SECTION 5

F.M. RECEIVER HR/12

Introduction

This f.m. receiver is used in conjunction with the Storno transmitter Type BQP45 at outside broadcasts in order to provide a high-quality radio link between a commentator's microphone and a base point. The transmitter is carried by the commentator and the HR/12 is situated at the base point. The receiver can be pre-set to any frequency in the range 87·5 to 94·5 Mc/s; the output from the receivers is at low volume (— 70 dB approximately) so that it is suitable for feeding into OBA/9 equipment without additional attenuators. A monitor output jack is fitted which provides an output used for pre-fade listening.

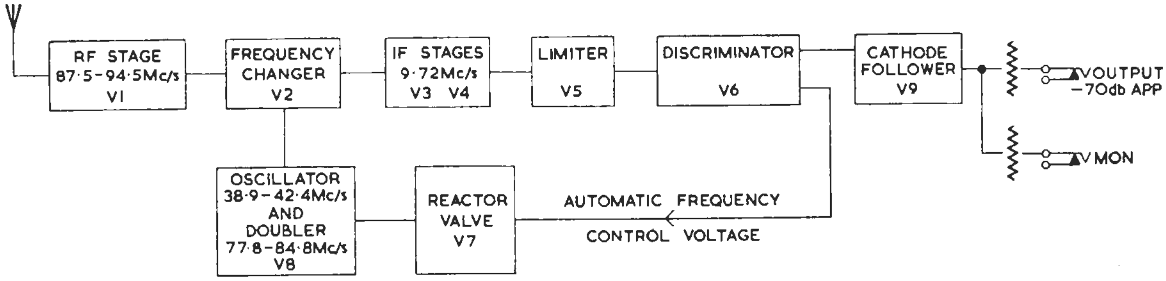

Fig. 5.1. Receiver HR/12: Block Schematic Diagram

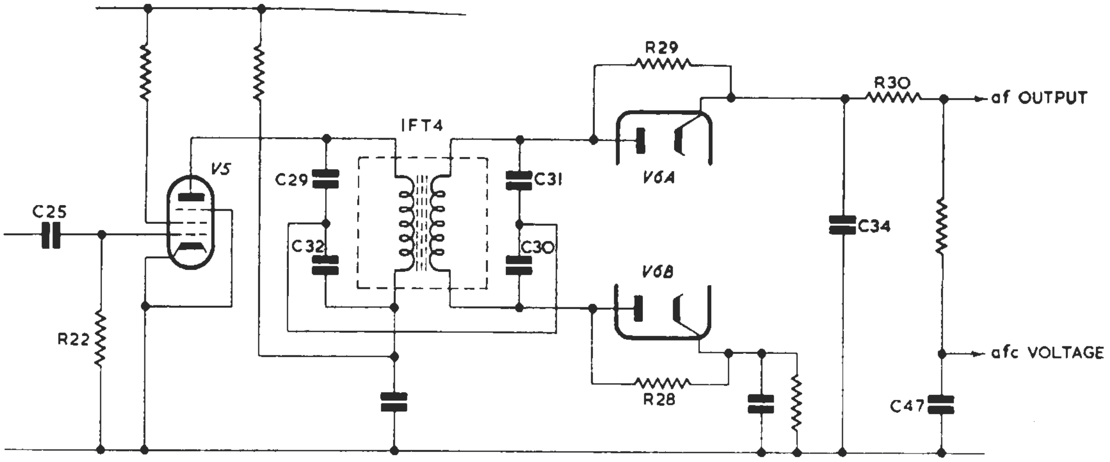

Fig. 5.2. Receiver HR/12; Simplified Circuit Diagram of Limiter and Discriminator Stages

General Description

This receiver comprises a modified r.f. chassis of an E.M.I.-type 1250 receiver, crystal-controlled calibration oscillator OS/12 and a Mains Unit MU/42. These are mounted in a case fitted with carrying handles and enclosed by a perforated cover. The mains unit supplies power to both receiver and the calibration oscillator, and works from 200-250 V 50-c/s mains or batteries. The

Circuit Description

R.F. Chassis

A circuit diagram of this unit is shown in Fig. 14 and a block schematic diagram in Fig. 5.1. The r.f. stage (V1) and oscillator-doubler stage (V8) outputs are coupled to the frequency changer V2 by π-section network; the i.f. stages (V3 and V4) are of conventional design; the i.f. frequency is 9·72 Mc/s.

