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Please get in touch with me at archivist@vmarsmanuals.co.uk.

Richard Hankins, VMARS Archivist, Summer 2004

RESTRICTED

AIR PUBLICATION

2528M

VOLUME 1

ARI. 18041

# SINGLE-CHANNEL VHF EQUIPMENT TR2002 AND TR2002A

## GENERAL AND TECHNICAL INFORMATION

Prepared by direction of
the Ministry of Aviation

Henry Hardman

Promulgated by Command
of the Air Council

L. J. Dean.

AIR MINISTRY

# THE PATENT 'LOXON' LOOSE-LEAF BINDER

Patent Nos. 700547 and 802577

## HOW TO USE THIS BINDER

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**REF.** F 3447

Hunt & Broadhurst Ltd., Oxford.

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To record the incorporation of an Amendment List in this publication, sign against the appropriate A.L. No. and insert the date of incorporation.

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| 1 to 17 | Incorporated in this reprint | Sept. 1962 |
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## NOTE TO READERS

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The inclusion of references to items of equipment does not constitute authority for demanding the items.

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## ASSOCIATED PUBLICATIONS

| | A.P. |
|---|---|
| *10-Channel VHF and airborne relay equipment* ... ... | *2538HA* |
| *Multimeter Type CT38* ... ... ... ... ... ... | *2879AG* |
| *Instruction book for frequency meter set SCR.211D* ... | *33A1-5-19-1 (TM11-300)* |
| *R.A.F. signal manual, electrical equipment (airborne)* ... | *1186D* |
| *Signal generator Type 31* ... ... ... ... ... | *2879P* |
| *Signal generator Type 56* ... ... ... ... ... | *2879D* |
| *Signal generator Type 62* ... ... ... ... ... | *2536BN* |
| *Test kit Type 7* ... ... ... ... ... ... ... | *2538J* |
| *Common test gear for radio equipment* ... ... ... | *2536C* |

# LIST OF PARTS AND PRELIMINARY MATTER

## PRELIMINARIES



## PARTS

# LEADING PARTICULARS OF ARI.18041

## Transmitter-receiver Type TR2002 and TR2002A

### General

| | |
|---|---|
| *Stores ref.* | 10*D*/17997 *TR.* 2002<br>10*D*/22941 *TR.*2002*A* |
| *Purpose of equipment* | *Single channel v.h.f. communications equipment for airborne use* |
| *Type of transmission* | *Voice* |
| *Frequency* | 121·5*Mc/s* |
| *Frequency control* | *Crystal-controlled ; separate crystals for transmitter and receiver* |
| *Crystal mult. factor* | *Transmitter,* 12 *; receiver,* 8 |
| *Power supply* | 24*V d.c., normally derived from two* 12*V accumulators,* (5*J*/3307) *housed in battery box Type* 15 |
| *Power consumption* | *Not more than* 62*W* |
| *Range* | *Approx.* 80 *nautical miles at* 5000 *ft* |

### TRANSMITTER

| | |
|---|---|
| *Type* | *Transmitter unit Type* 98 *or Type* 98*A* |
| *Stores ref.* | *Type* 98 10*R*/176 *Type* 98*A* 10*R*/149 |
| *R.F. output* | *Minimum of* 1*W into* 45*-ohm line* |
| *Modulation and harmonic content* | *Amplitude modulation up to* 100%. *The harmonic content is not greater than* 12% *at* 80% *modulation with* 1000 *c/s tone* |
| *Audio frequency response characteristic* | *With a constant input which gives* 80% *modulation depth at* 1 *kc/s, the output for a frequency excursion of* 500 *c/s to* 3 *kc/s is within* ± 4 *dB relative to the output at* 1 *kc/s. Below* 500 *c/s the attenuation exceeds* 5 *dB per octave relative to the level at* 500 *c/s* |

### RECEIVER

| | |
|---|---|
| *Type* | *Receiver unit Type* 127 |
| *Stores ref.* | 10*P*/13202 |
| *Intermediate frequency* | 9·72 *Mc/s* ± 0·01% |
| *I.F. bandwidth* | *At* 6 *dB down, not less than* ± 35 *kc/s*<br>*At* 40 *dB down, not greater than* ± 130 *kc/s* |
| *Sensitivity* | *R.F. input required for* 30μ*A diode current is not greater than* 10μ*V* |
| *Signal/noise ratio* | *For an r.f. input of* 10μ*V modulated at* 1 *kc/s to a depth of* 30%, *the signal to noise ratio is not less than* 20*dB* |
| *Second channel suppression* | *Not less than* 50 *dB* |
| *A.G.C.* | *For an increase in r.f. input from* 10μ*V to* 100*mV the increase in demodulator diode current is not more than* +6*dB* |

