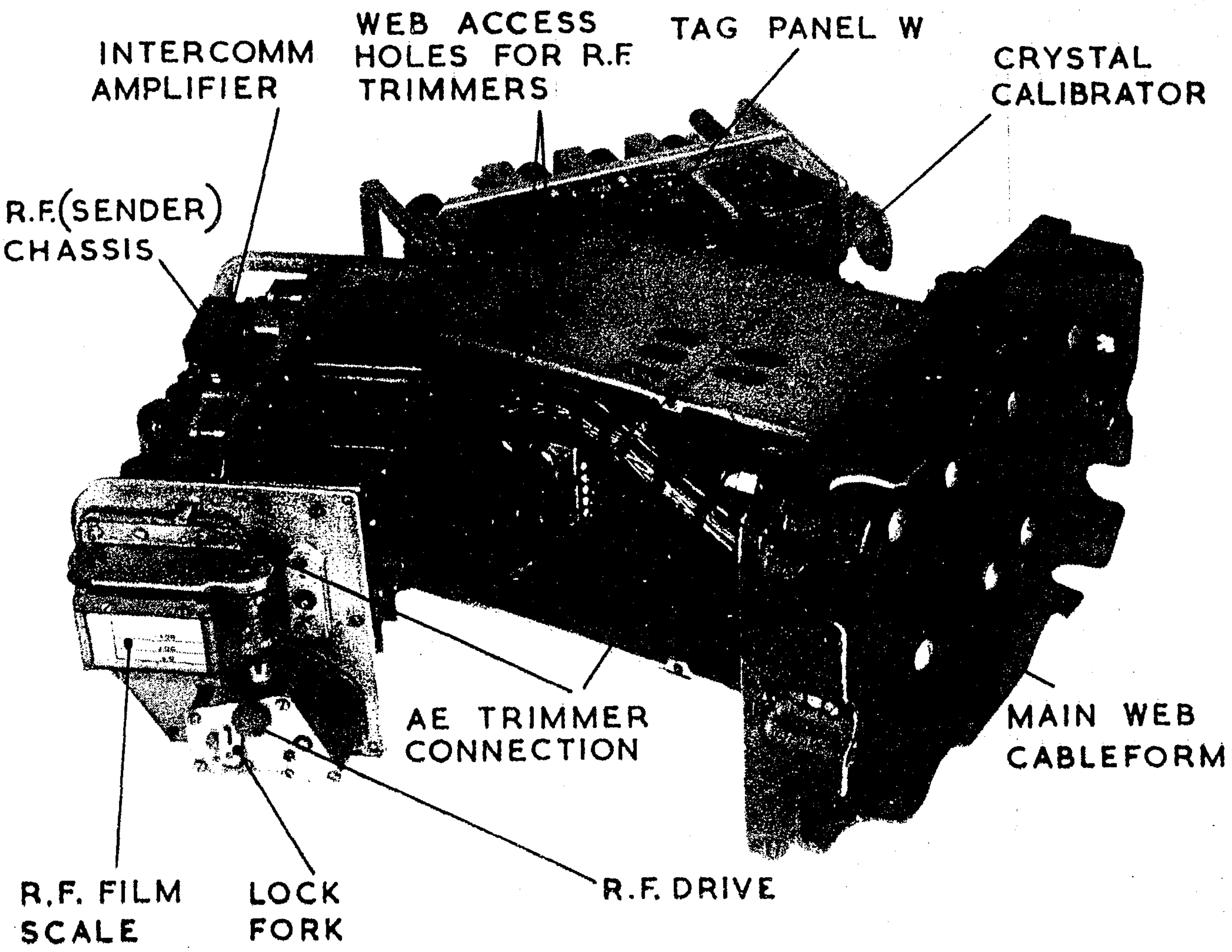

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Fig 3 - TRC13 construction, r.f. chassis side

22. The front panel is of cast aluminium and is fixed by seven 1/4 in. ~~UNF~~ UNC bolts (which are held by Araldite) to a central cast aluminium H-shaped web. The use of shims between these two parts ensures that the heat generated in the main chassis of the set is conducted efficiently to the front panel to be dissipated. Because of the Araldite (used to ensure rigidity on bump and vibration) the front panel and web cannot be separated for repair. The two chassis are fitted into either side of the H web and hinged left and right for servicing as indicated in Fig 3 and 4.

23. Referring to Fig 1 the control components actually mounted on the front panel are System switch (SB), CW TONE (C1), SENDER switch (SA), MODULATION switch (SC), AE plug (PLB), the P.S.V. plug (PLA) and the HARNESS socket (SKTC). The main tuning controls, ie RF control, CHANNEL control and MC/S switch are connected by gears which automatically disengage and re-engage when the chassis are opened or closed (provided the LOCK controls are locked). The only other mechanical connection to the front panel is the flexible coupler from the AE TRIMMER control to the capacitor on the r.f. chassis (see Fig 3). Four captive No 2 BA screws secure each chassis to the central web. The 'hinges' consist of two steel pins threaded into the web casting.

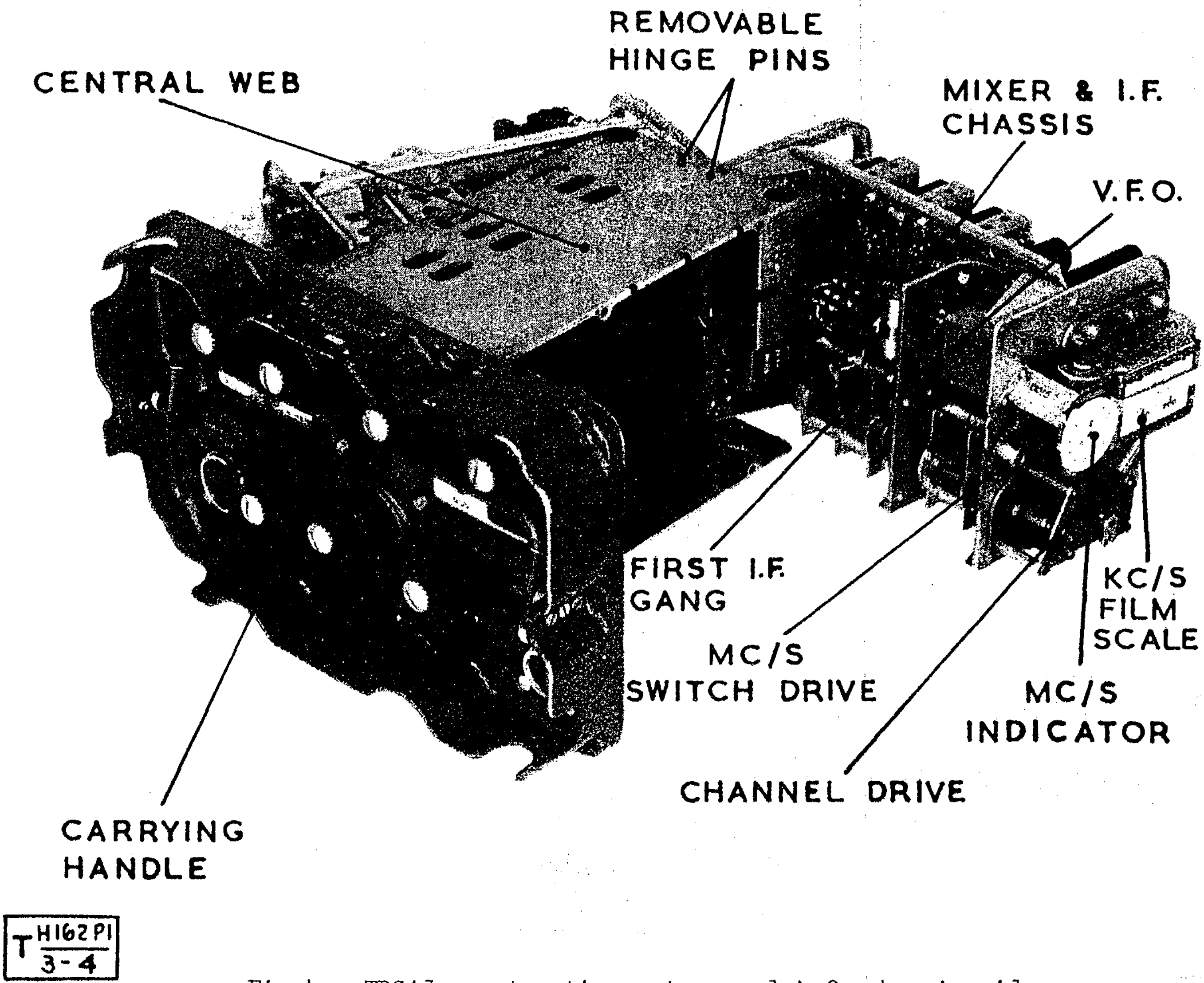

Fig 4 - TRC13 construction, mixer and i.f. chassis side

24. Electrical connections between chassis and front panel components are by cableforms terminated mainly on three soldered tag panels, TX (on r.f. chassis) M and I.F. (on mixer and i.f. chassis respectively). A tag panel, W, mounted on the web is used as a junction panel and connections to the calibrator are made to soldered stand-off tags on the calibrator chassis. The cabelforms on the two main chassis are of sufficient length so that, after removing the hinge pins, the chassis can be laid on a bench for servicing without unsoldering. The set may be aligned without unhinging since all the trimmers on the mixer and i.f. chassis are on the outer face while the r.f. trimmers are adjustable through slots in the central web.

25. Fig 3 shows a general view of the set to illustrate some of these points and the r.f. chassis is hinged outwards to show the crystal calibrator and main web cableform. The r.f. chassis contains all the r.f. circuits, gang capacitor and film scale. The intercomm amplifier is mounted on this chassis although the cableform is connected by the main web cableform direct to the front panel sockets (sufficient cableform is allowed for servicing the unit when removed from the main chassis). Switch SF (12/24 V), used only on TRC13 Mk 1, and Ledex relay are not shown in Fig 3 as both are mounted on the rear of r.f. chassis.

26. Fig 4 shows a general view with the mixer and i.f. chassis hinged. The main sections shown on this chassis are the MC/S switch, KC/S film scale with its associated v.f.o., and the 1st i.f. circuits. The 2nd i.f. and a.f. circuits are mounted on a separate chassis which is screwed to the lower side of the mixer chassis and electrically connected by two r.f. plug/socket leads and by the M and I.F. tag strips on the rear of the respective chassis.

DETAILED DESCRIPTION

General

27. Before a detailed explanation of the circuits employed is given, several general points need clarification.

Layout and coding

28. The circuit diagrams and component layout of TRC13 Mk 1 and Mk 2 individual chassis are shown in Fig 2520 and 2531. Each chassis or part has been allocated a block of component numbers:-

a. Front panel and web: 0-99.

b. R.F. (sender) chassis: 101-199.

c. Mixer chassis: 201-299.

d. I.F./a.f. chassis: 301-399.

29. Fig 2504-2507 show the set functionally operating as a transmitter and receiver. These diagrams are electrically complete with all switching shown but size limitation necessitate the omission of heater circuits, relay base and transformer tag coding etc. It will be necessary to refer to the individual chassis circuit for this type of information. Junctions between chassis on these complete circuits are shown as numbers on the coded tag panels of the particular chassis, eg IF 26-M21. Some sections of the circuits are shown twice (eg RLA 1 contact) to avoid long 'tramlines'. Where this occurs one section is shown dotted and is grid referenced to the other section(s).

Ledex relay

30. The Ledex relay mentioned in para 12.a.(1) and 25 is shown mechanically and diagramatically in Fig 5. The use of this device avoids the necessity for front panel manual control of the wave changing switch for the three r.f. bands. Basically it is a uniselector, coupled to a wafer switch, and remotely controlled by a wafer of the MC/S switch (SD) on the mixer chassis.

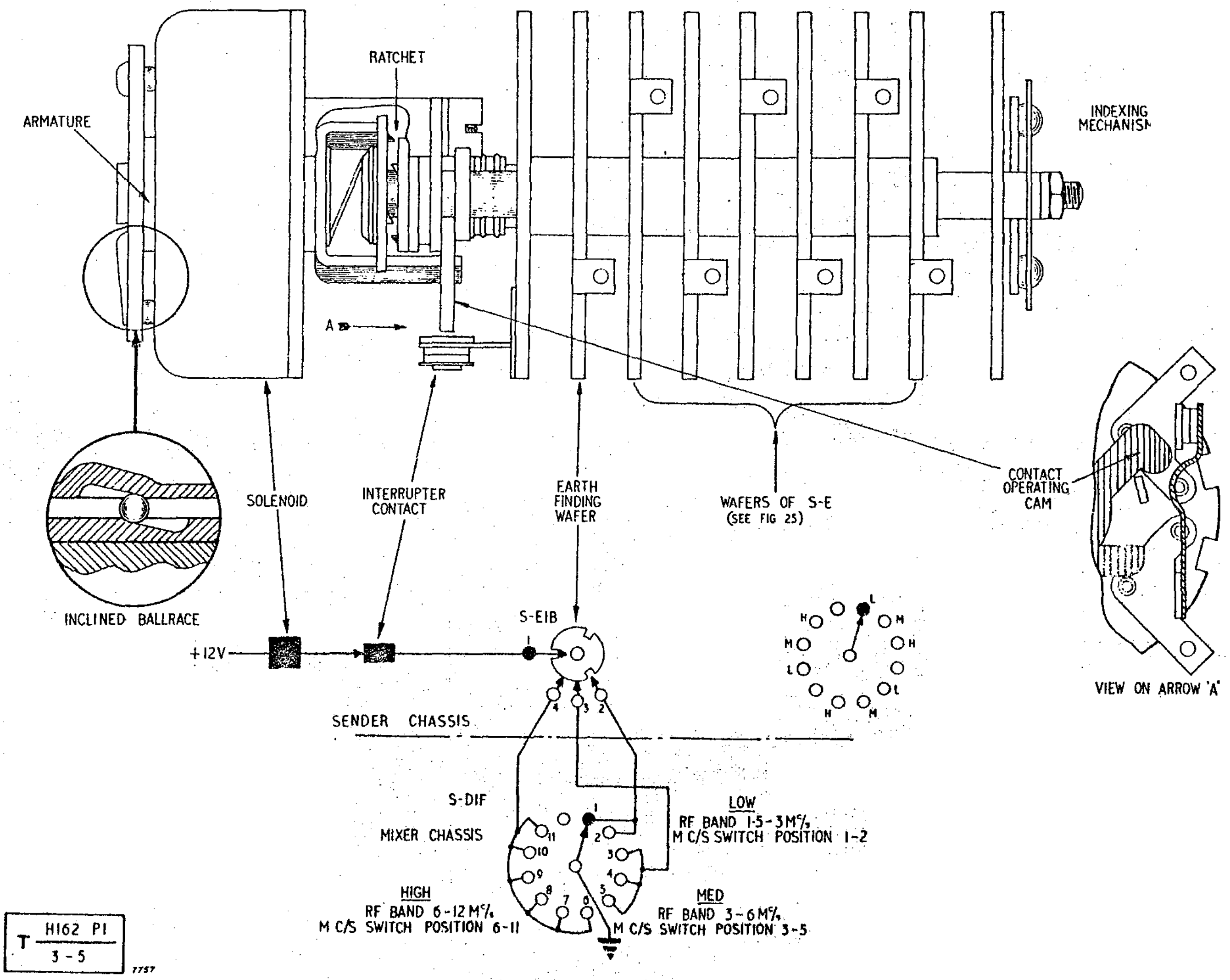

Fig 5 - Schematic operation of Ledex relay

31. Referring to Fig 5 consider the MC/S switch is moved from the 1Mc/s position shown to 6Mc/s. The solenoid will be energized through the interrupter contact and the earth finding wafer of SE1B tag 4. The armature will be drawn forward, and, due to the inclined ball race shown in inset, the forward motion will be changed to a rotary thrust which will turn the ratchet, and hence SE, one step. The precise amount of rotation is governed by the length of the inclined race and is in fact about 36^{o}, ie slightly greater than one step of the switch indexing mechanism (about 30^{o}). This allows for any slight misalignment of the switch wafers etc. As the ratchet turns the switch, the interrupter contact is broken by the action of the cam illustrated (view on arrow A), the energizing voltage to the solenoid is removed and the ratchet spring returns the armature and interrupter contact to normal. SE1B will have moved so that tag 3 is now disconnected from the slider. There is still, however, an earth via tag 4 so the sequence repeats, turning SE another step. This brings pin 4 of SE1B to an unearthed position so that the Ledex action ceases, leaving SE switched to HIGH, ie 6-12Mc/s band. The stepping action is, of course, practically instantaneous (speeds of 30-40 steps per second are achieved depending on the number of wafers etc).