A simplified diagram of the limiter and discriminator is shown in Fig. 5.2. V5, the limiter stage, is operated with a low screen potential, and is self-biased by the action of C25 and R22. With a fairly strong signal (greater than 2 V at the grid of V5) the valve is operating in Class C, and under these conditions, variations of input-signal amplitude produce only very small variations of signal amplitude in the anode circuit.

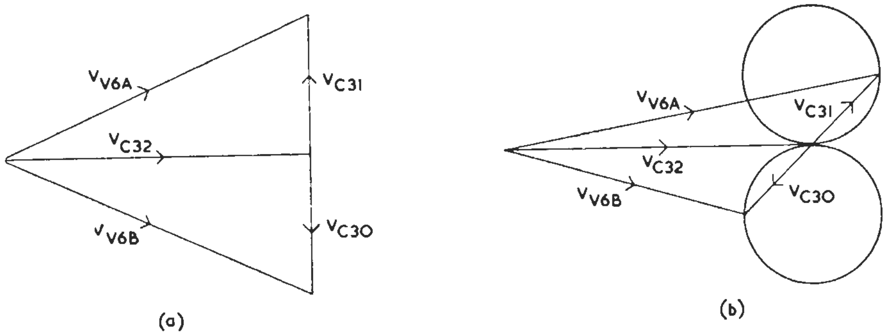

Fig. 5.3. Receiver HR/12: Discriminator Vector Diagrams

The voltages developed across capacitors C30 and C31 (referred to their junction) are equal in magnitude but 180° out-of-phase and, when the applied signal is at the frequency at which the primary and secondary of the transformer IFT4 are resonant, each is 90° out-of-phase with voltage developed across C32. This is because at resonance the voltage developed across the primary winding of the transformer is in quadrature with the voltage developed across the secondary. These relationships are shown by the vector diagram in Fig. 5.3. The voltage applied to the diode V6A is the vector sum of the voltages across C32 and C31. The voltage applied to divide V6B is similarly the vector sum of the voltages across C32 and C30. These voltages are equal in magnitude when the applied signal is at the resonant frequency of the transformer; equal and opposite voltages are then developed across R28 and R29 and there is no output signal developed across C34. When the incoming signal is not at the resonant frequency of the transformer the primary and secondary voltages are no longer in quadrature and the voltages applied to V6A and V6B are not equal in magnitude (see Fig. 5.3). There is now an output signal developed, the amplitude of which is proportional to the deviation of the signal from the transformer resonant frequency over a wide range. This is shown in Fig. 5.4. Thus when a f.m. signal is received, an a.f. output will be developed across C34, and applied to the grid of V9. R30, R40 and C74 provide de-emphasis.

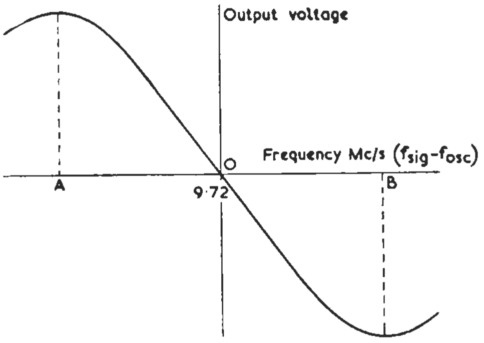

Fig. 5.4. Receiver HR/12: Discriminator Input/Output Characteristic

If the unmodulated frequency of the incoming signal, or the frequency of the receiver oscillator alters, the mean voltage developed across C34 is no longer zero, and a steady voltage is developed across C47 which is proportional to the difference of the unmodulated frequency of the signal applied to the discriminator from the resonant frequency of the transformer IFT4. This voltage is applied through R36 and R32 to the grid of the reactance valve V7 (see Fig. 5.5). V7 behaves as an inductor; its action is explained below.

The anode of V7 is coupled by C40 to the oscillatory circuit L14, C43 associated with V8, the cathode, control grid and screen grid of which form part of a Hartley shunt-fed oscillator. A portion of this oscillatory voltage is fed back by C38 and R31 to the grid of V7. The impedance from the grid of V7 to earth is predominantly capacitive (input capacitance of V7), the actual magnitude of the impedance being much less than that of R31 and R32. The voltage at the grid thus leads the voltage at the anode by approximately

90° and this voltage gives rise to an alternating component of anode current, also leading the anode voltage by approximately 90°.

When the bias applied to the valve alters, the mutual conductance also varies, altering the magnitude of the alternating component of the anode current, and thus the effective inductance of the valve. Thus when the frequency of the unmodulated i.f. signal derived from the incoming signal departs from the resonant frequency of IFT4, the local oscillator is re-tuned so as to reduce the frequency difference.