**Note . . .**

*All r.f. inputs are quoted as open circuit voltage from a* 50*-ohm source.*

## PRINCIPAL ITEMS OF A TYPICAL INSTALLATION ARI. 18041

| | Overall Dimensions Height (in.) | Width (in.) | Depth (in.) | Wt. (lb.) |
|---|---|---|---|---|
| *Transmitter receiver Type TR2002 or TR2002A* | 7¼ | 4¾ | 12 | 9 |
| *Mounting Type* 1028 (10*AJ*/209) (*Mounting increases the overall height of transmitter-receiver by* 1*in.* *or* *Mounting Type* 1031 (10*AJ*/212) | | | | |
| *Battery box Type* 15 (10*AP*/189) | 5¼ | 4¾ | 11¼ | 12 (*with batteries*) |
| *Mounting Type* 1029 (10*AJ*/210) (*Mounting increases the overall height of battery box by* ¼ *in.*) | | | | |
| *Attenuator units Type* 7157 (10*L*/292) | | | | |
| *Switch, magnetic relay, Type S*4 (5*C*/3945) | | | | |
| *Switch, tumbler, Rotax* (5*C*/4182) | | | | |
| *Switch, tumbler* | | | | |
| *Aerial, aircraft, Type* 226 | | | | |
| 10*B*/16566 | | | | |
| *Connector set* | | | | |

**Note . . . .**
*Installations employing carbon microphones will require an adaptor.*

### VALVES

| *Circuit reference* | *Function* | *CV No.* |
|---|---|---|
| *Transmitter* | | |
| 1*V*1 *and* 1*V*2 | *Speech amplifiers* | 2135 |
| 1*V*3 *and* 1*V*4 | *Modulators* | 416 |
| 1*V*5 | *Oscillator and frequency trebler* | 416 |
| 1*V*6 | *1st frequency doubler* | 416 |
| 1*V*7 | *2nd frequency doubler* | 416 |
| 1*V*8 | *Power amplifier* | 416 |
| *Receiver* | | |
| 2*V*1 | *R. F. amplifier* | 850 |
| 2*V*2 | *Frequency changer* | 850 |
| 2*V*3, 2*V*4, 2*V*5 | *1st, 2nd and 3rd i.f. amplifiers* | 131 |
| 2*V*6 | *Detector and a.g.c. delay* | 140 |
| 2*V*7 | *A.F. amplifier* | 138 |
| 2*V*8 | *Oscillator and frequency quadrupler* | 850 |
| 2*V*9 | *Frequency doubler* | 850 |

| | | |
|---|---|---|
| *Crystals* | | |
| *Transmitter* | =10·125 *Mc/s* | *Type* 10*X*/*ZDH*/ (*tolerance* 0·005% −20 *to* +70°*C*) |
| *Receiver* | =13·9725 *Mc/s* | |
| *Fuses* | 250*mA cartridge Type* 153 (10*H*/18680) | |

## PART 1

# GENERAL DESCRIPTION AND TECHNICAL INFORMATION

### LIST OF CHAPTERS

Note.—*A list of contents appears at the beginning of each chapter*



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# Chapter 1

# GENERAL DESCRIPTION AND OPERATING INSTRUCTIONS

## LIST OF CONTENTS



## LIST OF ILLUSTRATIONS



### Introduction

**1.** ARI. 18041 is intended for emergency and standby use in aircraft. A typical installation (*para.* 16) includes a transmitter-receiver Type TR2002 or TR2002A, a battery box Type 15, a relay unit, a V.H.F. switch, a power supply switch, an aerial Type 226 and suitable connectors. The transmitter-receiver (*fig.* 1) is a single-channel, lightweight airborne equipment for voice communication. It operates on a carrier frequency of 121·5 Mc/s, the frequency being controlled by two crystals, one for the transmitter and one for the receiver. In addition, Type TR2002A has the facility for intercommunication which can be switched in or out as required; details of TR2002A are given in Chap. 4. The transmitter range under normal conditions is approximately 80 miles at an altitude of 5000 ft.

**2.** The transmitter-receiver is normally quite independent of the aircraft power system, the operating power being obtained from two 12-volt accumulators (Ref. 5J/3307) connected in series to give 24V. These accumulators are housed in a special battery box (Type 15). The output from the accumulators supplies the valve heaters and also operates a motor-generator (located on the transmitter chassis) which in turn provides a 170V h.t. supply necessary for the operation of the transmitter and the receiver. In some installations provision is made for the equipment to be operated from the normal aircraft supply.

**3.** Fig. 1 shows the transmitter-receiver complete with case. It is of the "miniaturized" type, the transmitter unit and receiver unit, together with the motor generator and its associated smoothing circuits, being contained in a case measuring only 7¼ in. × 4¾ in. × 12in.; the total weight of this assembly is 9 lb.


**Fig. 1. Transmitter-Receiver Type TR.2002, General View**

## Circuit summary

*Transmitter unit*

**4.** Reference to fig. 2 shows that the transmitter employs a crystal-controlled oscillator valve (1V5), which also serves as a frequency-trebler. This stage is followed by two frequency doubler stages (1V6 and 1V7), giving a final output frequency of twelve times the crystal fundamental frequency; this output is applied to a power amplifier (1V8).