32. In the case of the TRC13 the rotor of each wafer of SE is symmetrically divided (SE1B for example) to use the 12 positions in three blocks of four. The Ledex always drives in one direction so the switching steps correspond to LOW, MEDIUM, HIGH bands, a blank then repeat LOW, MEDIUM, HIGH, etc.

Modulation system

33. The TRC13 has two forms of r.t. modulation (amplitude and phase) controlled by switch SC (MODULATION: NORMAL/PHASE) on the front panel. Phase modulation gives an increase in range of communication by reason of the increase in available r.f. power and slightly better receiver performance. The major advantage of phase modulation, however, is that the C13 modulated output can be used to drive an r.f. amplifier (Amplifier, r.f. No 7) operating in the efficient class C condition. This of course, could not be achieved using a.m.

34. Phase modulation is used with a maximum angular deviation of 1.4 radians since this can be reasonably accommodated in the normal a.m. bandwidth of about 6kc/s at the 6dB points. To explain this a brief outline of the differences between f.m. and p.m. is given. Fuller details will, however, be found in Tels A 013.

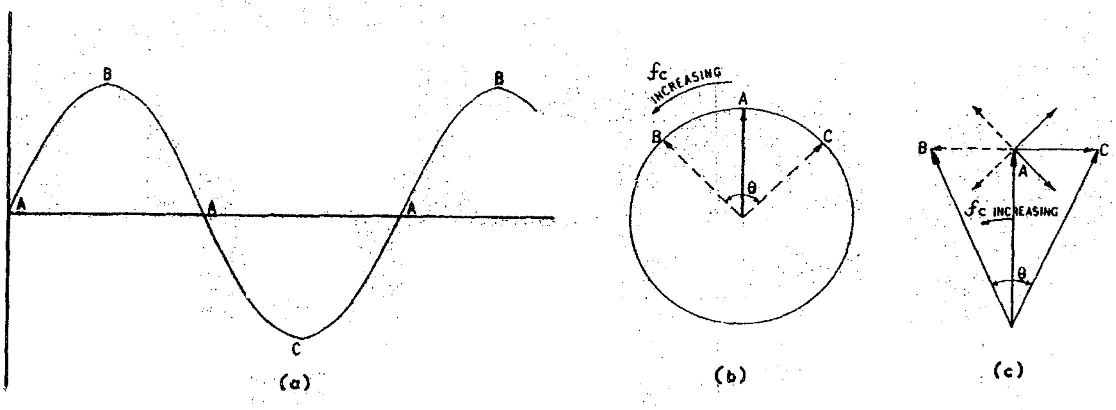

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Fig 6 - Vector representation of phase modulated carrier

35. Consider that a carrier wave is subjected to angular modulation. We define frequency modulation as being a change in instantaneous frequency proportional to the amplitude of the modulating wave. Phase modulation on the other hand should ideally mean that the phase angle change is proportional to the modulating wave amplitude only as in the case shown in Fig 6. In practice these rigid definitions cannot be achieved.

36. Fig 6(b) shows a carrier represented as a rotating vector assumed stationary at A in its unmodulated state. If we modulate by a single tone a.f. sinewave then the phase of the carrier will advance to B at the maximum positive value of the a.f. wave and swing to C at the maximum negative value shown. If we increase the amplitude of the a.f. the angle θ traced out will increase linearly as shown in Fig 7(c). (This type of phase modulation can be almost achieved by adding the resultant of two sidebands produced by normal a.m. at 90° to a carrier as shown in Fig 6(c) but is only fully correct if more pairs of sidebands ($fc \pm 2fm$), ($fc \pm 3fm$) etc are added to reduce the a.m. content).

37. If we consider also the instantaneous frequency change (deviation) in Fig 6 and 7; at the turning points B and C the frequency must be that of the unmodulated carrier, and the frequency will vary sinusoidally decreasing from B-A-C and increasing from C-A-B. The maximum deviation from carrier frequency fc will be as the vector passes through A anticlockwise, ie the carrier frequency varies with the a.f. amplitude although it is 90° out of phase with the wave as indicated in Fig 7(b).

38. There is, therefore, no difference in effect between f.m. and p.m. when only one modulation frequency is involved, (an increase in amplitude results in an increase of θ and Δfc as shown in Fig 7(c)).

39. Consider the effect on θ and Δfc if the modulating frequency is doubled but its amplitude remains the same as before. Referring to Fig 6(b) the phase change traced out will reach the same limits B and C, ie for a change in modulation frequency θ remains unaltered. The time taken to travel from C to B, however, is halved, ie the speed through A is doubled which means the maximum increase in frequency or Δfc (Fig 7(b)) is doubled. Taking other values of modulating frequency it can be seen that the maximum deviation increases proportionally to the modulation frequency. Fig 8 shows these relationships.

40. This is the characteristic of phase modulation and cannot (by definition) be frequency modulation since the frequency of the carrier is dependent upon both amplitude and frequency of the modulating wave.

41. If the modulating wave is passed through a network whose a.f. response is as shown in Fig 9, the frequency deviation can be made constant for all modulating frequencies. We have, therefore, turned phase into frequency modulation where the angular swing θ will be inversely proportional to the modulating frequency and the rate of swing through A(Δfc) will be constant for all modulating frequencies (Fig 10).

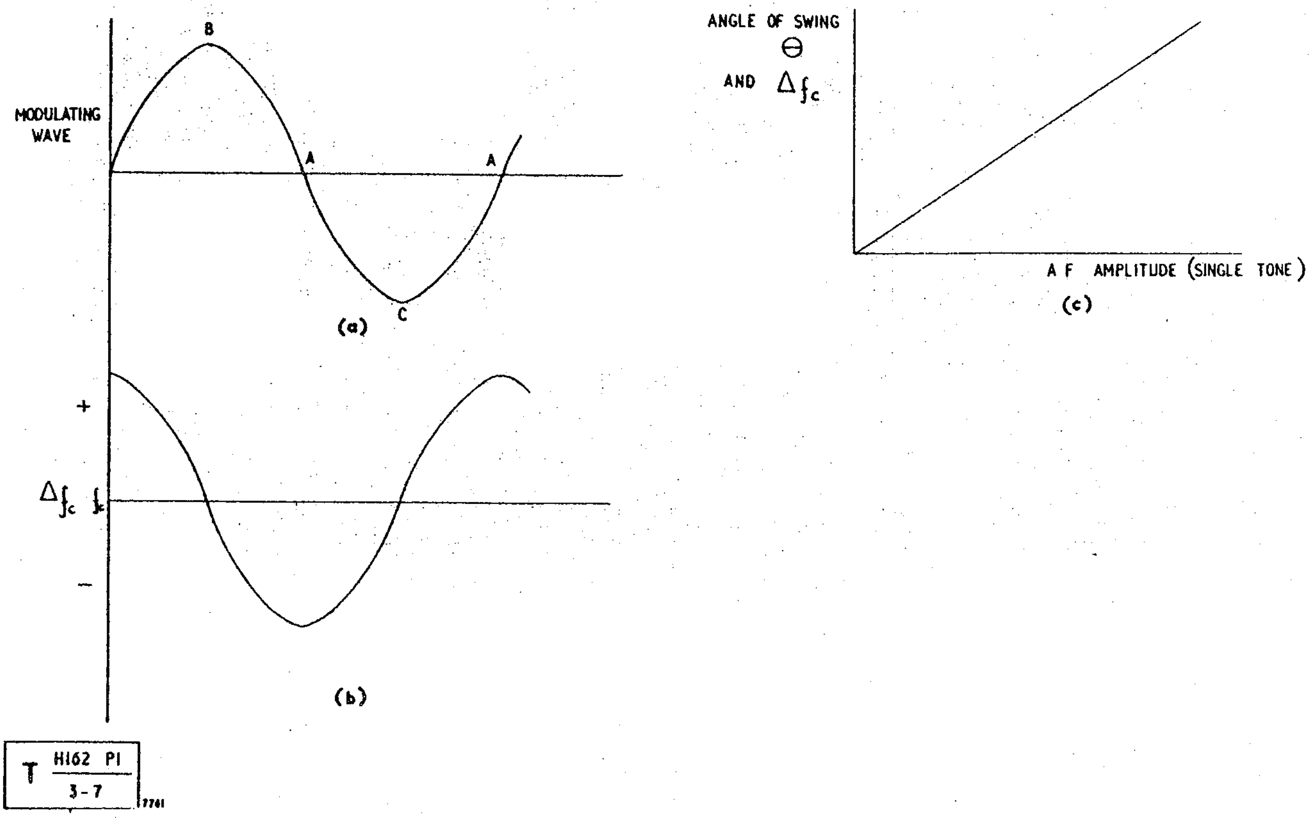

Fig 7 – Change of carrier frequency with single tone phase modulation

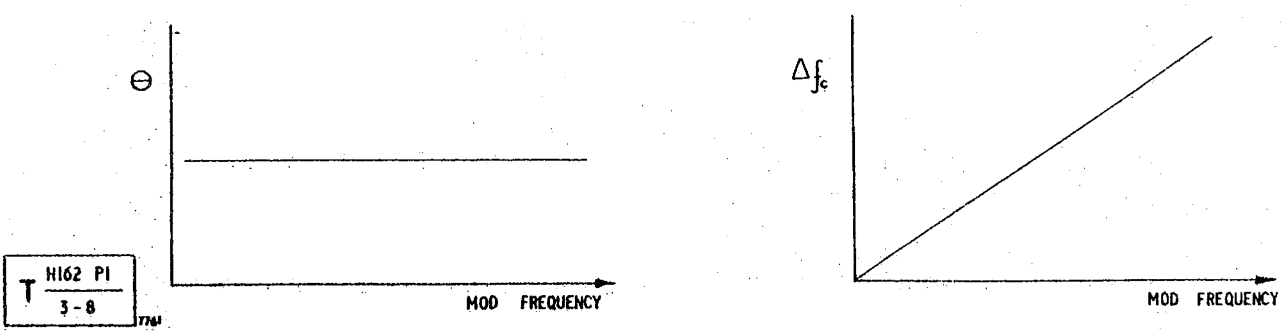

Fig 8 – Change of θ and Δfc with modulating frequencies (fixed amplitude) for phase modulation

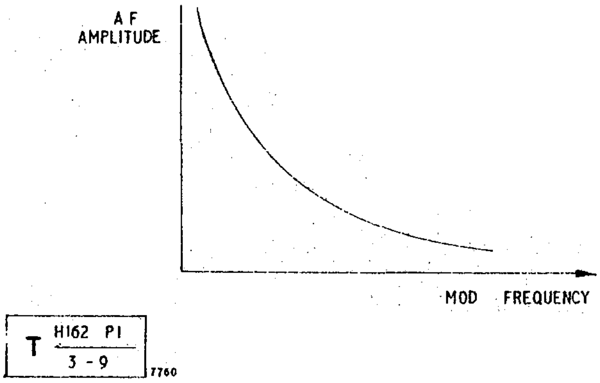

Fig 9 - A.F. corrector characteristic, phase to frequency modulation

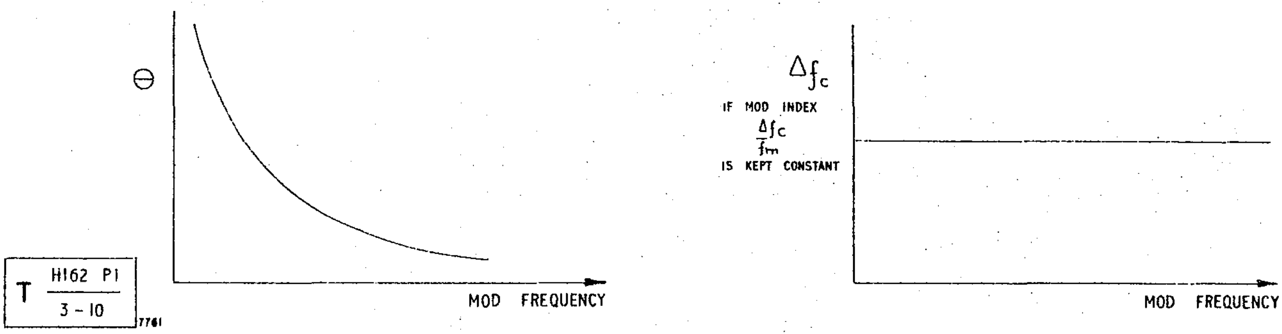

Fig 10 - Change of θ and Δfc with modulating frequency (fixed amplitude) for frequency modulation

42. Conversely, and this is the C13 case, we can produce f.m. by a reactance valve which varies the oscillator frequency according to the a.f. but the audio input is applied to the reactor via a corrector network whose response is directly proportional to modulating frequency (Fig 11). This gives the θ and Δfc characteristics for phase modulation shown in Fig 8.