Consider the initial conditions when a signal is received. If the frequency of the unmodulated signal differs from the frequency of alignment by less than 100 kc/s (approximately), the resultant i.f. signal will fall within the working range of the discriminator, and a control voltage will be developed which will re-tune the local oscillator, so that the i.f. signal frequency will be brought nearer to the centre frequency of 9·72 Mc/s. The automatic frequency-control circuit can only reduce, and not cancel, the magnitude of the tuning error; for if the tuning error were reduced to zero, there would be no control voltage developed to re-tune the local oscillator.

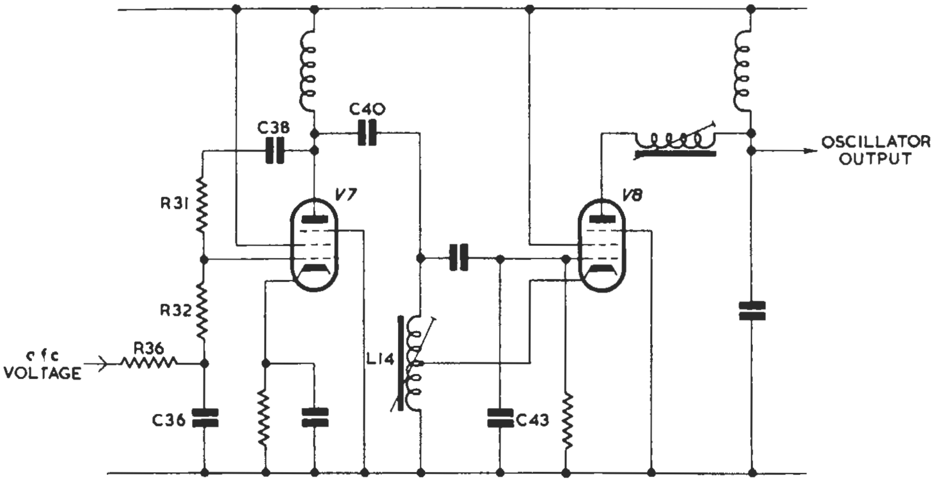

Fig. 5.5. Receiver HR/12: Simplified Circuit Diagram of Reactance Valve and Oscillator

If the signal fulfils the initial conditions (i.e., is within approximately 100 kc/s of the frequency of alignment) the automatic frequency control circuit will then compensate for frequency drift in the incoming signal or the local oscillator over a range of the order of ± 200 kc/s from the the frequency of alignment.

The maximum frequency drift which can be corrected is set by the maximum output from the discriminator; this occurs when the signal frequency at the discriminator is equal to OA or OB (Fig. 5.4) when the i.f. signal frequency is in the region of 100 kc/s off tune, and the total drift in the incoming signal and local oscillator is then about 200 kc/s. Further drift of the signal frequency, or local-oscillator frequency, increases the amount by which the i.f. signal is off tune and so reduces the control voltage, which in turn alters the oscillator frequency in a manner tending to increase the change. The receiver then goes rapidly off tune. However, before this stage is reached, distortion occurs, since the discriminator is working on the non-linear portion of the characteristic.

The local oscillator V8 is so arranged that the cathode, control grid and screen grid are coupled in a shunt-fed Hartley oscillator; the anode circuit is tuned to accept the second harmonic of the oscillator fundamental frequency.

To assist in the alignment of the receiver oscillator, and to provide a check on the degree of mis-tuning in the received signal, provision has been made for monitoring the anode current of the reactance valve V7 by means of a 0-3 mA meter. The departure of the meter reading from its quiescent value (approximately mid-scale) gives an indication of the degree of mis-tuning.

Crystal Oscillator OS/12

This oscillator is a calibration unit used in checking the alignment of the receiver unit and the unmodulated frequency of the Storno transmitter. It is mounted on a small sub-chassis in the HR/12 case, and derives its h.t. and l.t. supplies from the Mains Unit MU/42.