**5.** The a.f. output from the microphone is applied through a microphone transformer to the grids of the push-pull speech amplifier valves (1V1, 1V2). The amplified a.f. signal passes thence to the push-pull modulator stage (1V3, 1V4). The output from this stage is used to modulate the r.f. output of the power amplifier (1V8), and the resulting modulated r.f. output is applied to the aerial, through the contacts of the aerial change-over relay. Sidetone is taken from the secondary of the modulation transformer and applied to the a.f. stage of the receiver. The motor-generator used to provide the h.t. supply is included in the transmitter chassis, together with the associated filter circuits. This is not indicated on the diagram, but is covered in the detailed circuit description given in Chapter 2.

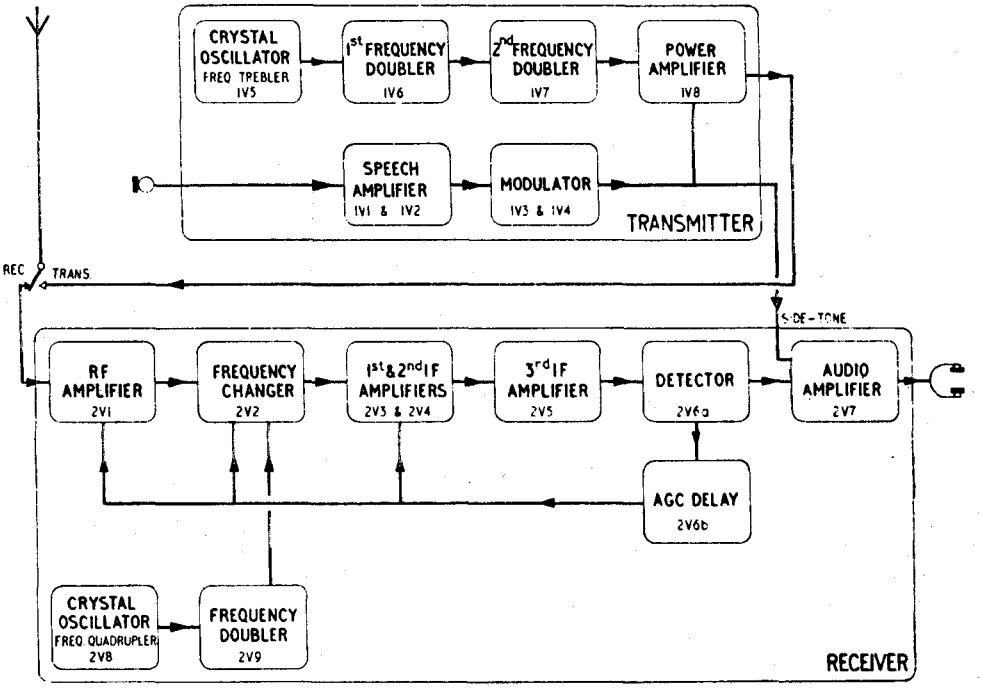



**Fig. 2. Transmitter-Receiver Type TR.2002, Block Diagram**

*Receiver unit*

**6.** The receiver circuit (*fig.* 2) employs a crystal-controlled oscillator valve (2V8) which also serves as a frequency quadrupler. The output from this stage is passed through a frequency doubler stage (2V9). The final frequency, which is eight times the crystal fundamental frequency, is applied to the frequency-changer stage (2V2).

**7.** The output from the single r.f. stage (2V1) is applied to the frequency-changer stage (2V2), where it is combined with the oscillator output to provide an i.f. frequency of 9·72 Mc/s. This stage is followed by three i.f. amplifiers (2V3, 2V4, 2V5) and a diode detector which uses one half of a double diode valve (2V6a). The resulting a.f. signal is amplified by valve 2V7, and the amplified signal applied to the telephones. A portion of the rectified i.f. voltage developed across the detector diode load resistors is used for a.g.c. purposes, and is applied to the grids of the r.f., frequency-changer, and first and second i.f. valves. A.G.C. delay is provided, and the second section of the double-diode valve (2V6b) is used to control this. A complete description of this circuitry is given in Chapter 2.

## Structural description

*Transmitter-receiver*

**8.** The transmitter-receiver consists of a transmitter unit and a receiver unit mounted one above the other on a front panel and protected by a light alloy case; the receiver is mounted at the top. Fig. 1 shows the external appearance of the assembled equipment. When installed in the aircraft the transmitter-receiver is normally mounted on an anti-vibration mounting to which it is secured by two locating spigots at the rear, and two knurled nuts at the front end.

*Case*

**9.** The case, as shown, is provided with louvres for the circulation of cooling air. The air circulation is assisted by a cooling fan on the motor-generator mounted on the transmitter chassis. This fan draws air through a gauze-covered aperture in the rear of the case and impels it forward into the chassis, whence it escapes via the louvres.

**10.** The case is secured to the transmitter-receiver by two coin-slotted captive screws which engage with tapped bushes in the rear flanges of the transmitter and receiver chassis.

*Front panel*

**11.** This is the principal structural member of the equipment, since it serves as mounting rack for the transmitter and receiver. All external connections to the transmitter and receiver units are made through three plugs mounted on the front panel (*fig. 1*). One of these plugs (PL6) is of the coaxial type and takes the aerial connection. The remaining two plugs are of the Plessey type. The lower one, PL2, takes the connection from the 24-volt battery, while the upper one, PL1, provides the remainder of the connections, including those for telephones, microphone and control circuits. Two cartridge-type fuse holders, F1 and F2, mounted below the aerial plug, contain the fuses for the transmitter and the receiver HT supplies, respectively. Two further fuse holders mounted on the panel below F1 and F2 contain spare fuses; they are in no way connected to the circuitry of the equipment. A carrying handle is provided at the bottom of the panel.