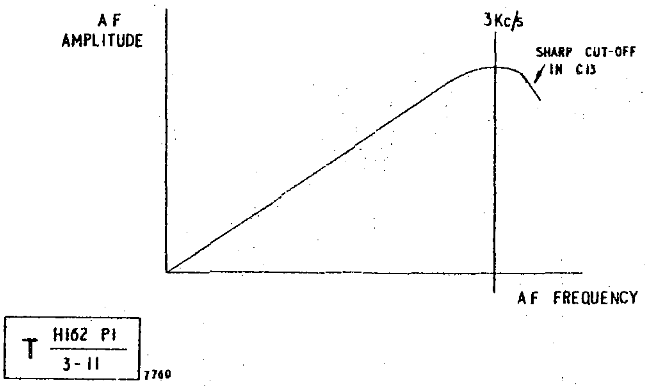

Fig 11 – A.F. corrector characteristic, frequency to phase modulation

43. The fundamental relationship between the three variables in angular modulationship is given by the equation: $\Delta fc = \theta \times fm$ (where Δfc = maximum frequency deviation in c/s, θ = angular swing in radians, and fm = modulation frequency in c/s). Assuming that we decide to make θ proportional to the amplitude of the signal and fix the maximum change to be 1.4 radians where the highest modulation frequency to be considered is 3kc/s. The maximum deviation (Δfc) will be ±4.2kc/s.

44. To calculate the bandwidth required to accommodate this, it is necessary to consider the f.m. and phase modulation spectrum. With a modulation index of 1.4 in f.m. (equivalent to swing of 1.4 radians in p.m.) reference to the Bessel function graph (Fig 12) shows that both the 1st, 2nd and 3rd pairs of sidebands are of significant amplitude. We should, therefore, require to pass frequencies up to fc ±2fm, ie a total bandwidth of 18kc/s. Fortunately, where the highest frequency is involved in the speech band, the amplitude is never enough to fully modulate to 1.4 radians. In practice the maximum amplitude is likely to occur about 1kc/s where full amplitude gives a maximum deviation of 1.4kc/s, requiring a total bandwidth of 6kc/s. Other factors preventing modulation spreading beyond the a.m. band in the C13 are:-

a. The a.f. pre-emphasis (corrector) network cuts off sharply above 3kc/s (Fig 11).

b. Efficient automatic modulation control.

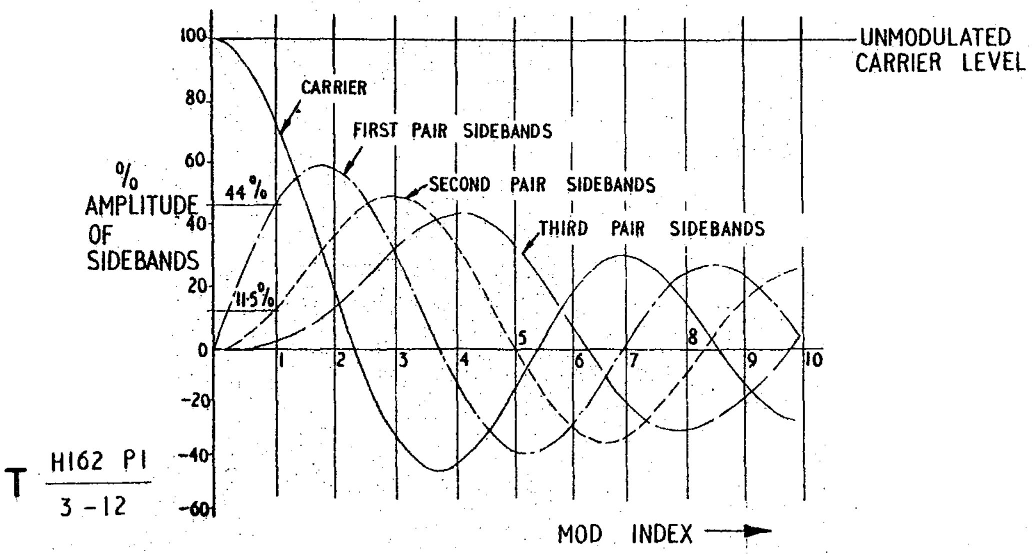

Fig 12 – Bessel function graph showing sideband amplitude

Send/receive switching

45. Fig 13 shows a composite relay circuit with the contacts detached to illustrate the circuit changes made from receive to send. The circuit is switched to send when:-

a. SB is at RT or CW and the pressel switch or key is earthed via harness socket pin D.

b. SB is at TUNE AE.

c. SA is at TRIM AE.

46. When switched as in para 45.a. high or low power is available by earthing RLF1 in the p.s.v. When switched as in para 45.b. and c. the set is always on low power and the send condition is independent of the pressel line.

47. The relay sequence in all three systems is:-

a. RLA (and RLB if SC is set to PHASE) is energized; RLA2 contact changes the aerial tuned circuit from r.f. grid to p.a. anode circuit. RLA1 contact:-

(1) Alters the p.a. cathode potential from cut-off to an operating level dependent on system switching

(2) Removes the earth from the sidetone oscillator (if SB is at CW)

(3) Earths coil of relay RLD.

b. RLD is energized and:-

(1) RLD1 switches the 1st a.f. V311 grid from the demodulator output to the microphone input

(2) RLD2 earths the coil of RLC and RLE (p.s.v.).

c. RLC contacts make and:-

(1) RLC1 switches the 150V ALL (h.t.) line from the receive circuits to the send circuit (Fig 13)

(2) RLC2 unearths the suppressor grid of 1st limiter V307 and connects the second mixer output to it.

d. RLE, situated in the p.s.v., is energized and:-

(1) RLE1 short-circuits the resistor in series with the send vibrator VB2 transformer primary

(2) RLE2 connects the output from VB2 to the p.s.v. output socket, supplying h.t. to the p.a. stage.

48. RLA acts as the keying relay on c.w. since RLC and RLE are held on between characters by the time delay network across RLD coil. To incorporate this network it is necessary to use a high resistance coil fed from the 150V line and a rectifier V315 is inserted to prevent spurious operation from p.a. cathode current. These relays will, however, release between words for break-in operation. When the system switch is set to TUNE RF, RLC and RLE only are energized so that the circuits are as on send but the p.a. stage is still biased off.

49. Relay RLF is also situated in the p.s.v. and is energized when SA is at high power (HP). In this condition the outputs from VB2 are increased.

50. If switch SC is at PHASE and the set is in a send condition, relay RLB is energized and the contacts perform the following functions:-

a. RLB1 switches the input to V103 to receive amplified microphone a.f. on NORMAL and a.f. from the discriminator for a.m.c. on PHASE.

b. RLB2 switches the amplified microphone a.f. from the modulator V103 on NORMAL to the reactance valve V101 on PHASE.

c. RLB3 changes the a.m.c. threshold level for a.m. or phase modulation.

d. RLB4 switches V103 anode to the modulation transformer on NORMAL and to the a.f. choke L108 on PHASE.

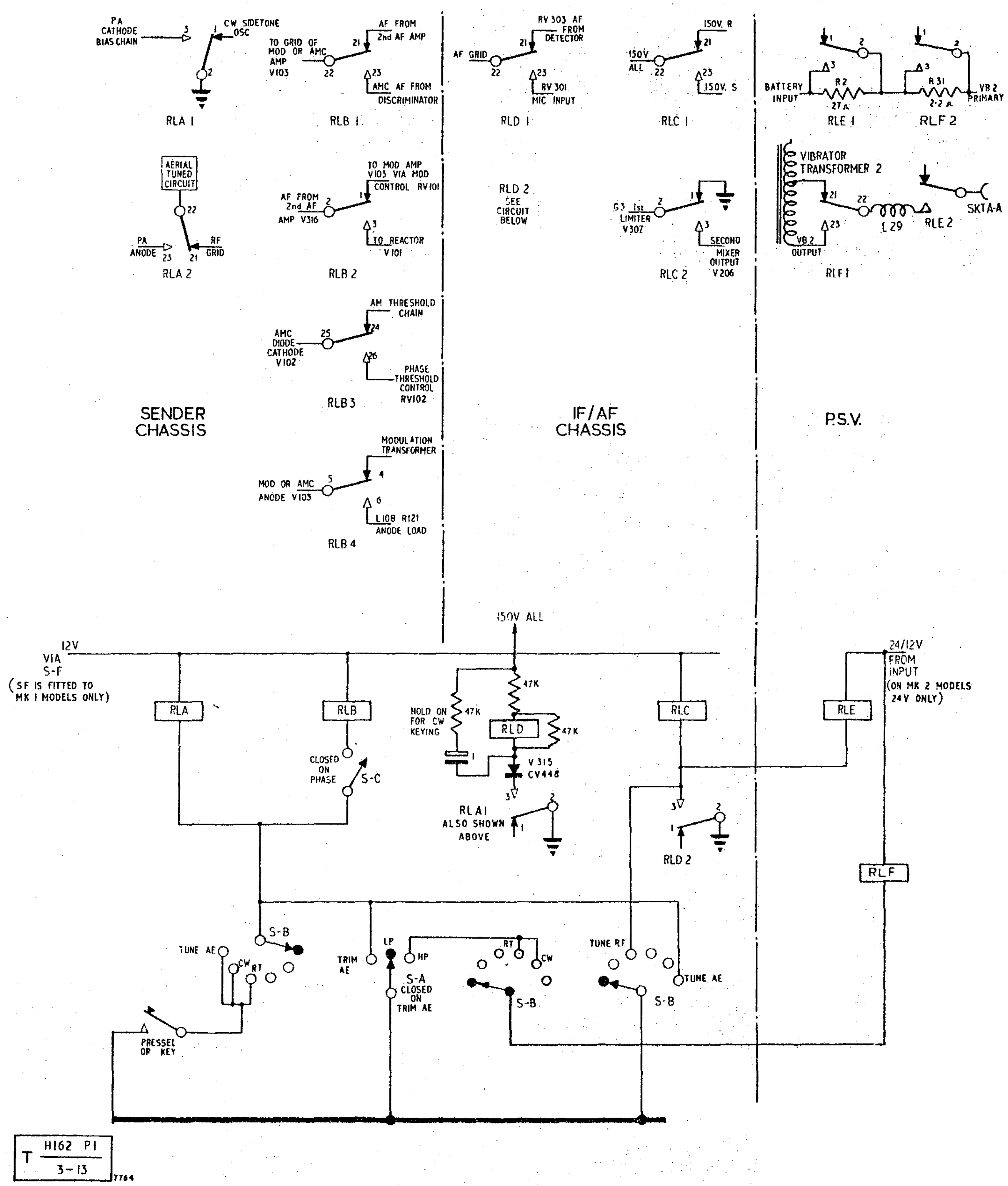

Fig 13 – Composite relay circuit

51. Fig 14 shows the distribution and switching of the h.t. supplies by relay and system switch control.

52. The three main h.t. supplies from the p.s.v. are:-

a. 150V from VB1, which is switched to the required valves mainly by RLC1 on send or receive and labelled 150V ALL, 150V S, or 150V R as appropriate.

b. 600V HP or 300V LP from VB2 for the power amplifier anode.

c. 300V HP or 150V LP from VB2 for the power amplifier screen.

53. The main circuit diagrams, Fig 2504-2507, are based on the functional operation of the set in the send and receive conditions, circuits not operating being omitted, ie 150V 'ALL' and 150V 'S' circuits in Fig 2504, 2505 and 150V 'ALL' and 150V 'R' circuits in Fig 2506 and 2507 respectively. Limiters V307 and 310 are shown in both cases since their h.t. feed changes according to the mode of operation (SB and SC settings).

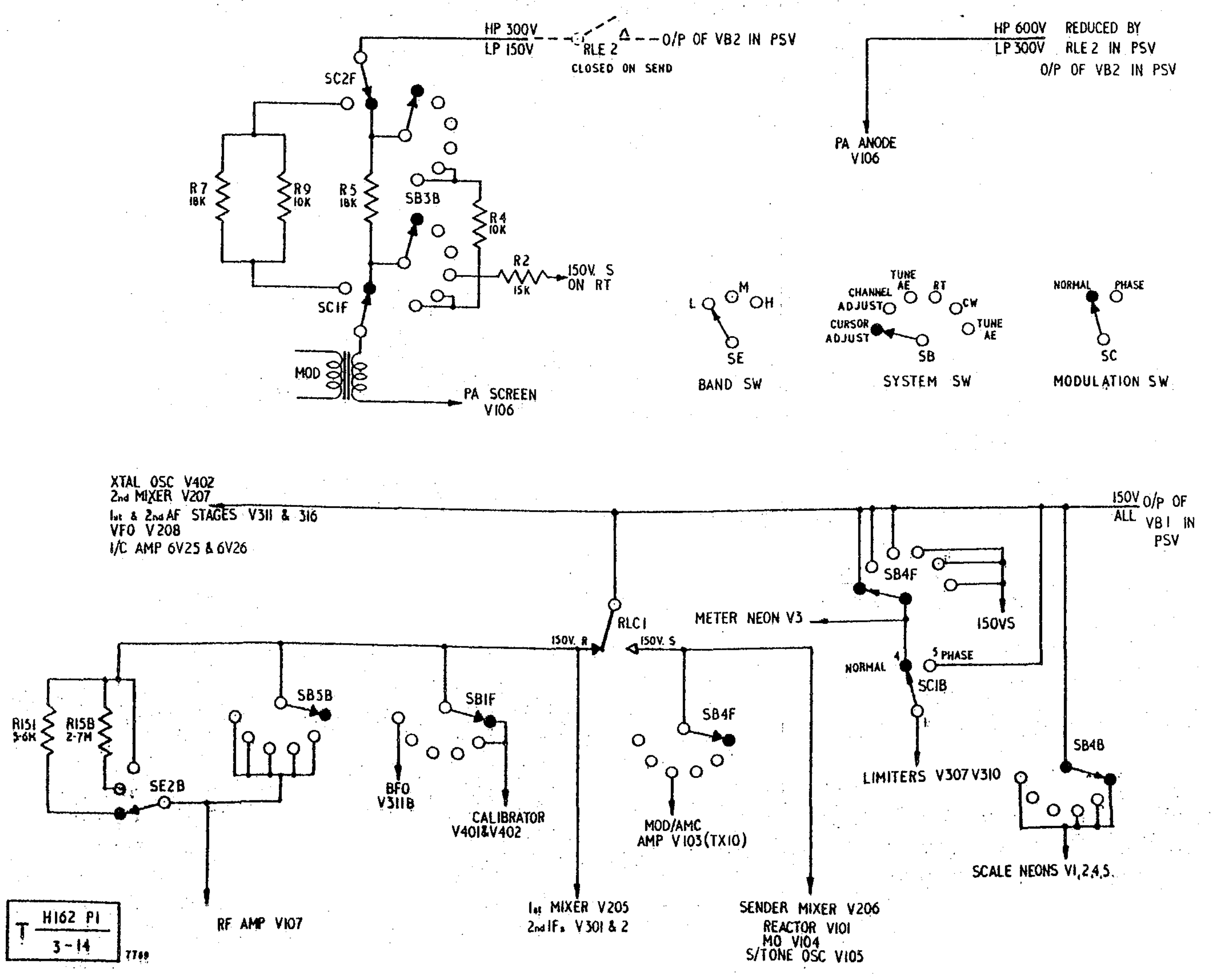

Fig 14 - H.T. distribution

54. Referring to Fig 14. With SC at NORMAL the limiters are fed from 150V ALL on the three calibrate positions of SB and from the 150V S on operating positions (for a.f.c. use). With SC at PHASE they are in use on both operate send and receive and are, therefore, fed from 150V ALL irrespective of system switch position.