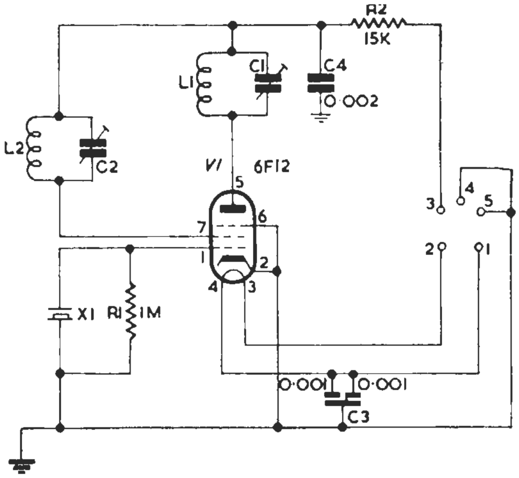

Fig. 5.6. OS/12; Circuit Diagram (Socket Connections Viewed from Back of Pins)

A circuit diagram of the oscillator is shown in Fig. 5.6. The tuned circuit L2, C2 is resonant at the fundamental frequency of the crystal X1, whilst the tuned circuit L1, C1 is resonant at the fifth harmonic; the crystal is chosen so that the anode circuit is resonant at the operating frequency of the Storno transmitter. There are no connections between the oscillator and the receiver; if the receiver is correctly aligned, and has no aerial connected, there is sufficient fortuitious pick-up to suppress the receiver noise. The receiver tuning may be checked by observing the anode current of V7, by means of the meter. (See Fig. 14.) The departure of its reading from the quiescent value gives an indication of the degree of mis-tuning.

Mains Unit MU/42

This mains unit supplies h.t. and l.t. for the receiver unit and the calibration oscillator OS/12 from 200-250 volt 50-c/s mains or from 250-volt h.t. and 6-volt l.t. batteris. It is of conventional design, its circuit diagram being given in Fig. 5.7. A switch is included in the h.t. lead to the calibration oscillator, so that this latter unit may be switched to a standby condition when not in use.

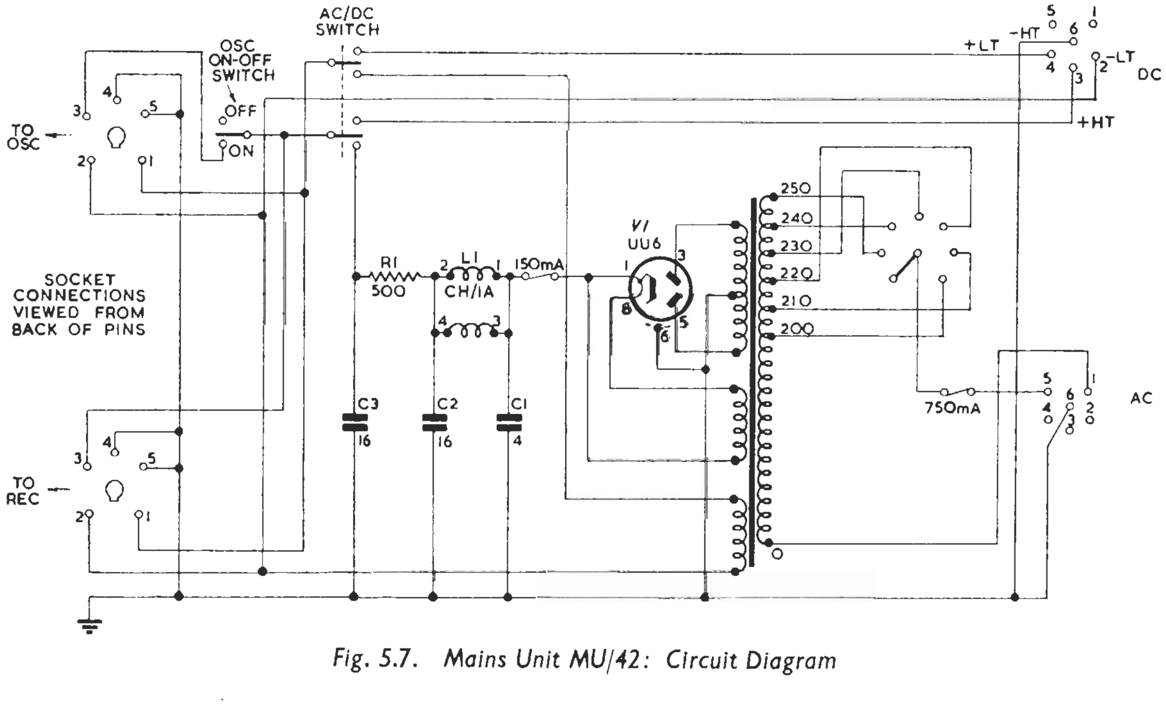

Fig. 5.7. Mains Unit MU/42: Circuit Diagram

The mains and battery inputs are applied through 6-point plugs and sockets.

A diagram of the face panel of the unit is shown in Fig. 5.8.