**12.** The transmitter and receiver units are assembled on the back of the panel as shown in fig. 3. It is seldom necessary to remove the transmitter unit from the panel, consequently it is secured by normal screws with locknuts or lockwashers. It may, however, be necessary to remove the receiver unit for access to components on its lower side, or to components on top of the transmitter chassis. Consequently, it is secured to the panel only by four captive screws, and may be electrically disconnected from the remainder of the equipment by releasing and withdrawing the coaxial socket SK3 and the eight-pole socket SK2. The rear mounting plate which assists in supporting the receiver unit has a projecting pin at each corner; the two upper pins engage with holes in the rear flange of the receiver chassis, and the lower two engage similar holes in the rear flange of the transmitter chassis. The mounting plate is secured by the single recessed screw visible in the illustration.

*Transmitter and receiver chassis*

**13.** The transmitter and receiver chassis are of the normal light-alloy, box-form type. Brackets spot-welded to each side of the chassis enable them to be secured to the front panel. Four spring contacts, one mounted on each bracket, provide electrical connection between the chassis and case. The transmitter chassis carries the motor generator and the associated filter circuitry in addition to the transmitter components. The connection between

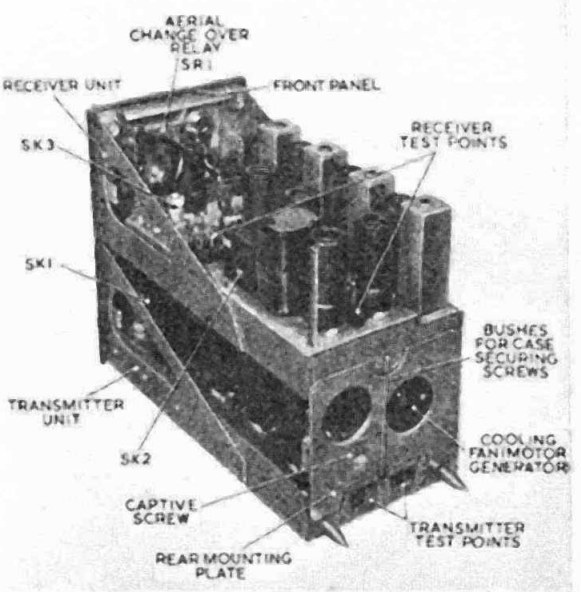



**Fig. 3. Transmitter-receiver, case removed**

the aerial change-over relay and the transmitter is by a coaxial socket SK1. The remainder of the connections between the front panel and the transmitter are by permanent wiring, as the transmitter and panel are not normally separated. The connections from the various transmitter test points are taken to two 6-pole plugs at the rear of the chassis (*fig. 3*).

**14.** As noted in para. 12, the receiver chassis is removable from the front panel, all connections to it being made through sockets SK2 and SK3 of the panel, which engage with corresponding plugs PL4 and PL1 on the chassis. The receiver chassis is stepped-down at the left-hand side to provide more room for the IF transformers, and has a curved guard plate attached to its forward end to prevent damage to the wiring at the rear of the front panel. Four test points are provided on the receiver, the connections to them being made via a six-pole plug mounted near the co-axial plug, and a 2-pole plug mounted towards the rear of the receiver.

**Battery box Type 15**

**15.** Battery box Type 15 contains the standby accumulators. It consists of a metal case with ventilating louvres in the sides and a detachable cover secured by a large knurled nut. A socket and terminal block are mounted on the front of the box, the connections to the installation being made through the socket; the terminal block facilitates testing of the accumulator voltage, or serves for the connection of additional items of equipment. A simple metal strip carrier is provided for each accumulator to facilitate its insertion or removal from the box. To safeguard the accumulators, non-absorbent sponge rubber packings are provided in the case, on the lid, and on the carriers.

The complete battery box, when installed in the aircraft, is secured in a mounting Type 1029 by two locating spigots at the rear and two spring latches at the front. The accumulators used are capable of maintaining their full charge capacity for a period of four weeks, provided that no discharge has taken place.

### TYPICAL INSTALLATION

**16.** Complete information regarding the installations ARI.18041 is not available at the time of going to press, but the following paragraphs may be taken as summarizing a typical installation. Diagrams and descriptions of specific installations will be issued in Chapter 3 as the information becomes available.

**17.** A typical installation ARI.18041 will include a transmitter-receiver Type TR.2002 (with anti-vibration mounting Type 1028), a battery box Type 15 (with mounting Type 1029, and containing two 12-volt accumulators), a relay unit Type S4, a single-pole two-way switch marked POWER SUPPLY NORMAL—STANDBY, and a two-pole two-way switch marked VHF NORMAL—STANDBY; a separate aerial Type 226 is also provided. In some installations, where carbon microphones are used, a special attenuator unit is included.