55. Neons V1, 2, 4 and 5 are used to illuminate the tuning scales and are energized from the 150V ALL on the three calibrate and the TUNE AE positions of SB. Neon V3 illuminates the meter from 150V ALL on the three calibrate positions of SB and from 150V S on RT, CW and TUNE AE, the meter then being required to indicate antenna current.

56. Only the 300/150V screen supply to the p.a. is switched from send to receive (by RLE1), due to the problem of arcing which would be encountered if the 600V were switched.

Sender
(Fig 2504-5)

Master oscillator

57. The master oscillator, V104, is shown in simplified form in Fig 15. The grid tuned circuit is effectively between screen grid and control grid of the valve, C128 decoupling the screen to form an inverted Hartley oscillator. On the two lower frequency ranges C114B gang section tunes the circuit L104, C116 between 1.5 and 3.0Mc/s and on the high range tunes L105, C120, C124 between 3.0 and 6.0Mc/s. The signal is electron-coupled to the anode circuit where the gang section C114A tunes the three anode tuned circuits, L106, C122; L107, C125; and L109, C130; to 1.5-3.0, 3.0-6.0, and 6.0-12Mc/s on low, medium and high ranges respectively. Selection of band in both grid and anode is by SE which is driven by Ledex relay controlled from the MC/S switch SD (see para 30 to 32). C114 is geared to the RF control and indication of tuning is by a film scale calibrated in the three bands. Accurate tuning is achieved by comparing the m.o. frequency with the calibrated receiver at the TUNE RF position of SB. In each case the anode is taken to a tap on the coil to match the circuit to the valve and to avoid m.o. frequency shift due to reflections from the p.a. circuit. C127, R123 provide auto-bias to the m.o. stage.

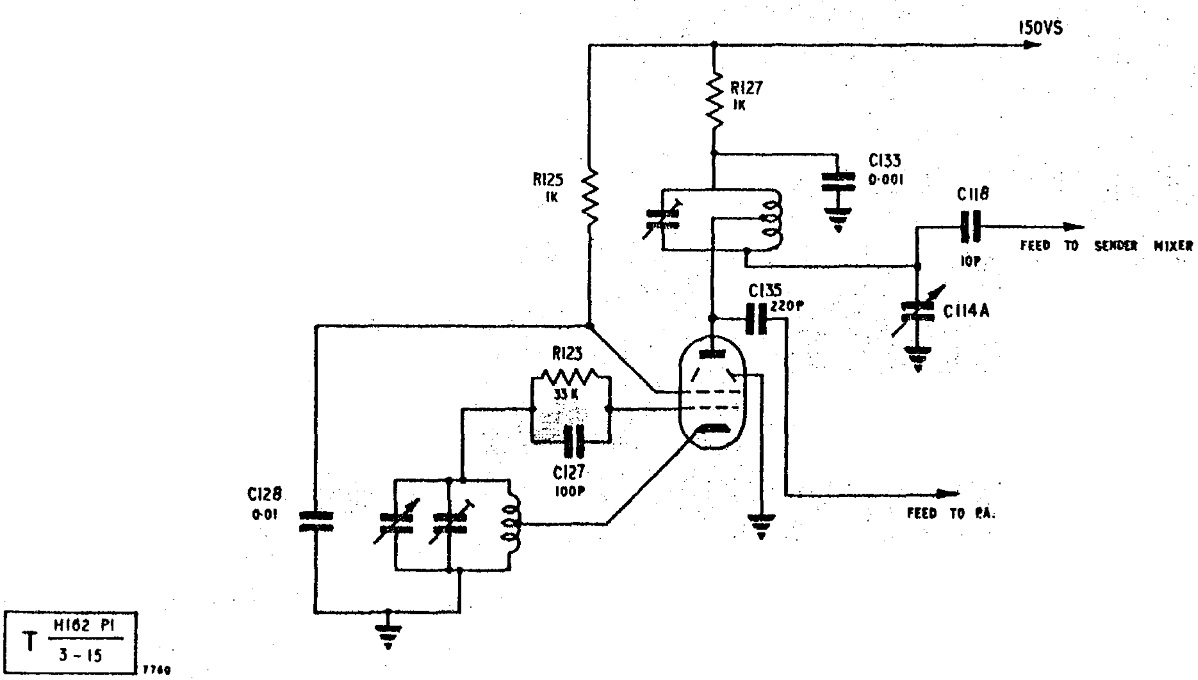

Fig 15 - Master oscillator basic circuit

Power amplifier

58. C135 couples the signal to the grid of the p.a. V106 where it is developed across R128 and r.f. choke L111 decoupled to chassis via C136. The signal is amplified, developed across the anode feed inductor L113 (decoupled to chassis by C142) and coupled to the tank circuit via C141 and contact RLA2 (closed on send). The main tuning capacitor is the third section of the gang capacitor (C114C), but a further variable capacitor C140 (AE TRIMMER on front panel) permits the p.a. anode circuit to be separately tuned to ensure the correct operation of the stage. Two impedance taps RT and CW are used. The RT tap is used to allow for the change in conditions in the p.a., when used on RT, NORMAL. On all other systems the CW tap is used, switching being carried out by SB5F and SC2F.

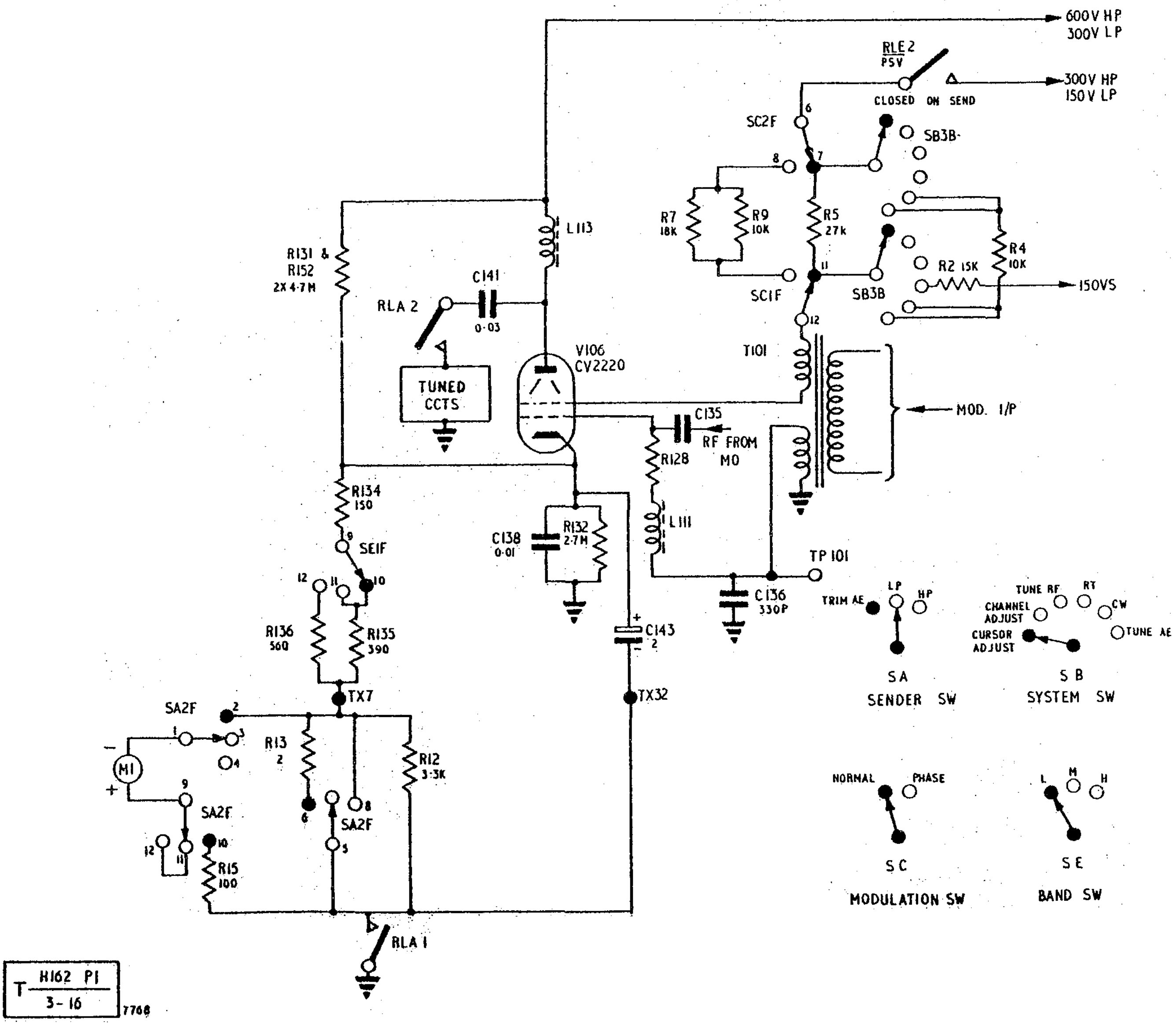

Fig 16 - P.A. cathode and screen switching

59. Fig 16 shows the screen and cathode switching of the stage. On c.w. to give optimum r.f. output the screen voltage is increased by switching R4 in parallel with R5 and, on RT, PHASE, SC switches R7 and R9 in circuit to give exactly similar conditions. The anode voltage is not switched from send to receive because of arcing difficulties but the screen supply is broken by RLE in the p.s.v. The stage is biased off when not on send by the voltage across R132 in the chain R131, R152, R132. When RLA1 is closed this bias is reduced to an operating level variable according to the band switch SE and/or the SENDER switch SA. On HP and lower frequency band for example, R132 is parallelled by R134, R135 to chassis. The voltage from the h.t. chain R131, R132 is then negligible, so normal cathode bias is developed across approximately 500Ω resistance. When SA is at the spring-loaded TRIM AE position the meter, with multiplier R15, is connected across the 1Ω resistor R13. The meter is a centre-zero type polarized so that the cathode current will back-bias the meter, ie anticlockwise. The operator tunes C140 for maximum deflection clockwise which is in effect the dip in cathode current indicating the correct tuning of the anode circuit.

60. C143 (the a.f. bypass capacitor) is switched into circuit on send only to avoid the high voltage from the 600V h.t. chain on standby. A test point TP101 is provided to permit the measurement of drive in order to align the m.o. anode circuit.

Automatic frequency control

61. A separate mixer V206 is used on send to reduce switching problems and, since each mixer is used for one purpose, optimum operating conditions can be achieved in each case. Only part of the receiver circuit is used for a.f.c. because a wider pass band is necessary to achieve the correct capture range. One stage of 1st i.f. and two stages of 2nd i.f. amplification are omitted. Except for this the a.f.c. follows the receiver path and is dealt with more fully in para 77-94.

62. The master oscillator output is loosely coupled by C118 and fed by a coaxial lead to the injector grid of the pentagrid mixer V206 on the mixer chassis. The crystal oscillator output is coupled to the control grid of V206 by C211 at a frequency dependent on the MC/S switch setting as explained in para 79-80. The mixer output is developed across L201 and coupled across the tuned secondary of T202 or T203 (dependent on the frequency in use) via R216, C223. These components and R220 help to prevent the crystal oscillator frequency signal being fed (through the inter-electrode capacitance of V206) to the second mixer V207 on receive. The v.f.o. V208, ganged to the 1st i.f. tuning capacitor, gives an input to V207 such that the output is 500kc/s (2nd i.f.). This signal, developed across T204, is coupled by C238 and SKTD to the i.f. chassis. Contact RLC2 is closed on send and connects the signal to the suppressor grid of the first limiter V307.

63. The anode circuit of V307 consists of inductor L302 with R318 in parallel. These, with the valve and stray capacitance, form a low Q parallel tuned circuit resonant at 1Mc/s, the second harmonic of the i.f. If the anode were tuned to 500kc/s, more anode than grid limiting in the first stage would tend to give an asymmetrical input to the second limiter and hence to the discriminator. An error voltage could thus be falsely produced from the discriminator which would give a false meter zero on calibrate positions or by a.f.c. action, cause a shift of several kc/s from the correct frequency. The circuit used gives a more symmetrical input to the second limiter avoiding these effects.

64. The second limiter V310 has its screen voltage stabilized by V308 to help maintain a constant limiting level. The anode circuit consists of a 500kc/s tuned circuit tightly link-coupled to the discriminator.

65. The discriminator used is a Foster-Seely of standard type. The d.c. output is taken via L303 and L304 to four wafers of the MC/S switch SD. SD6B and SD6F earth one side of the output and feed the other to the a.f.c. line. This is necessary to give the correct polarity since both the crystal oscillator and/or the v.f.o. can operate above or below their respective signal input frequencies. This d.c. voltage is fed via filter R101, C103 (and C101 at PHASE) to the grid of V101 correcting the frequency by normal reactance valve action.

66. At the calibrate positions of SB the discriminator d.c. output is coupled via SD5F and SD4F to the meter M1. At TUNE RF the a.f.c. is also in circuit so R230 is inserted to partly damp the a.f.c. effect and to reduce the meter sensitivity to give smooth readings on adjusting the RF control.

67. There will be an a.f. output from the discriminator if the transmitter is phase modulated. This is taken from the centre of R354, R355 and fed via C346 to the a.m.c. circuits (para 74).

Modulation - speech amplification

68. The microphone input from SKTC is coupled by microphone transformer T303 RLD1 and R336 to signal and control grids of V311A. C308 cuts the high frequency response and RV301 is used to adjust V311A input (on PHASE only). The signal is amplified by V311A and V316 and developed across the primary of output transformer T307. Anode follower feedback is applied via R359, and sidetone is taken from the transformer secondary to the phone pins of harness socket SKTC. Two modulation paths are now possible dependent on condition of RLB:-

a. Amplitude modulation path.

b. Phase modulation path.

Amplitude modulation path

69. When SC is at NORMAL, RLB is de-energized and the amplified a.f. (coupled via C352, RLB2) is developed across the potentiometer chain RV101, R14 (short-circuited on high power) R124 to chassis. The a.f. across R124 is connected to V103 grid. At the RT position, SB4F connects the 150V S to this stage and the signal is amplified and developed across modulation transformer T101. R126 and C131 provide negative feedback via the de-energized RLB1 contact. T101 has two secondaries; one connected in series with the h.t. feed to the screen of the p.a. and the other to the grid of the p.a. via r.f. filter L111, C136 and R128. There is, therefore, a combination of screen and control grid modulation applied to the p.a. stage.

70. The screen feed is taken on RT, NORMAL via R5 and R20 in parallel from the 300/150V supply. This supply is also, at the RT position, connected through R2 and SB3B and SB4F to the 150V S h.t. line. This tends to stabilize the modulation depth since it limits the swing on high power modulation to between 150V and 300V. R120 is short-circuited to chassis on NORMAL by SC1F.