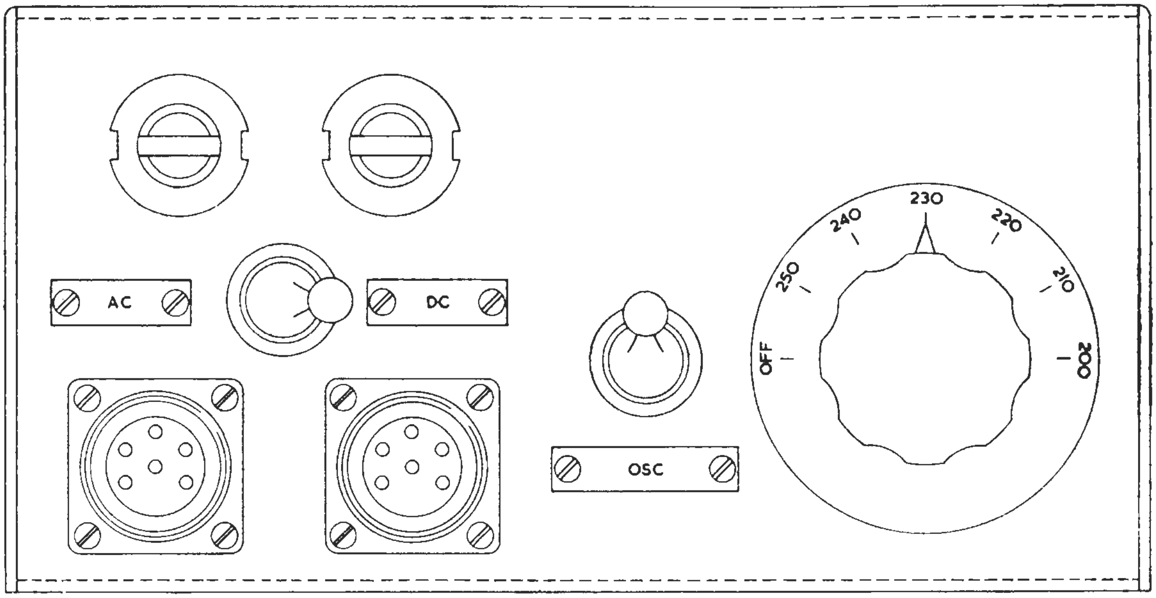

Fig. 5.8. Mains Unit MU/42: Front Panel

Operating Instructions

1. Check that the a.c./d.c. switch on the front panel of the MU/42 is at the correct position.
2. If the equipment is operating from a.c. mains, set the mains-adjusting switch on the MU/42 to the tapping nearest to the measured mains voltage.
3. Switch on the HR/12 and allow a period of at least 10 minutes for it to warm up.

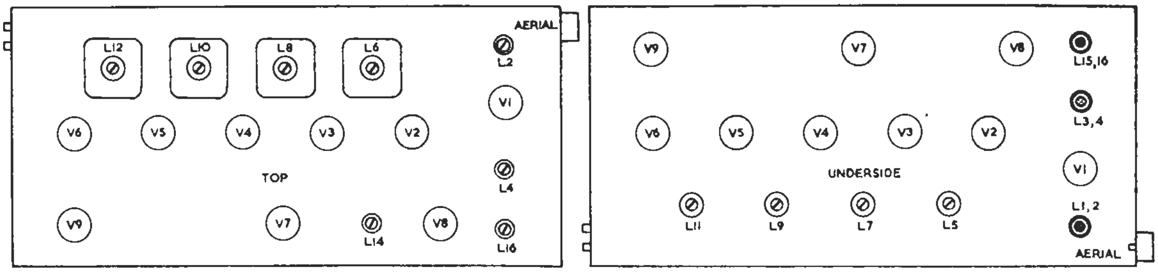

Fig. 5.9. HR/12 Component Layout

4. Check that the HR/12 is tuned to the correct frequency in the following manner:
   - 4.1. Disconnect the aerial at the aerial socket and insert the test-meter plug in the socket on the chassis. Note the meter reading with no input signal present. It should be in the region of 1·0 to 1·5 mA. This is the quiescent value of the anode current of V7.
   - 4.2. Switch on the calibrating oscillator OS/12. If the HR/12 is correctly aligned, the test-meter reading should not change and the receiver noise should be muted. No physical connection between the oscillator and receiver is necessary as there is adequate fortuitous pickup.