**18.** The POWER SUPPLY switch enables the standby equipment to be operated either from the NORMAL aircraft power supply or from the STANDBY batteries. When the two-pole VHF switch is set to STANDBY one of its poles connects the power supply (selected by the POWER SUPPLY switch) to the standby transmitter-receiver; the other pole of this switch controls the relay unit Type S4. The relay unit connects the telephones, microphone and press-to-transmit switch either to the NORMAL VHF equipment or to the STANDBY equipment, depending on the setting of the VHF switch.

### OPERATING INSTRUCTIONS

**19.** Differences may exist between installations, e.g., alternative power supplies may not be provided in some instances; the following instructions apply to a typical installation.

**20.** As noted in para. 16, the controls introduced by ARI.18041 are two in number, a POWER SUPPLY switch, and a VHF switch. These switches should be operated as follows:—

(1) If the normal VHF equipment has failed but the aircraft power supply system is in order, leave the POWER SUPPLY switch at NORMAL and set the VHF switch to STANDBY. The standby equipment is now in action and connected to the telephones, microphone and PRESS-TO-TRANSMIT switch of the normal installation; these may now be used in the usual manner.

(2) If the normal power supply fails, set both the POWER SUPPLY and the VHF switch to STANDBY and proceed as before.

**Note . . .**

*The maximum time for which the standby batteries will operate TR.2002 (no other load being applied) is 1½ hours at normal temperatures, falling to ¾ hour at 0 deg. C. The duration at intermediate and lower temperatures will vary accordingly. For this reason the standby batteries must not be used for testing the equipment on the ground. All such testing should be done on the aircraft power supply.*

# Chapter 2

# DETAILED CIRCUIT DESCRIPTION

## LIST OF CONTENTS



## LIST OF ILLUSTRATIONS



### Introduction

**1.** The complete transmitter-receiver Type TR. 2002 comprises a case, a transmitter unit Type 98 and a receiver unit Type 127. The structural aspects of the equipment are dealt with in Chap. 1. The input power supply for the equipment is 24V DC, and is derived from accumulators. This 24V supply provides the heater current for the valves and is also used to drive a rotary transformer, the output from which provides a 170V HT supply both for the transmitter and the receiver. As the equipment operates on a single pre-tuned channel, no channel-selecting circuitry is required.

**2.** The rotary transformer and the associated smoothing circuit components are mounted on the transmitter chassis. These components, together with the components (plugs, send/receive relay, etc.) mounted on the front panel, form part of transmitter unit Type 98, and are indicated on the transmitter circuit diagram, fig. 9; for convenience of description, however, they are here considered under the separate heading "Control and power circuits" (*para.* 25 *to* 28).

### Transmitter unit Type 98

**3.** From the block diagram (*fig.* 1) it will be seen that the actual transmitter portion of the unit comprises a crystal oscillator and frequency-trebler stage (1V5) followed by two frequency-doubler stages (1V6 and 1V7) and a power amplifier (1V8). The output from the microphone is applied via a push-pull speech amplifier stage (1V1, 1V2) and a push-pull modulator stage (1V3, 1V4) to the power amplifier stage (1V8). The resulting modulated RF output is applied to the aerial through the contacts of a send/receive relay. Sidetone is taken from the secondary of the modulation transformer and applied to the AF stage of the receiver. The complete transmitter circuit is shown in fig. 9; fig. 2 and 3 will assist in locating any specific component in the transmitter.

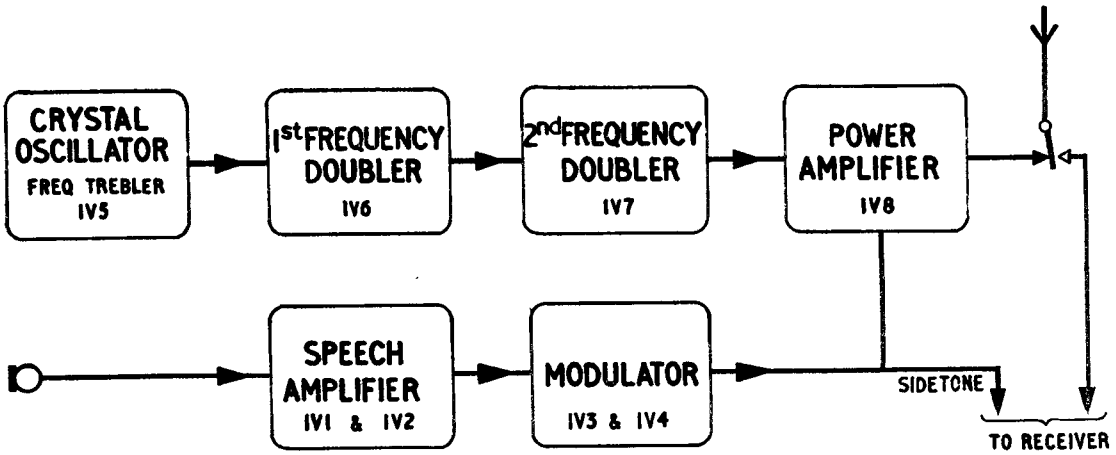



**Fig. 1. Transmitter unit Type 98, block diagram**

*Crystal oscillator*

**4.** The beam tetrode 1V5 (*fig.* 9) serves both in the crystal oscillator and in the frequency-trebler circuits. When considering the oscillator circuit the cathode, control grid and second grid may be regarded as a triode, the second grid serving as "anode" to this portion of the circuit, while the true anode forms part of the frequency-trebling circuit.