71. The amplified a.f. is also coupled by C124 to the anode of a.m.c. diode V102 and rectified if above the delay voltage value on V102 cathode. The rectified negative d.c. voltage is fed via R117, C119 (whose time constant is such that a.f. variations are smoothed out) and applied as bias to the grid of first a.f. amplifier V311A. The delay on amplitude modulation is controlled by combinations of R116, R112, R113 and R111 as potentiometer chains between 150V S and chassis, the cathode of V102 being connected via the de-energized RLB3 contact to the junction of R116, R112. On LP R113 is short-circuited by SA1F and on HP this resistor is switched in series with R112 to increase the threshold level. On both LP and HP the delay is decreased on the high RF band by connecting R111 in parallel with R112 (or R112 and R113 in series) by switch wafer SE7B.

Phase modulation path

72. With SC on PHASE, RLB is energized in the send condition. The a.f. across T307 in the second a.f. amplifier V316 anode is then connected by C352, RLB2 and C102 to the corrector networks, C105, R103; C106, R104 and C104, R102. These networks have the pre-emphasis characteristic with increase of modulation frequency mentioned in para 42 and give the effects of phase modulation although the reactance valve used actually controls the frequency of the master oscillator. Fig 17 shows the reactance valve circuit. The output of the corrector network is applied to V101 screen grid which is connected to h.t. by R106, L102 and R107 decoupled by C107. L102 in series with R106 is effectively across C108 forming a parallel tuned circuit. This circuit resonates at about 3kc/s combining with the corrector characteristic to give a response to a.f. as in Fig 11, so preventing frequency deviations due to the high modulation frequencies spreading beyond the pass band of the set.

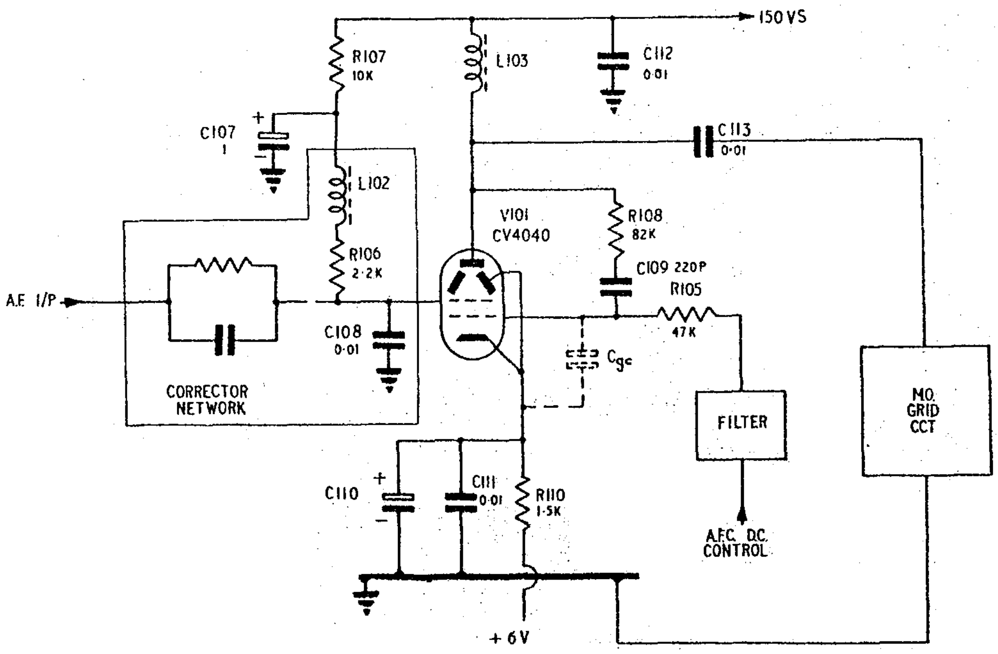

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Fig 17 - Reactance valve circuit

73. The reactance valve is a variable inductance type, R108 with Cgc (grid to cathode capacitance) providing the quadrature r.f. feed from the master oscillator grid circuit with C109 as a d.c. block. Changes in gm due to screen variations (ie a.f. modulation), or grid bias changes (ie a.f.c. d.c. control voltages), will give an effective change of inductance across the master oscillator tuned circuits by normal reactance valve action. The % angular modulation due to the a.f., will vary with the master oscillator frequency, different corrector networks are, therefore, switched into circuit on the three bands. There will still, however, be a theoretically unavoidable 2:1 change from one end to the other of each band, which is reduced by a.m.c. action. L103 provides a high impedance feed (at r.f.) to the valve anode and C111, C110, are r.f. and a.f. decoupling capacitors respectively.

74. To provide a.m.c. on phase modulation it is necessary to have an a.f. signal proportional to the depth of modulation and this is most readily available at the output of the discriminator. The a.m.c. path, therefore, follows the a.f.c. circuit (see para 61 to 67) and the a.f. output from the discriminator is fed via RLB1 to the grid of V103 in its function of a.m.c. amplifier. RLB4 is closed, connecting L108, R121 as the anode load across which the amplified a.f. is developed and passed via C124 as before to the a.m.c. rectifier V102. The threshold level for a.m.c. operation is set by RV102 since the cathode of V102 is connected by RLB3 to the chain R114, RV102, R115 from h.t. to chassis. This control is set to keep the maximum deviation at 1000c/s below 1.4 radians (1400c/s deviation) over the range of 40mV to 400mV a.f. input. This cannot be achieved in all cases due to changes in valves etc. altering the a.m.c. loop gain. A preset amount of negative feedback is, therefore, applied to V103 by inserting either R120 or R156 or both in its cathode circuit. Selection is made by a preset link position.

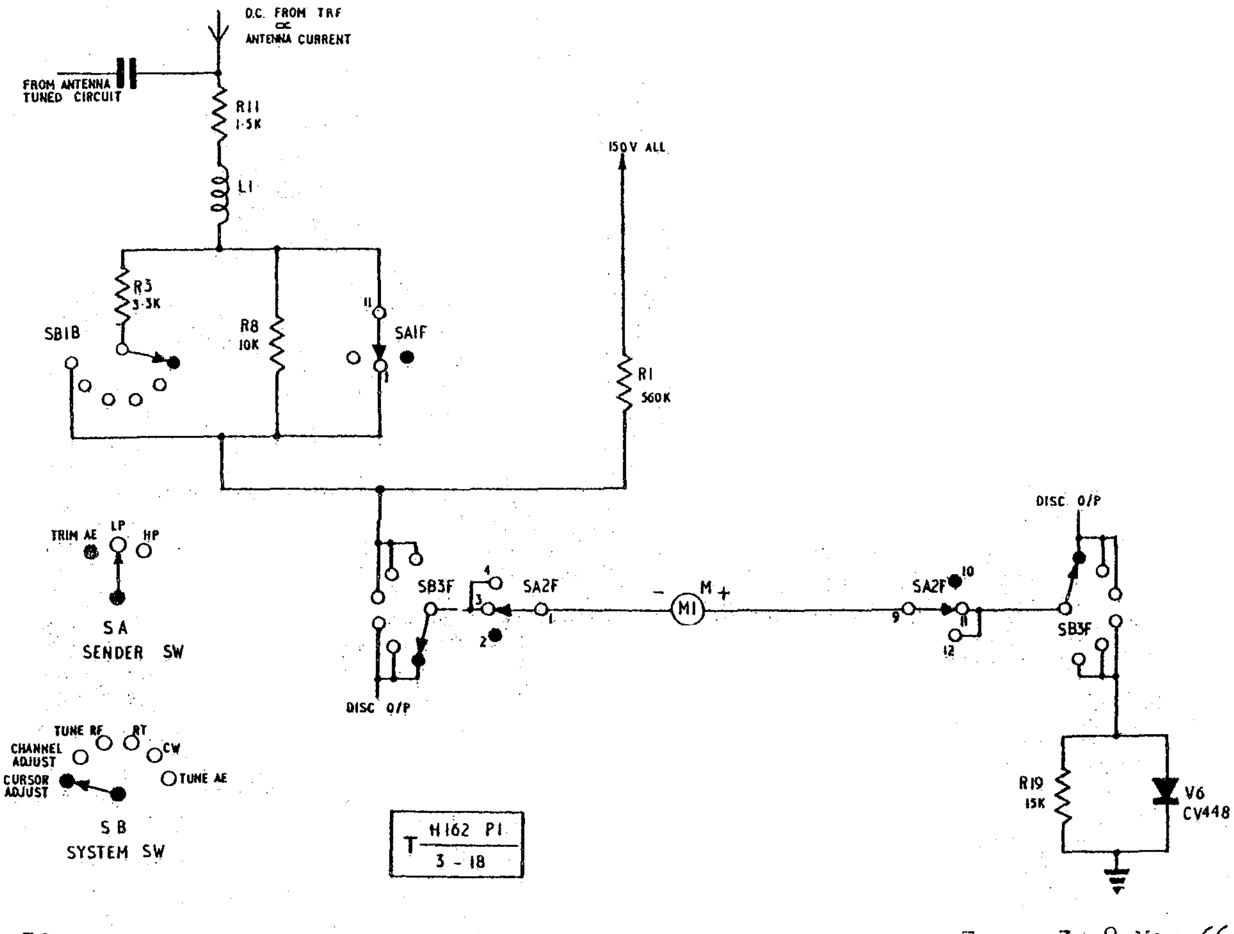


Fig 18 - Antenna current metering

C.W. sidetone

75. Sidetone is provided as a keying aid to the operator on c.w. operation. V105 is a neon oscillator which operates when SB2F disconnects R133 from chassis on CW position, provided RLA1 is energized (ie send conditions). The tone generated (approx 1kc/s) is coupled by C144, R358 to the grid of the second a.f. amplifier, amplified and fed to the phones via T307, SKTC etc.

Antenna tuning indication

76. When SB is at the operate positions, the meter M1 is connected as shown in Fig 18. Two voltages feed the meter, one from the chain between 150V h.t. and chassis formed by R1, SB, M1 and R19, V6. This biases the meter to approximately zero while that from the T.R.F. No 11 (Fig 2535) a negative d.c. voltage, proportional to the antenna current, counters this effect so allowing the t.r.f. to be tuned for maximum current. L1 is an r.f. choke and R8 is switched by SA in series with R11 on HP. R3 is similarly switched by SB at the TUNE AE position, when the set gives a low power irrespective of SA position. The insertion of germanium diode V6 and R19 renders the meter scale non-linear above 1/2 scale, giving a reasonable indication on LP without endangering the meter movement when used on HP.

Receiver

R.F. amplifier

77. When SB is at any operate position (RT, CW or TUNE AE), the signal from the antenna is connected via C2 to the antenna tuned circuit (L110, L112, L114 etc.). RLA2 is then de-energized switching these circuits from the p.a. anode to the grid of r.f. amplifier V107. This stage is necessarily on the sender chassis since the grid and anode tuning capacitors C114C and D are part of the r.f. 4-gang capacitor. Band switching is accomplished by the Ledex relay as described in para 30-32.

78. The amplified r.f. signal at V107 anode is connected by coaxial lead to the mixer chassis and hence to the control grid of the heptode portion of V205 (ie V205A).

Oscillator and first mixer

79. At positions 1 and 2 of SD no crystal is connected between anode and grid of the Pierce crystal oscillator. The mixer on these ranges thus acts as a second r.f. amplifier and its anode circuit is tuned on position 1 over the range 1.5-2Mc/s by T202 primary and secondary with C205A and C205B respectively. Only half the available gang swing is used on this position since the r.f. (sender) circuits do not tune below 1.5Mc/s. At position 2 of SD, SD3F and 2F switch T203 primary and secondary across the respective gang capacitors covering the range 2-3Mc/s.

80. At position 3 of SD a 5Mc/s crystal is switched into circuit. With the input signal variations on this position (3-4Mc/s) this gives a 1st i.f. output varying from 2 to 1Mc/s. At position 4 (4-5Mc/s) the crystal of 7Mc/s selected gives an i.f. varying from 3-2Mc/s. The same 7Mc/s crystal of position 5 (5-6Mc/s) gives the low i.f. band, ie 2-1Mc/s. Similarly on each successive step a suitable crystal is selected to convert the required frequency to either the low or high i.f. band. Table 1 gives the frequency relationships, and it can be seen that from this stage the receiver can be regarded as a two band superheterodyne receiver covering the range 1-3Mc/s.

First i.f. and variable frequency oscillator

81. Each band of the first i.f. is tuned over 1Mc/s using the two gang capacitor C205. Additional capacitance is connected in series with the gang sections by switch wafers SD3B and SD2B to reduce the swing on the high i.f. band. The local oscillator (v.f.o. V208) is, therefore, only required to operate over a very restricted range of frequencies (1Mc/s) and can consequently be made very stable. The operating frequency is from 1.5 to 2.5Mc/s and tuning is achieved by C222, coupled to the 1st i.f. gang C205. The oscillator is a Hartley type with special precautions taken to ensure stability. Some of these are:-

a. Low dynamic tuned circuit by virtue of the large fixed capacitance C226, C227 across the variable capacitor.

b. Negative feedback in the valve cathode R222 to reduce frequency variation with valve parameter changes.

c. L202 is a high Q coil wound on a large former with the tuning slug inserted only slightly, to minimise changes due to iron temperature co-efficient.

d. C226, C227 are special non scintillating (capacitors so made that there is the minimum random change of frequency due to scintillation on the edges of the plates) and temperature compensating types.

e. Electronic coupling to a low value anode load (1.5kΩ) to prevent loading affecting the frequency.

82. Tuning indication on the CHANNEL dial is achieved by using a film scale geared to the v.f.o. and 1st i.f. circuits. The film scale is calibrated from 0 to 1000kc/s (the range of the v.f.o.) and has an effective scale length of approx 40 in. (Since this repeats 11 times throughout the frequency range of the set (1.5-12Mc/s) the total effective scale length is nearly 450 in.). This permits very accurate indication of frequency; a difference of 5kc/s being about 1/4 in. on the film scale. As explained in para 11 and illustrated in Fig 2 the film scale is calibrated from each end to give a straightforward Mc/s + kc/s reading of frequency at all times.

Second mixer and second i.f.

83. The inputs to the second mixer are, therefore, signal inputs of 1-2Mc/s or 2-3Mc/s with an oscillator frequency of 1.5 to 2.5Mc/s giving an i.f. of 500kc/s when operated above or below signal respectively. (This is the only frequency practicable for the 2nd i.f. since the v.f.o. is to operate on one range of frequencies only. For example, if 400kc/s were chosen, on the low i.f. band the v.f.o. could operate from 1.4 to 2.4Mc/s but on the high band it would be required to operate from 1.6 to 2.6Mc/s).

84. T204 in the anode of the second mixer, V207, has a secondary critically coupled by a link winding SKTE and coaxial line to the i.f./a.f. chassis and hence to T301. This is double-tuned giving an effective triple tuned circuit from mixer anode to V301 grid.