     If the HR/12 is slightly off-tune there will be a deflection of the meter but the receiver noise will still be suppressed when the oscillator is switched on. If the receiver HR/12 is considerably off-tune, there will be no appreciable meter deflection and no noise suppression when the oscillator is switched on. In either case the receiver must be retuned. This is achieved by adjustment of L14 (HR/12 oscillator frequency). The position of L14 core is shown in Fig. 5.9.

4.3. To retune the HR/12, adjust L14 core, with the OS/12 on, to give the quiescent value of meter reading noted in 4.1.

There are a number of settings of L14 which give the required value of anode current but the correct setting can be identified by noting how the meter reading varies when L14 is adjusted. At the correct setting, rotation of L14 core in one direction (e.g. clockwise) causes the meter reading to rise above the quiescent value and rotation of the core in the reverse direction (i.e. anti-clockwise) causes the meter reading to fall below the quiescent value. When the correct setting of L14 has been identified, set L14 accurately to give the quiescent reading.

4.4. Switch off the OS/12 and re-connect the aerial.

With the Storno transmitter switched on, check that the meter still gives the quiescent reading and that rotation of L14 core gives meter deflections above and below the quiescent value as under 4.3.

If the meter reading alters when the Storno transmitter is switched on this suggests that the transmitter frequency is not equal to that of the OS/12 and adjustment of the transmitter is required.

Alignment

Equipment required includes a signal generator covering range 9-10 Mc/s, and a valve voltmeter of very high input impedance, or d.c. meters reading 0-2 mA and 0-10 mA (see Alternative Alignment Procedure). The positions of the major components in the receiver are shown in Fig. 5.9.

(a) *I.F. Alignment*

(1) Connect the valve voltmeter to test point ' A ' (—) and chassis (+). Remove V8.

(2) Inject an unmodulated signal at 9·72 Mc/s, via a 0·001-μF capacitor, between the grid (pin 1) of V3 and chassis.

(3) Adjust cores of L10, L9, L8, L7 in that order for maximum output.

(4) Inject an unmodulated signal at 9·72 Mc/s, via a 0·001-μF capacitor, between the grid (pin 1) of V2 and chassis.

(5) Adjust cores of L6, L5 in that order for maximum output.

(6) Repeat operations 2 to 5, until no further improvement is obtained. Replace V8.

Note: It is advisable to adjust discriminator circuit after carrying out i.f. alignment, without changing generator frequency.

(b) *Discriminator Alignment*

(1) Connect the voltmeter to test point ' B ' (—) and chassis (+). Remove V7 and V8.

(2) Inject an umodulated signal at 9·72 Mc/s, via a 0·001-μF capacitor, into the grid (pin 1) of V2 and chassis. Adjust generator output to 10 mV.

(3) Adjust core of L11 for maximum output.

(4) Connect valve voltmeter to junction of R32 and R36 (—) and chassis (+).

(5) Adjust core of L12 for zero output.

(6) Repeat twice operations 1 to 5. If the discriminator is aligned correctly, an increase in the injected signal frequency from the signal generator will produce positive a.f.c. correcting voltage, shown by a reading below zero on the valve voltmeter.

(7) Replace V7 and V8.

(c) *Oscillator and R.F. Alignment*

(1) Short-circuit C36 (grid circuit of V7).

(2) Connect the voltmeter to test point ' A ' (—) and chassis (+).

(3) Inject a signal at the operating frequency at the aerial socket, or switch on the oscillator OS/12.

(4) Fully unscrew core of L14.

(5) Screw in core of L14 for maximum output (screw in to the second tuning point).

(6) Adjust cores of L4, L16, L2 in that order for maximum output.

(7) Repeat operations (5) and (6) until no further improvement can be obtained.

(8) Remove a.f.c. shorting link from C36.

Alternative Alignment Procedure

The alignment above requires the use of a high input impedance valve voltmeter, but the following instructions enable alignment to be carried out without this instrument, when necessary.

(a) *I.F. Alignment*

(1) Remove V7 and V8.

(2) Connect a 0-2 mA d.c. meter across R25 (anode circuit of V5).

(3) Inject a C.W. signal of 9·72 Mc/s through a 0·001-μF capacitor into grid of V3 and chassis.
(4) Adjust signal input until meter reads 1·8 mA.
(5) Adjust cores of L10, 9, 8 and 7 for minimum meter reading keeping signal input adjusted so that meter never reads less than 1·7 mA.
(6) Inject a C.W. signal of 9·72 Mc/s through a 0·001-μF capacitor into grid of V2 and chassis. (Connect to chassis at V2 suppressor to avoid instability.)
(7) Adjust signal input until meter reads 1·8 mA.
(8) Adjust cores of L10, 9, 8, 7, 6 and 5 in that order for minimum meter reading, keeping signal input adjusted so that meter never reads less than 1·7 mA.
(9) Replace V7 and V8.