**5.** A crystal 1XL1 (fundamental frequency 10·125 Mc/s) is connected between the control grid of 1V5 and earth, and positive feedback is obtained by connecting two capacitors 1C8 and 1C9 in series with each other and in shunt across the crystal in the Colpitts manner, the junction of the capacitors being connected to the cathode of 1V5. The cathode is maintained at an RF potential by an inductor 1L5, which also serves to complete the cathode DC path to earth. A meter plug 1PL5/3, connected across 1R14 (part of the grid-leak chain 1R13, 1R14), enables an indication of the grid current, and consequently of the amplitude of oscillation, to be obtained.

*Frequency trebler*

**6.** Valve 1V5 serves also as a frequency trebler. Energy is transferred within the valve from the oscillatory circuit to the anode circuit by electron coupling and, since the anode circuit is tuned by inductor 1L4 and capacitor 1C10 to the third harmonic of the crystal frequency, the output frequency of the anode circuit will be three times the crystal fundamental frequency, or 30·375 Mc/s. Resistor 1R16 and capacitor 1C11 provide decoupling for the frequency trebler, and 1R15 and 1C7 for the oscillator portion of 1V5. Automatic bias is applied to the control grid by the voltage drop across resistors 1R13 and 1R14 due to grid current.

*First and second frequency doublers*

**7.** The output from the oscillator-trebler stage is applied to the grid of the first frequency-doubler valve, beam pentode 1V6, through capacitor 1C12. The anode circuit comprises an inductor 1L6 which is tuned by the preset capacitor 1C15 to the second harmonic of the output frequency of the trebler stage, consequently the output frequency of this stage will be 60·750 Mc/s. The anode and the second grid of 1V6 are decoupled by 1R20, 1C19 and 1R17, 1C14, respectively. Automatic grid bias is obtained from the voltage drop across 1R18 and 1R19, and a meter plug 1PL4/3 connected across 1R19 enables an indication to be obtained of the excitation applied to this stage. The second frequency-doubler stage is similar to the first, with the exception that the anode circuit of this stage is tuned to the second multiple of the output frequency of the first doubler stage, consequently the final frequency will be 121·5 Mc/s. The meter plug for this stage is 1PL4/2.