85. Two stages of 500kc/s i.f. amplification are used, V301, V302. T301, 302, 304 are all slightly overcoupled transformers. A small portion of the cathode load, R309 of V302, is un-decoupled and is used to feed the b.f.o. signal into the i.f. At the output circuit of T304 the split between amplitude and phase modulation takes place.

Detector, noise limiter and quieter (NORMAL)

86. Fig 19 shows the detector and associated circuit redrawn for easy reference. The silicon junction diodes are referred to as if they were conventional diode valves, the arrow head being the anode and the +ve (red dot) end the cathode. The output of T304 is detected by V305 and developed across R316, R317 to chassis, the return d.c. path being via R312, T304 to V305. The negative voltage proportional to the signal across R312 is connected to indicate detector current at HARNESS socket SKTC pin H for testing, to agree with the limiter grid current normally fed out on the f.m. v.h.f. range of sets.

87. The signal across R316, R317 is fed via an a.f. filter R321, C322 to the anode of V306 through R324, ie the positive anode potential will depend on the unmodulated carrier level. The cathode of V306 will be biased (also positively) to a d.c. level dependent on the peak modulated wave. Potentiometer chain R316, R317 sets the proportionate amount of bias to such a level that, where the peak modulation is below 100%, the diode will conduct, but where 'spikes' of noise or other modulation are above this level the diode is cut off.

88. When V306 conducts the a.f. signal is passed by C321 to the a.f. potentiometer chain R328, R329, C325 to chassis. The a.f. signal, whose level is set by RV302, is fed to the grid of the 1st a.f. amplifier V311A via R332, RV303, relay contact RLD1 and R336.

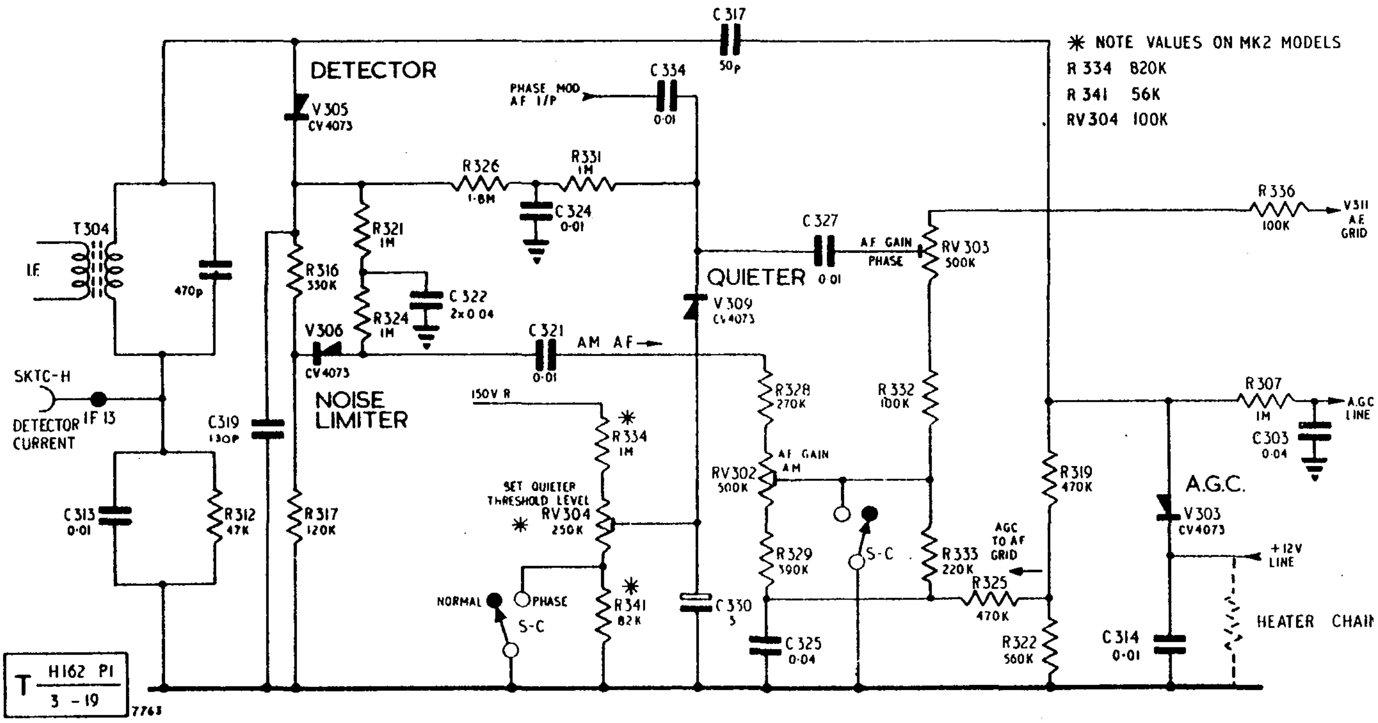


Fig 19 - Detector, noise limiter and quieter circuit

89. Quieter diode V309 cathode is biased proportionally to the carrier level via filter R326, C324, R331. The anode of V309 is set at a positive potentional derived from the chain R334, RV304, R341 across the 150V h.t. supply. RV304 is preset so that, with no signal input, V309 conducts, short-circuiting the a.f. at V311A grid to chassis via C327. V309 is cut off by the increase of positive bias on the cathode on receiving a signal.

Automatic gain control

90. From the secondary of T304 a signal is fed via C317 to a.g.c. diode V303. The diode load is R319, R322 and d.c. return is via the valve heater chain, from which a 12V positive voltage is obtained to delay the a.g.c. action. The negative a.g.c. voltage is fed via R307, C303 (except on calibrate positions) to the r.f. amplifier V107, first mixer V205A, and both 2nd i.f. amplifiers V301, 302. On PHASE, R305 in series with R307 to earth feeds a reduced amount of a.g.c. to V107 and V205 but the feed to V301, V302 is short-circuited by SC2F. A portion of the voltage developed across R322 (part of V303 load) is fed via R325, R333 etc. to the grid of the 1st a.f. amplifier V311A to provide additional gain control.

Limiter and quieter (PHASE)

91. On reception of phase modulated signals SC1B switches the 150V ALL line to feed h.t. to limiter valves V307, 310. A signal is fed from the 2nd i.f. amplifier (T304 pin 4) to the control grid of V307 via C315, C316. At the junction of these two capacitors is V304 (phase modulation quieter). In the no signal condition the diode is conducting due to the positive bias from V308 (V310 screen supply); C320 is, therefore, virtually between the grid of V307 and chassis, short-circuiting any noise input signal. On receiving a signal V304 rectifies the signal, and, due to the large diode load R315, and its sharp 'turn-over' characteristic, the silicon diode cuts off. This isolates C320 and the signal passes to V307.

92. The limiters and discriminator are described in para 63-67. The a.f. output is taken from the mid point of the discriminator, ie the junction of R354, R355. This avoids complicated switching since, for a.f.c. purposes, either side of the discriminator may be earthed. The combination of R354, R355, C350 and R344 provides de-emphasis and the a.f. is passed via C334 to the junction of R331 and quieter V309 cathode. This diode provides additional quieting by the same action as on NORMAL but the threshold level is altered by SC1F shorting R341. Another pole of the same switch connects the slider of RV302 (a.m. gain) to chassis thus short-circuiting any a.m. signal or a.g.c. to the 1st a.f. amplifier grid. The amplitude of demodulated PHASE a.f. fed to the grid of V311A by C327 is controlled by RV303.

A.F. amplifiers and b.f.o.

93. The a.f. amplifiers V311A, V312, are as described for a.f. modulation in sender, relay contact RLD1 switching the required input to the strapped injection and control grids of V311 heptode section (V311A).

94. The triode section of V311 (V311B) is used as a beat frequency oscillator, h.t. being applied, on CW only, by SB1F. To accommodate differing levels of input signal a constant voltage output circuit is used. The b.f.o. circuit is shown in Fig 20. The circuit oscillates at approximately 500kc/s (a front panel control C1 (CW TONE) being fitted for adjustment of tone). Part of the oscillator output is developed across R348 and fed to the suppressor grid and cathode of the second 500kc/s amplifier V312 isolated by R309 from chassis. The beat signal is passed through the detection

and a.f. circuits in the normal manner. The b.f.o. output is also fed by C338 to diode detection circuit V312, R346. A delay voltage is taken from the cathode bias resistor of V311 and, if the b.f.o. output overcomes this delay, a negative controlling voltage will be fed via filter R347, C342 to the oscillator grid. Also applied to the oscillator grid via R323 is a positive d.c. voltage derived from the signal detector V305 cathode. As the signal increases this gives a corresponding increase in b.f.o. output tending to keep the signal and oscillator relative levels constant.

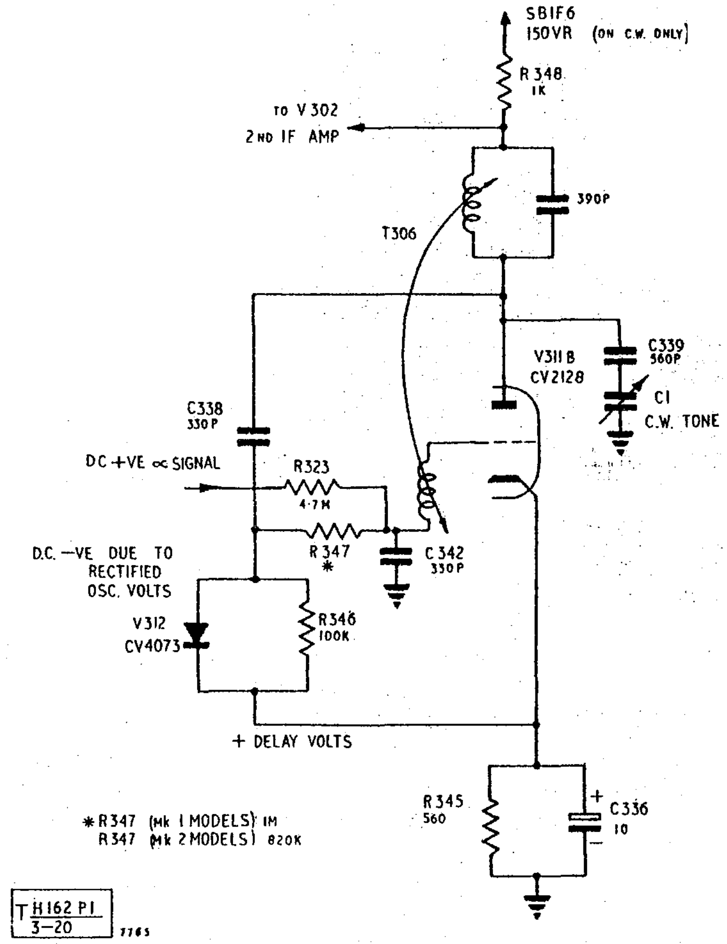


Fig 20 - B.F.O. voltage control circuit

Calibrate
(Fig 2506-7 , 2519a)

95. When SB is at CURSOR ADJUST or CHANNEL ADJUST h.t. is supplied from the 150V R line via SB1F to the calibrator (Fig 2519a). The heaters for the calibrator valves V401, V402, are connected at all times when the p.s.v. switch SC (Fig 2532) is at TRAFFIC. This permits quick checks of calibration while operating. When at STAND BY, however, heaters are switched on only at CURSOR ADJUST and CHANNEL ADJUST.

96. V401 is a 100kc/s crystal oscillator operating in a Pierce-Colpitts circuit between screen and grid. C402 gives slight adjustment of frequency for alignment purposes and the signal, rich in harmonics, is electron-coupled to the anode and fed via C405 to the grid of V402A.

97. At CURSOR ADJUST SB1F connects R409, at the grid of V402B, to chassis so that the valve acts as a normal two stage buffer amplifier, the second stage giving very small gain due to its low grid and anode loads. Harmonics of 100kc/s throughout the h.f. band are fed by C409 and SB4F to the c.w. tap on the r.f. antenna tuned circuit.

98. At CHANNEL ADJUST L401 C408 and C410 are brought into the grid circuit of V402B. These form a tuned circuit resonating at about 10kc/s. Capacitor C406 has an effective impedance of about 2kΩ at 100kc/s but 20kΩ at 10kc/s. Cathode coupling, therefore, exists to V402A, where the coupled signal is amplified and fed back to V402B to maintain oscillations. The exact frequency is governed by the fact that the 10kc/s oscillator tends to lock to an integral multiple of the 100kc/s signal present at its grid and cathode. In practice the required frequency is achieved by altering L401 to give a count down of exactly ten between any two 100kc/s (CURSOR DJUST) points.

99. Accurate signals at multiples of 100kc/s or 10kc/s are thus fed to the r.f. amplifier, through the receiver and limiting stages V307, V310. (These are then supplied from the 150V ALL line via SB4F). The discriminator d.c. output is connected, on calibrate positions, through SD to the centre zero meter. This will give indications at every 100kc/s point, to permit the cursor to be adjusted to the v.f.o. (KC/S) film scale and, on CHANNEL ADJUST, 10kc/s sub divisions of this. As a guide to the operator, the output from the discriminator is switched by SD5F and SD4F so that, at all frequency settings, the CHANNEL control moves in the same direction as the meter needle for the correct setting towards zero.

Intercomm amplifier
(Fig 2517)

100. The intercomm amplifier is identical to that used on the TRC42 (Tels H 442) except for the heater circuit where the valves are series-connected in the case of the C13. R136 also differs in value in the C13 but circuit references are identical.

101. Heaters are independently switched by SD in the p.s.v. and h.t. is derived from the 150V ALL line so that the unit is independent of switching in the set.

Heater circuits

102. The valve heater circuits are arranged in series and parallel and are shown on individual chassis diagram. Fig 2508 and Fig 2509 show a composite heater circuit diagram of TRC13 Mk 1 and Mk 2. The circuit and wiring detail of switch SF fitted to TRC13 Mk 1 ONLY is shown in Fig 2520 and 2521 respectively.

POWER SUPPLY, VIBRATORY, NO 16

BRIEF DESCRIPTION

General

103. The P.S.V. No 16 has been designed as a 24V and a 12V unit. As it is not expected that the 12V version will be brought into service, only the 24V type is therefore described in this regulation.

Construction

104. This p.s.v. is a sealed unit in a desiccated diecast case. The front panel is of cast aluminium and the H-shaped main chassis is composed of several pressed steel sub-chassis rivetted or screwed together. When six Allen screws are removed the front panel hinges on the main chassis giving access to components behind the panel.