(b) *Discriminator Alignment*

(1) With V7 and V8 removed, connect a 0-10 mA d.c. meter in the anode circuit of V9.
(2) Fully unscrew core of L12.
(2) Inject a strong signal of 9·72 Mc/s through a 0·001-μF capacitor, into grid of V2 and chassis. (Connect to chassis at V2 suppressor to avoid instability.)
(4) Adjust core of L11 for minimum meter reading.
(5) Short grid of V5 to chassis and note meter reading.
(6) Remove short from V5 grid.
(7) Screw in core of L12 so that meter goes through a minimum and back up to reading obtained in operation (5).
(8) Adjust L12 very carefully so that meter reads the same with V5 grid shorted or not shorted to chassis. If the discriminator is aligned correctly, an increase in the inject signal frequency from the signal generator will produce positive a.f.c. correcting voltage, shown by an increase in the reading on the meter.
(9) Replace V7 and V8.

(c) *Oscillator and R.F. Alignment*

(1) Short-circuit C36 (grid circuit of V7).
(2) Connect a 0-2 mA d.c. meter across R25 (anode circuit of V5).
(3) Inject a signal at the operating frequency at the aerial socket, or switch on the oscillator OS/12.
(4) Fully unscrew core of L14.
(5) Screw in core of L14 for maximum ‘ dip ’ in meter. (Screw in to the second tuning point.)
(6) Adjust cores of L14, L16 and L2 in that order for minimum meter reading.
(7) Repeat operations (5) and (6) until no further improvement can be obtained.
(8) Remove shorting link from C36.

HR/12

Supply: 200-250 V, 50 c/s or 250 V and 6 V batteries.

R.F. Chassis

Impedances:

Aerial input	50 ohms
Audio output	600 ohms

Output volume — 70 dB (approximately).
Sensitivity: 100 μV at aerial terminal for limiter saturation (2 V at grid of V5).
Total current: L.T. 2·7 A, H.T. 80 mA approx.

Valves

V1-V5, V7, V8	**Z77**, 6F12, EF91
V6	**D77**, CV140, 6D2, EB91
V9	**L77**

OS/12

Total current: L.T. 0·3 A; H.T. 3-4 mA at 250 V supply.
Crystal: S.T.C. Type 4013 Gp.1, cut for 1/5 Storno transmitter frequency.

Valves

V1	**6F12,** Z77, EF91.

MU/42

Valves

V1	UU6

Fuses

750 mA Bulgin PAK3.
150 mA Bulgin PAK1.