*Power amplifier*

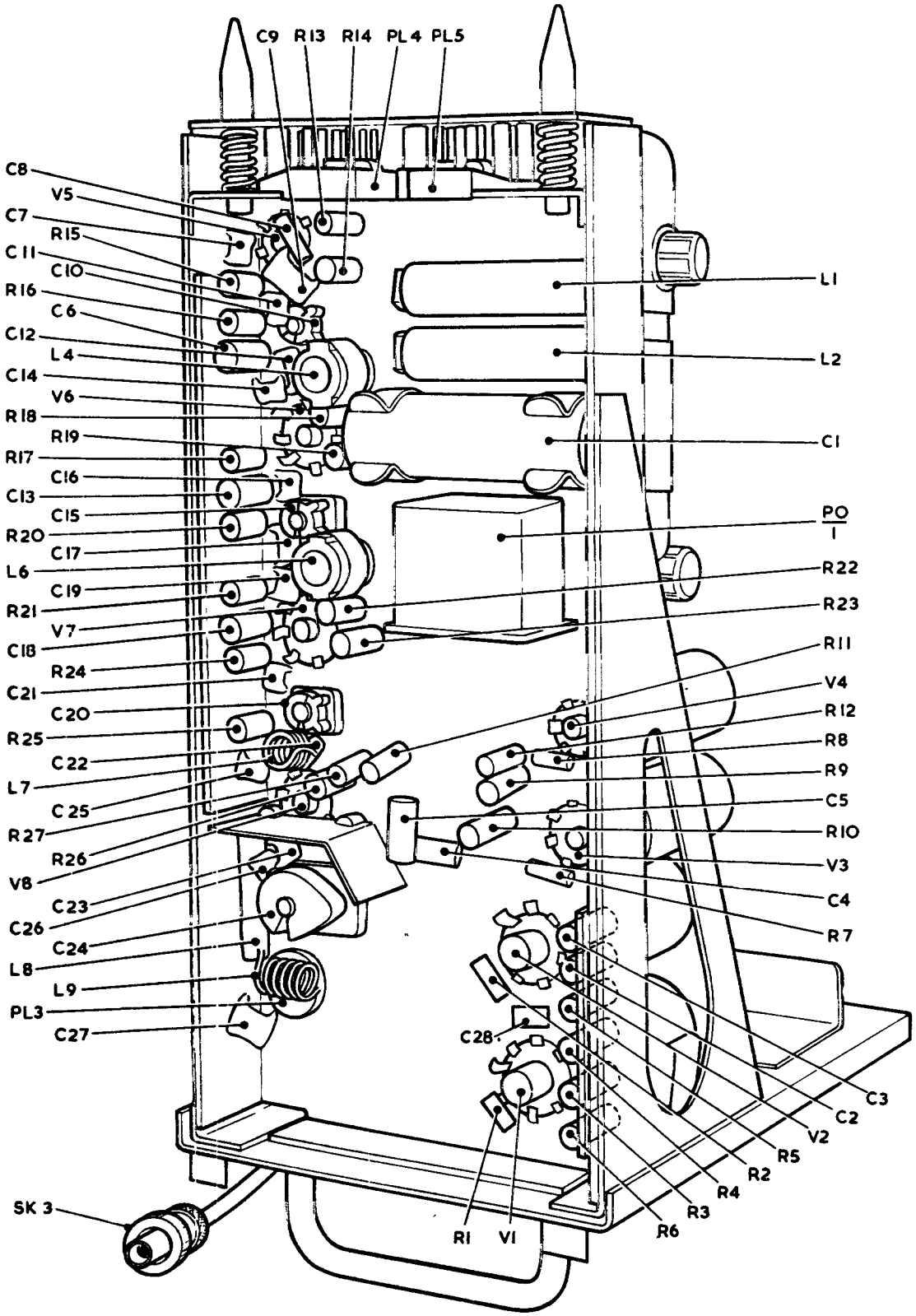
**8.** The output from the second frequency-doubler stage is applied through capacitor 1C22 to the grid of the power amplifier valve 1V8, and as the anode circuit of this valve includes an inductor 1L9 tuned by a preset capacitor 1C24 to the same frequency as the anode circuit of 1V7, it follows that the frequency of the amplified RF output will also be 121·5 Mc/s. The HT supply for the second grid and the anode of the power amplifier is taken through resistor 1R10 and the secondary winding of the modulation transformer 1TR2. From the above it will be seen that the AF voltages developed across the secondary winding of the transformer are in series with the HT voltage, and consequently will appear in the anode and screen circuits of 1V8, and so modulate the RF output of that stage. Capacitor 1C25 in conjunction with the normal filter consisting of 1R25 and 1C23 serves to decouple the second grid of 1V8 for RF, and a filter comprising inductor 1L8 and capacitor 1C26 prevents the RF output of the power amplifier from feeding back into the HT line and so affecting the other stages. The modulated RF output is applied to the aerial through capacitor 1C27, coaxial plug 1PL3 (on the transmitter chassis), socket 1SK1 (wired to the front panel), the send/receive relay 1SR/2, and the aerial plug 1PL6 (on the front panel). To enable indications of the grid and of the anode and screen current of the power amplifier stage to be obtained, a plug 1PL4/1 is connected across resistor 1R27 of the grid leak chain, and a plug 1PL5/2 is connected (in series with resistor 1R12) across resistor 1R10 in the anode circuit.

*Speech amplifier*

**9.** The microphone output is applied through pins C and D of plug 1PL1 as a balanced input to the centre-tapped primary of the microphone transformer 1TR1. The secondary of this transformer is also centre-tapped, the tapping being earthed and the resulting anti-phase output is taken from the extremities of the winding are applied to the grids of the speech amplifier valves 1V1 and 1V2 through resistors 1R1 and 1R2 respectively. These pentode valves work in push-pull circuit, and automatic bias is applied to both valves by a cathode resistor 1R6, which is bypassed by capacitor 1C28.

*Modulator*

**10.** The amplified signal from 1V1 and 1V2 passes through capacitors 1C2 and 1C3 to the grids of the push-pull modulator valves 1V3, 1V4. These valves, which are of the beam tetrode type, are supplied with a fixed cathode bias of +12V taken from the centre point of the series-connected valve heater chain. The outputs from 1V3 and 1V4 are applied to the extremities of the centre-tapped primary winding of transformer 1TR2, the HT voltage being applied to the tapping of this winding through a resistor 1R9 which also serves as meter shunt when checking the modulator anode and screen current at plug 1PL5/1. A voltage-dropping series resistor 1R12 is common both to the modulator and to the power amplifier check points. The AF voltages which appear in the secondary of the modulator transformer are applied to the anode and screen circuits of the power amplifier valve 1V8 and modulate the RF output of that valve as described in para. 8. A portion of the AF output from the modulator transformer is used as sidetone, being applied through resistor 1R11, capacitor 1C5 and pole 7 of 1SK2 to the AF amplifier stage of the receiver.