Controls etc

105. Fig 21 shows the front panel layout and the main controls etc are listed below:-

POWER OFF/ON	SA	Double-pole toggle switch which connects 24V to the 150V vibrator and the voltage control circuits.
WIRELESS SET OFF/ON	SB	Double-pole toggle switch which connects power to the receiver and calibrator heater supplies.
STAND BY/TRAFFIC	SC	Double-pole toggle switch which connects 24V to VB2, the 600/300V vibrator, on TRAFFIC.
I.C. OFF/ON	SD	Single-pole toggle switch which connects the heater supply to the intercomm amplifier.
BATTERY	PLA	2-pt Mk 4B small plug, orientation 0, used to connect 24V supply.
	SKTA	18-pt Mk 4B large socket, orientation 0, used to connect all supplies to the TRC13.
LT	FS3	10A fuse in heater and relay supply line.
R	FS1	4A fuse in line to VB1 150V.
S	FS2	7A fuse in line to VB2 600/300V.

DETAILED DESCRIPTION

L.T. supplies and voltage control
(Fig 2532)

106. When power is connected to PLA the supply voltage is indicated by M1 via FS3 etc. On switching POWER switch SA to ON the supply is available so that, when SB is closed, l.t. is supplied by dropping resistors to the 19V receive heater line (SKTA-J) and to the calibrator heaters (SKTA-R). When SC is closed the sender heaters are supplied through SKTA-L and the calibrators via SKTA-S (see para 95).

107. Also brought into circuit by SA is the voltage control circuit. RLD is the close-margin relay which will operate if the input rises above 25.5V de-energizing (by RLD1) the slave relays RLA, RLB, RLC. RLA, RLB change taps on vibrator transformers T1 and T2 while RLC inserts R12, R14, R21 and R27 in series with the respective heater lines. If the input then falls to 23.5V, RLD releases and the slave relays are again energized.

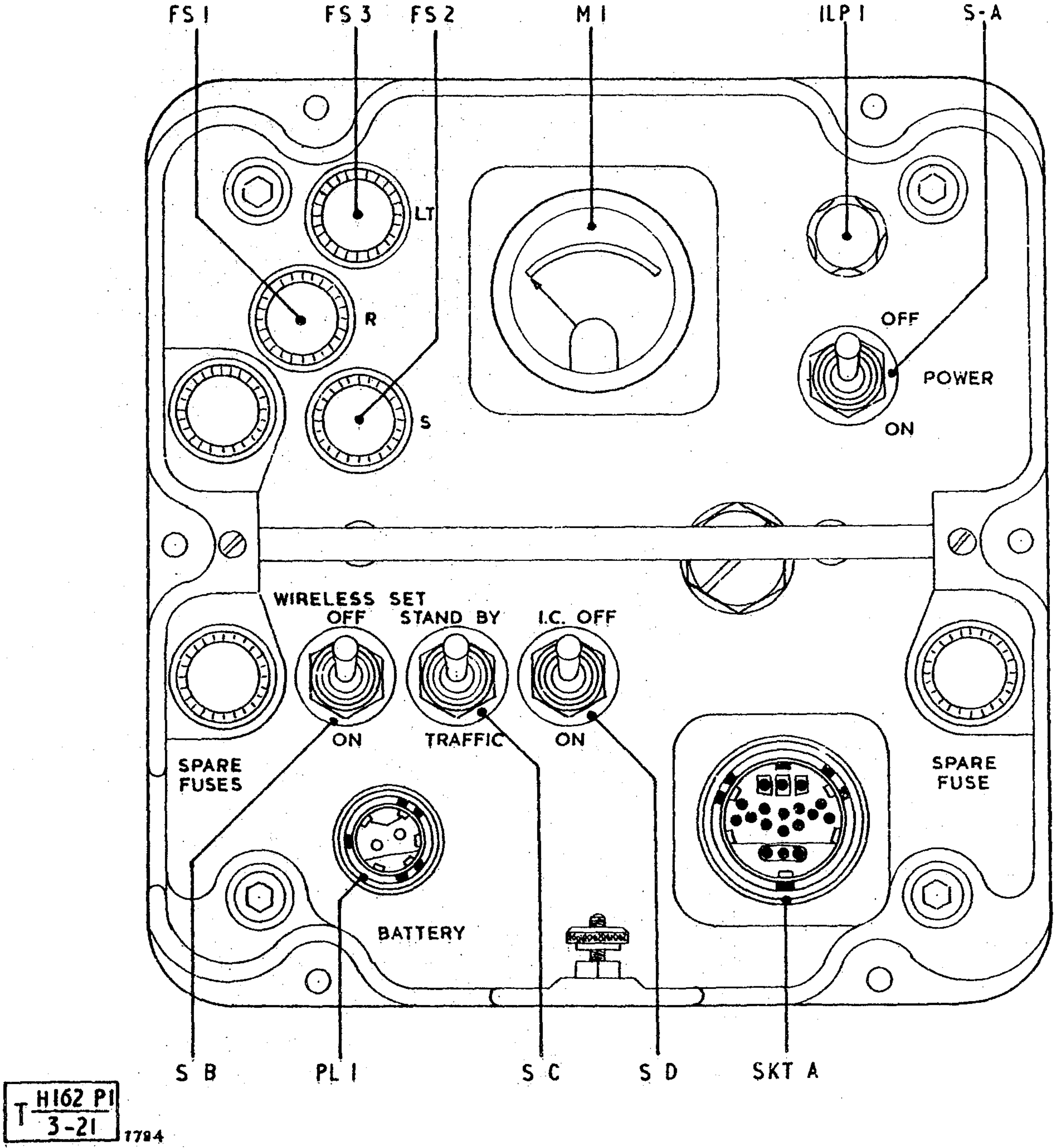


Fig 21 - P.S.V. No 16 front panel controls

H.T. supplies

108. The common h.t. supply for receive, intercomm amplifier and part of send is the 150V derived from VB1. This is brought into circuit immediately POWER switch SA is closed so allowing a choice of radio set or intercomm by SB or SD respectively without interlocking h.t. switching. At WIRELESS SET ON, however, SB short-circuits the series resistor R29 from the h.t. feed to SKTA-C since the drain is greater on this condition than on intercomm. L1 prevents r.f. interference being fed back to battery load and L5, C5 smooth any ripple on the input. The input is fed to VB1, which is a normal parallel-fed self-rectifying type of vibrator. R3, C10 form a

spark quench circuit which, with the 'Hash' filtering, is fitted in a suppressor box (shown in two sections for convenience).

109. These suppressor circuits consist of combinations of ferrite beads forming L6, L7 etc. and associated capacitors C6, C7 etc. (The beads are shown with inductor symbols since they are effectively r.f. chokes as opposed to those shown as FB which are normally purely antiparasitic devices). The feed to T1 primary is made through RLA3 and RLA4 on the high voltage condition (see RLD action) and via contacts RLA1 and RLA2 on low voltage. RLA3, RLA4 break early inserting R17, R18 to reduce the surge due to short-circuiting part of the winding, while R15, C45 form a spark quench on RLA1, RLA2 contacts. The vibrator rectifying contacts are spark quenched by R5, C20; R7, C18 and the output of the secondary is connected in a voltage doubling circuit across C47, C48 to chassis. The output is then fed by a.f. and r.f. filters to the output socket.

110. When SC is closed the 24V is applied to VB2, which is connected and suppressed in a similar manner to VB1 and has an identical voltage control circuit operated by RLB. T2 has, however, a higher step-up ratio and the output available is 300V across the doubler capacitors C49, C51 or 150V across C51 only to chassis. R25, R26 stabilize and ensure equal division of the voltages. When relay RLF is energized by the earthing of SKTA-Q in the C13, ie high power (HP) conditions, RLF1 increases T1 step-up ratio and the available outputs are 600V and 300V.

111. The outputs of VB2 are used to supply the p.a. stage of the TRC13 and are, therefore, only required on send conditions. The 300/150V line is, therefore, connected to SKTA-A via contact 2 of the relay RLE which is energized on send by earthing SKTA-N via C13 system switch or pressel key. It is impracticable to switch the 600V line due to arcing problems. To reduce surges in the primary on switching from send to receive RLE1 inserts resistor R2. Similarly when RLF is released, surges fed back from the charged capacitors are reduced by RLF1 bringing R31 into circuit.

TUNER, RADIO, FREQUENCY, NO 11

General

112. The T.R.F. No 11 is a sealed unit designed to match the sender 70Ω output impedance to the following antennae:-

a. 8 ft rod from 1.6-12Mc/s.

b. 12 ft rod from 1.5-12Mc/s.

c. 16 ft rod from 1.5-11.2Mc/s.

d. End fed wire antennae less than λ/4 or slightly less than 3λ/4.

113. For para 112.a., b. and c. the connector from the antenna base to the T.R.F. No 11 must be less than 18 in. Connection from the TRC13 to the t.r.f. can be made in two ways:-

a. 70Ω cable terminated in a 390pF capacitor when used with local antenna.

b. A length of standard 70Ω coaxial cable to the t.r.f. fitted on a special base (antenna base and coupling unit assemblies). This unit includes an antenna base and a remote antenna adaptor (Fig 2537) which is fitted with a meter and variable matching capacitor. This method of connection is used when the antenna is remote from the set.

114. The 390pF capacitor used in para 113.a. simulates the added capacitance due to the longer coaxial lead in para 113.b.

Technical description

115. The input to the T.R.F. No 11 is coupled via PLA across which is a range of matching capacitors C1-C4 switched into circuit by SA. This switch is ganged to SB, and to a drive which continuously varies the iron dust cores of a series of coils. On selecting a particular capacitor (say C4) by SA1B, SA2B and ceramic switch SB1B select L2 whilst SA2F and SB1B short-circuit and connect to chassis the unwanted coils L3-L7.

116. On rotating the control knob anticlockwise the core of L2 is moved into the coil and partly out before the switch cam rotates SA and SB to select the next capacitor, C3 and coil L3. This sequence repeats giving complete coverage over the band in six switched steps and permeability variation to cover the tuning between the steps. The switch positions are shown, through a window on the front panel, by a lettered disc (A-E) and the core position by a second disc numbered 1-11.

117. Tuning indication is electrically achieved by passing the lead to the series inductor through a toroidal wound coil T1, rectifying the voltage across T1 secondary, and feeding the d.c. back to the C13 panel meter (see Fig 2535). When used remotely this d.c. is fed to the meter on the remote antenna adaptor unit. L1 prevents bypass of the r.f. into the meter circuit. C6 stops the metering d.c. being short-circuited to chassis by the inductors and also prevents any voltages being fed back into the C13 should the antenna touch power lines or other voltage sources.

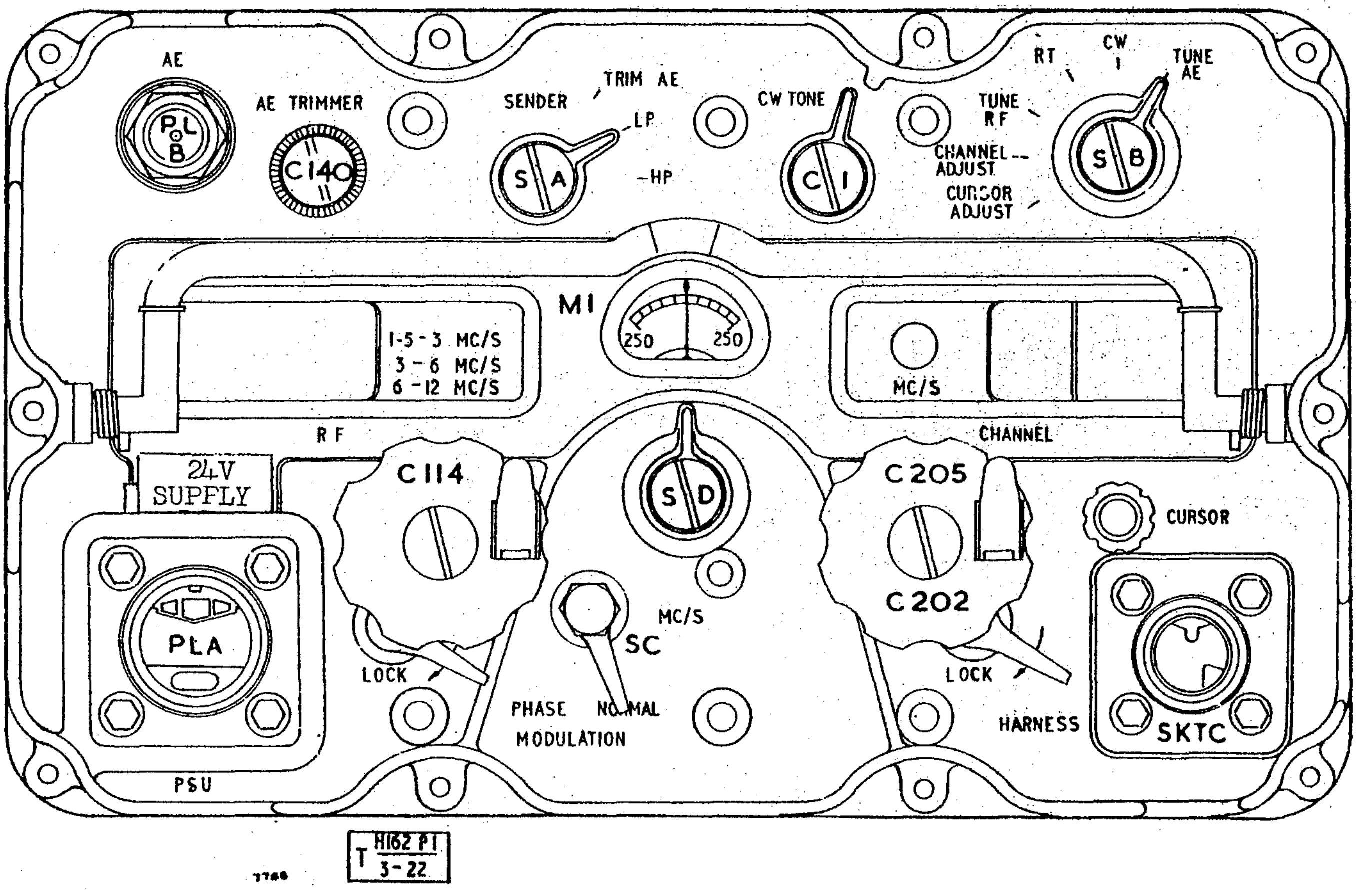
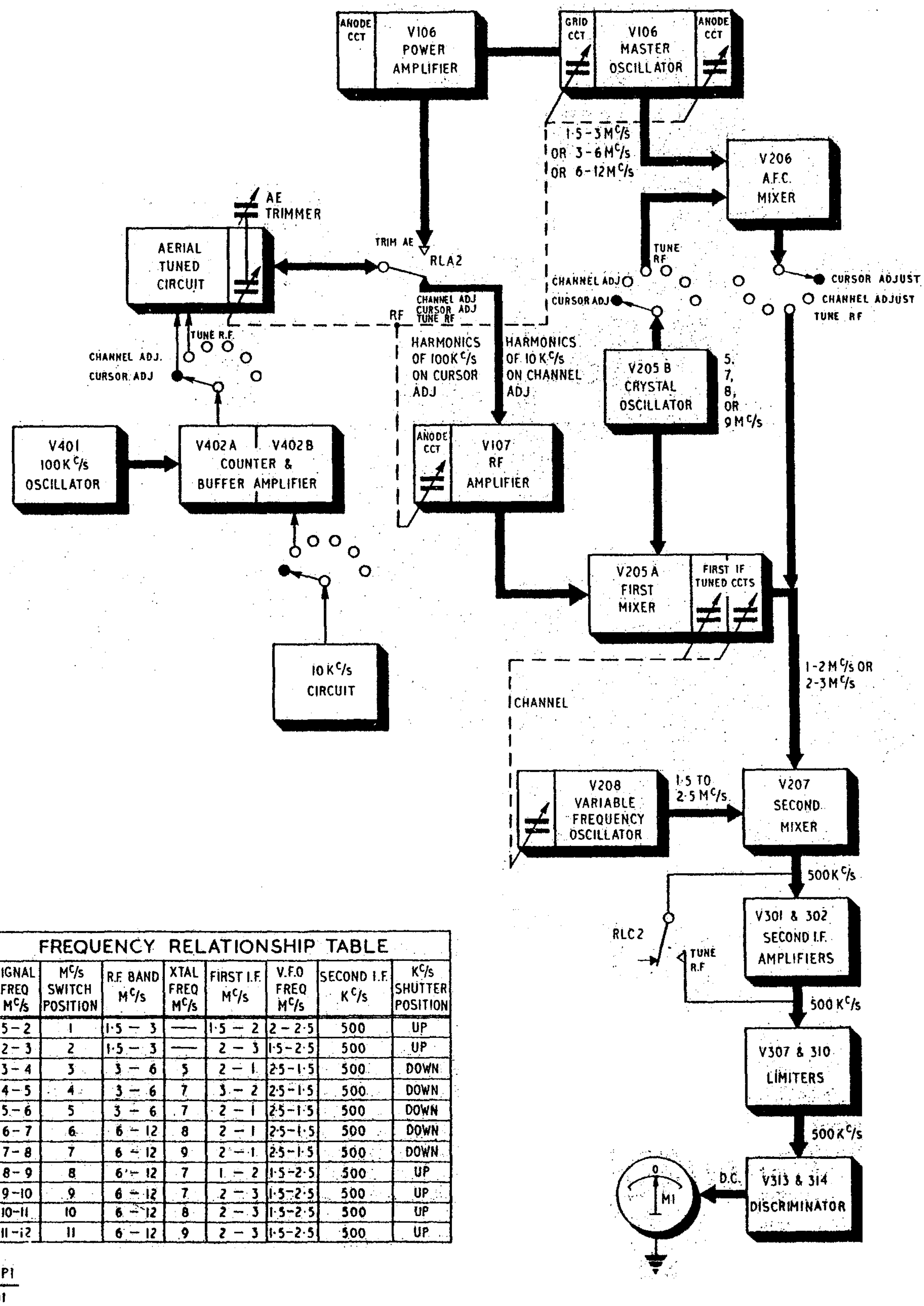