50/GGJ/006/AJP

FIG 14
4th ISSUE

RS.2

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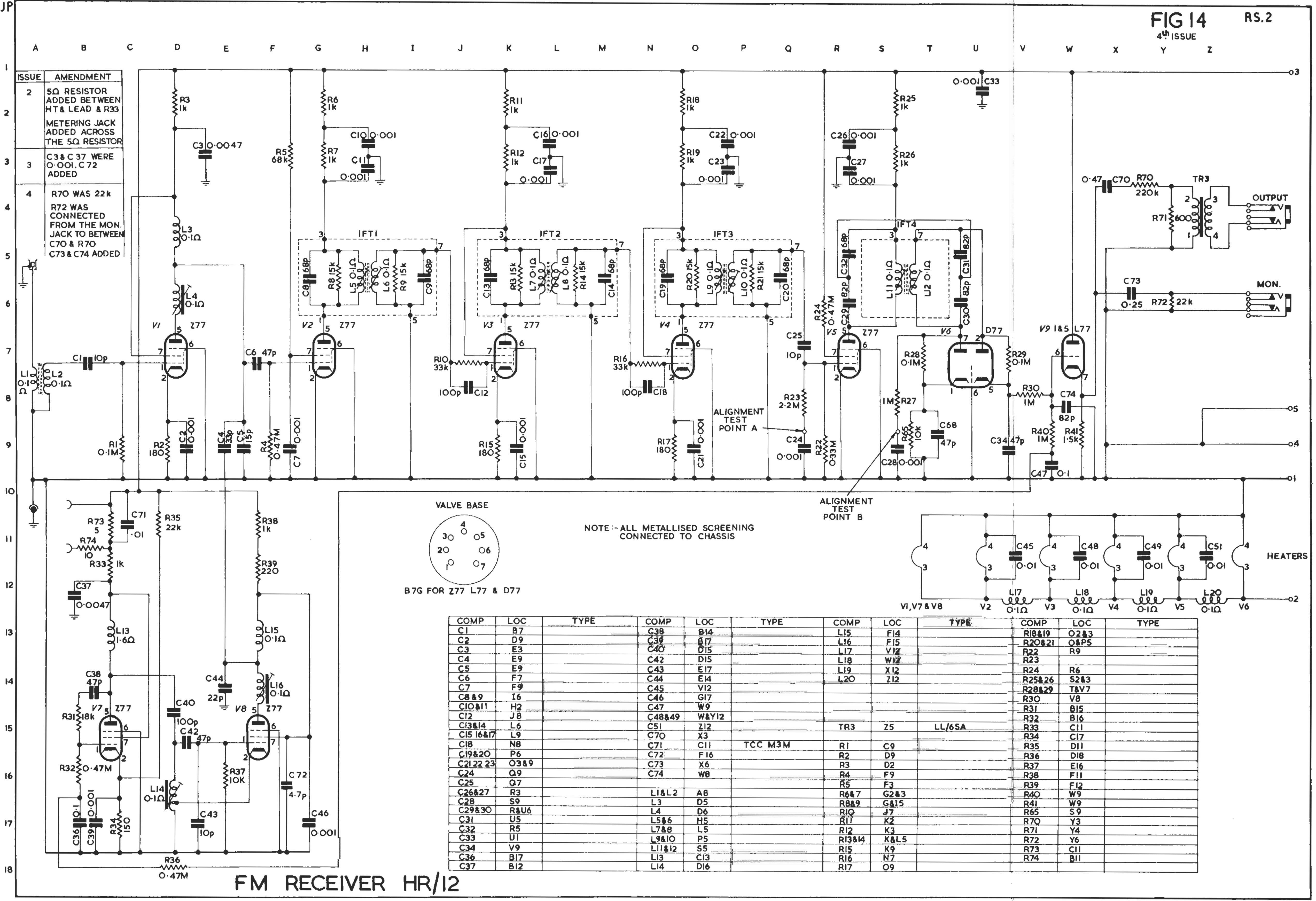
ISSUE	AMENDMENT
2	5Ω RESISTOR ADDED BETWEEN HT& LEAD & R33 METERING JACK ADDED ACROSS THE 5Ω RESISTOR
3	C3 & C 37 WERE 0·001. C 72 ADDED
4	R70 WAS 22k R72 WAS CONNECTED FROM THE MON. JACK TO BETWEEN C70 & R70 C73 & C74 ADDED



COMP	LOC	TYPE	COMP	LOC	TYPE	COMP	LOC	TYPE	COMP	LOC	TYPE
C1	B7		C38	B14		L15	F14		R18&19	O2&3	
C2	D9		C39	B17		L16	F15		R20&21	O&P5	
C3	E3		C40	D15		L17	V12		R22	R9	
C4	E9		C42	D15		L18	W12		R23		
C5	E9		C43	E17		L19	X12		R24	R6	
C6	F7		C44	E14		L20	Z12		R25&26	S2&3	
C7	F9		C45	V12					R28&29	T&V7	
C8&9	I6		C46	G17					R30	V8	
C10&11	H2		C47	W9					R31	B15	
C12	J8		C48&49	W&Y12					R32	B16	
C13&14	L6		C51	Z12		TR3	Z5	LL/6SA	R33	C11	
C15 16&17	L9		C70	X3					R34	C17	
C18	N8		C71	C11	TCC M3M	R1	C9		R35	D11	
C19&20	P6		C72	F16		R2	D9		R36	D18	
C21 22 23	O3&9		C73	X6		R3	D2		R37	E16	
C24	Q9		C74	W8		R4	F9		R38	F11	
C25	Q7					R5	F3		R39	F12	
C26&27	R3		L1&L2	A8		R6&7	G2&3		R40	W9	
C28	S9		L3	D5		R8&9	G&I5		R41	W9	
C29&30	R&U6		L4	D6		R10	J7		R65	S9	
C31	U5		L5&6	H5		R11	K2		R70	Y3	
C32	R5		L7&8	L5		R12	K3		R71	Y4	
C33	U1		L9&10	P5		R13&14	K&L5		R72	Y6	
C34	V9		L11&12	S5		R15	K9		R73	C11	
C36	B17		L13	C13		R16	N7		R74	B11	
C37	B12		L14	D16		R17	O9				

FM RECEIVER HR/12