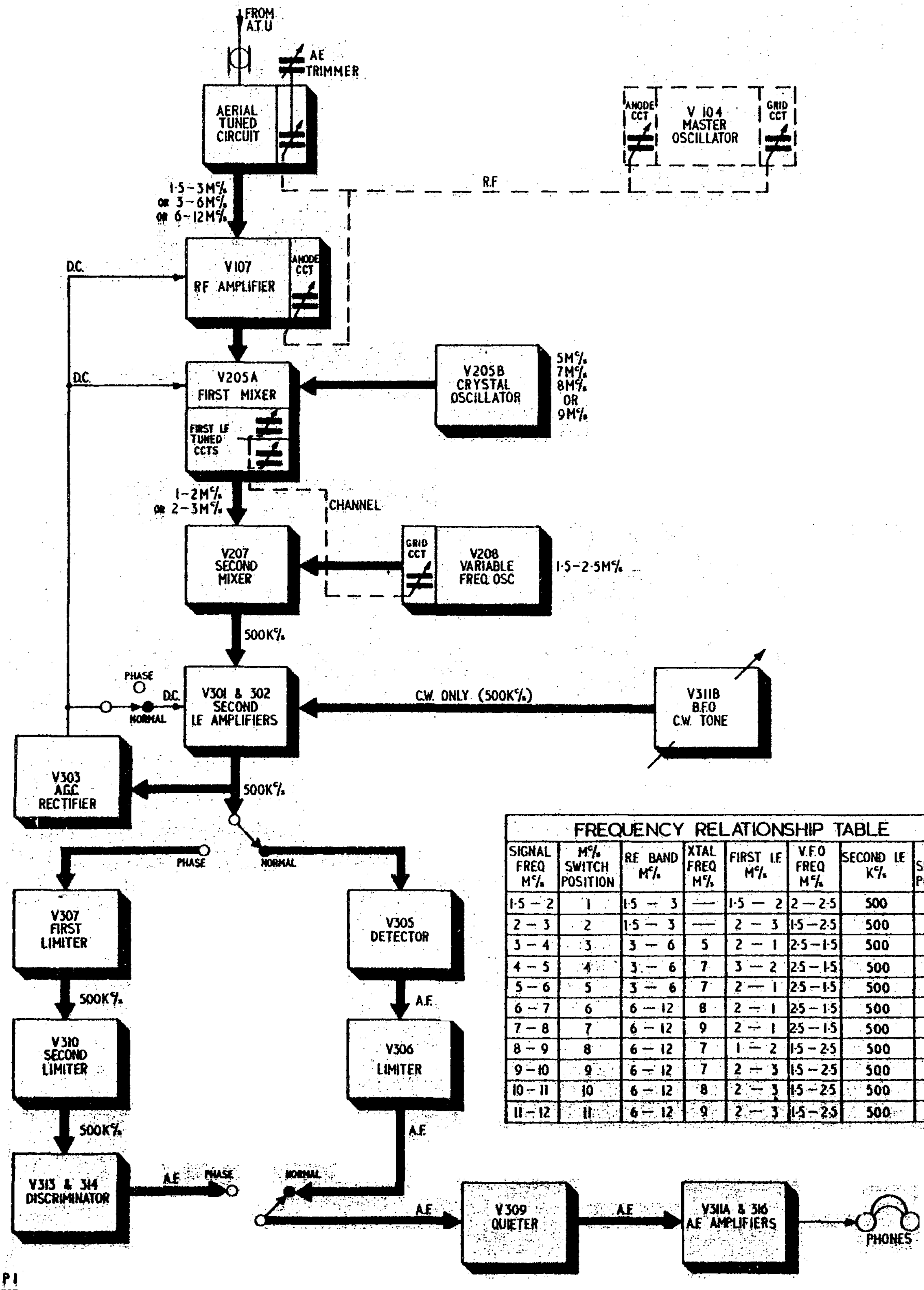
Fig 22 - Front panel controls etc (TRC13 Mk 2)

Note: The next page is Page 1001



FREQUENCY RELATIONSHIP TABLE							
SIGNAL FREQ Mc/s	Mc/s SWITCH POSITION	R.F. BAND Mc/s	XTAL FREQ Mc/s	FIRST I.F. Mc/s	V.F.O FREQ Mc/s	SECOND I.F. Kc/s	Kc/s SHUTTER POSITION
1·5 – 2	1	1·5 – 3	—	1·5 – 2	2 – 2·5	500	UP
2 – 3	2	1·5 – 3	—	2 – 3	1·5 – 2·5	500	UP
3 – 4	3	3 – 6	5	2 – 1	2·5 – 1·5	500	DOWN
4 – 5	4	3 – 6	7	3 – 2	2·5 – 1·5	500	DOWN
5 – 6	5	3 – 6	7	2 – 1	2·5 – 1·5	500	DOWN
6 – 7	6	6 – 12	8	2 – 1	2·5 – 1·5	500	DOWN
7 – 8	7	6 – 12	9	2 – 1	2·5 – 1·5	500	DOWN
8 – 9	8	6 – 12	7	1 – 2	1·5 – 2·5	500	UP
9 – 10	9	6 – 12	7	2 – 3	1·5 – 2·5	500	UP
10 – 11	10	6 – 12	8	2 – 3	1·5 – 2·5	500	UP
11 – 12	11	6 – 12	9	2 – 3	1·5 – 2·5	500	UP

Fig 2001 – Calibrate block diagram



FREQUENCY RELATIONSHIP TABLE							
SIGNAL FREQ Mc/s	Mc/s SWITCH POSITION	R.F. BAND Mc/s	XTAL FREQ Mc/s	FIRST I.F. Mc/s	V.F.O FREQ Mc/s	SECOND I.F. Kc/s	Kc/s SHUTTER POSITION
1·5 — 2	1	1·5 — 3	—	1·5 — 2	2 — 2·5	500	UP
2 — 3	2	1·5 — 3	—	2 — 3	1·5 — 2·5	500	UP
3 — 4	3	3 — 6	5	2 — 1	2·5 — 1·5	500	DOWN
4 — 5	4	3 — 6	7	3 — 2	2·5 — 1·5	500	DOWN
5 — 6	5	3 — 6	7	2 — 1	2·5 — 1·5	500	DOWN
6 — 7	6	6 — 12	8	2 — 1	2·5 — 1·5	500	DOWN
7 — 8	7	6 — 12	9	2 — 1	2·5 — 1·5	500	DOWN
8 — 9	8	6 — 12	7	1 — 2	1·5 — 2·5	500	UP
9 — 10	9	6 — 12	7	2 — 3	1·5 — 2·5	500	UP
10 — 11	10	6 — 12	8	2 — 3	1·5 — 2·5	500	UP
11 — 12	11	6 — 12	9	2 — 3	1·5 — 2·5	500	UP

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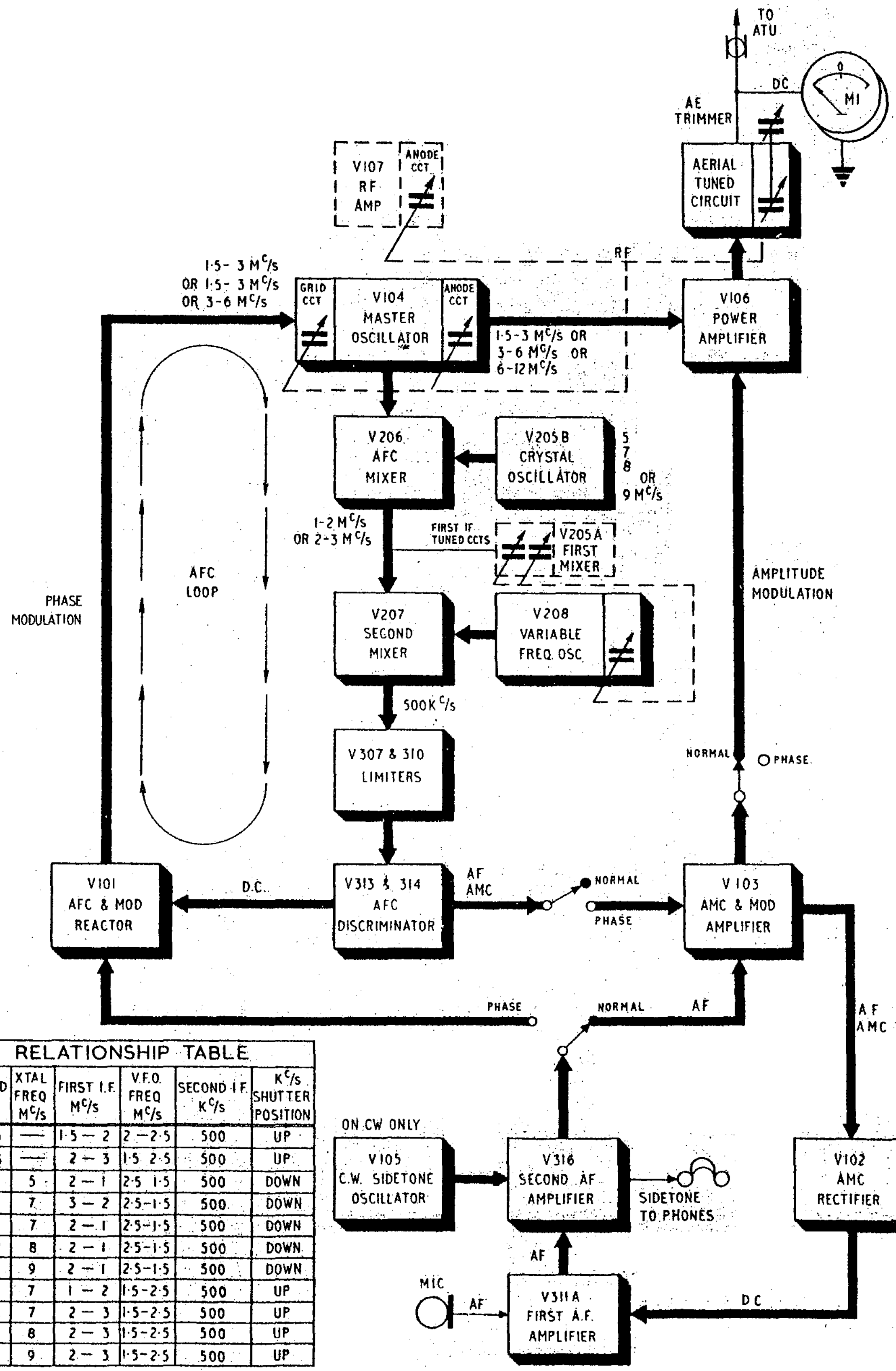
Fig 2002 - Receive block diagram



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FREQUENCY RELATIONSHIP TABLE

SIGNAL FREQ Mc/s	Mc/s SWITCH POSITION	R.F. BAND	XTAL FREQ Mc/s	FIRST I.F. Mc/s	V.F.O. FREQ Mc/s	SECOND I.F. Kc/s	Kc/s SHUTTER POSITION
1·5 – 2	1	1·5 – 3	—	1·5 – 2	2 – 2·5	500	UP
2 – 3	2	1·5 – 3	—	2 – 3	1·5 2·5	500	UP
3 – 4	3	3 – 6	5	2 – 1	2·5 1·5	500	DOWN
4 – 5	4	3 – 6	7	3 – 2	2·5 – 1·5	500	DOWN
5 – 6	5	3 – 6	7	2 – 1	2·5 – 1·5	500	DOWN
6 – 7	6	6 – 12	8	2 – 1	2·5 – 1·5	500	DOWN
7 – 8	7	6 – 12	9	2 – 1	2·5 – 1·5	500	DOWN
8 – 9	8	6 – 12	7	1 – 2	1·5 – 2·5	500	UP
9 – 10	9	6 – 12	7	2 – 3	1·5 – 2·5	500	UP
10 – 11	10	6 12	8	2 – 3	1·5 – 2·5	500	UP
11 – 12	11	6 – 12	9	2 – 3	1·5 – 2·5	500	UP

Fig 2003 – Transmit block diagram