ALL REF. NUMBERS HAVE PREFIX 1

Fig.2 Bottom view of transmitter chassis Fig.2

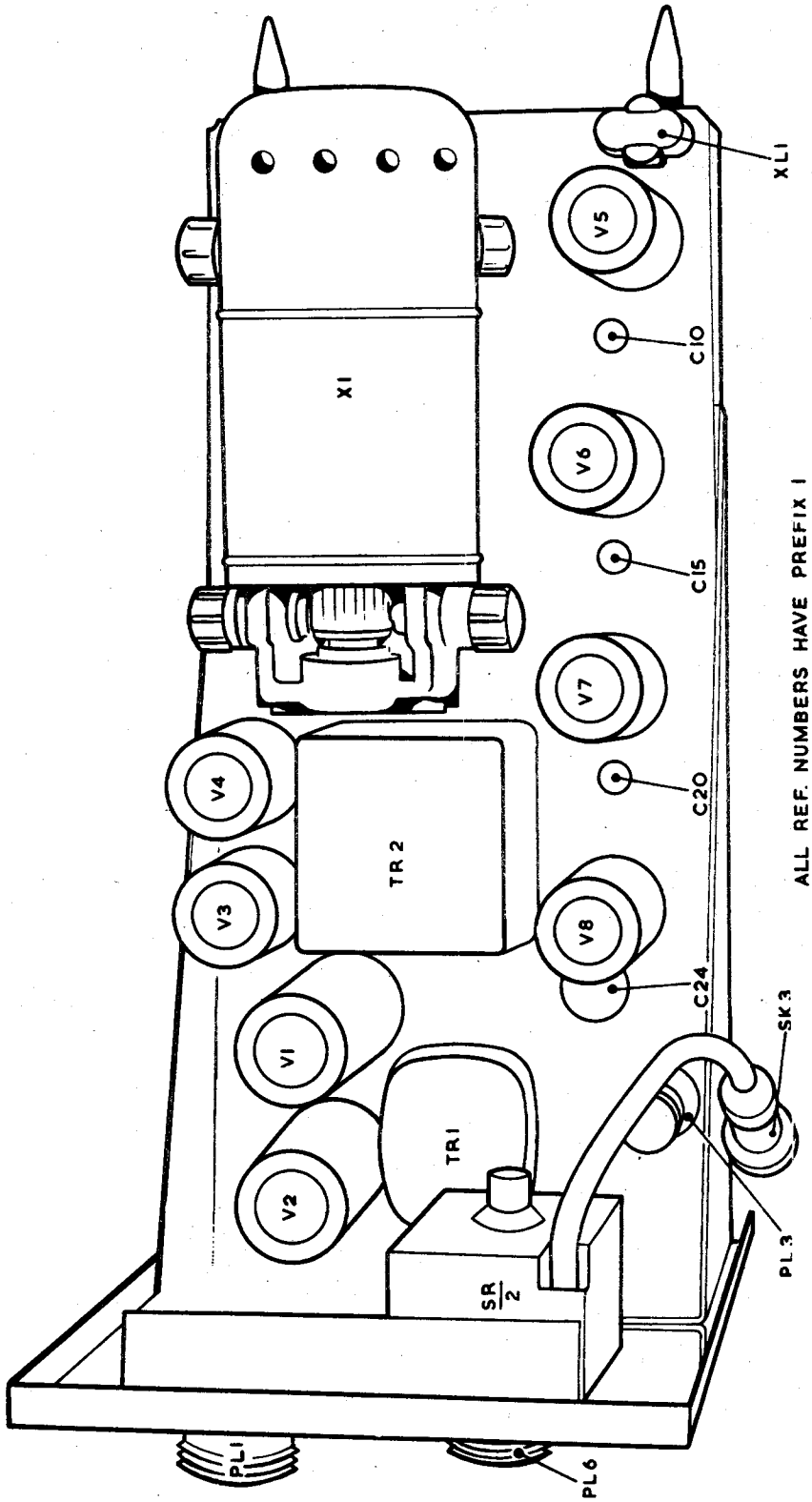



Fig.3 Top view of transmitter chassis Fig.3

*Valve heater circuit*

**11.** As the LT supply is 24V (nominal) and the valve heaters are designed for 6·3V, it is necessary to wire the heaters in a series-parallel arrangement. By reason of the differing heater currents required for the various valves, it is easier to consider the transmitter and receiver valves together. The combined heater circuit which results when the loose socket 1SK2 (permanently wired to the transmitter and panel circuits) and plug 2PL4 (on the receiver) are engaged is indicated in fig. 6. The heater arrangement may now be considered as consisting of four series-connected chains. Valves 1V5, 1V6, 1V7 and 1V8 of the transmitter all require the same current (0·3A) and are connected in series across the 24V supply; 2V8, 2V9, 2V2 and 2V1 of the receiver all require 0·175A, and are similarly connected. The heaters of the transmitter valves 1V4 and 1V3 require 0·3A, and are connected in series with the parallel heaters of 1V1 and 1V2 (0·15A each) and thence through pole 3 of plug 1SK2 and socket 2PL4 to earth via the heater of 2V6, which also requires 0·3A. This leaves a chain of three heaters, 2V3, 2V4 and 2V5 (0·2A) in series with 2V7. As the latter heater requires 0·3A, a resistor 2R42 is connected in parallel with the three series-connected heaters of 2V3, 2V4 and 2V5. The interconnections between the heater chains of the 6, 12 and 18 volt levels assist in securing correct voltage distribution across the heater chains. The positive cathode bias for the modulator valves is taken from the centre point (12V approx.) of the transmitter heater chain. Capacitors 2C56, 2C57, 2C58 and 2C59 in the receiver are provided at the 6, 18 and 24V levels to filter out any RF interference arising in the rotary transformer.

**Receiver unit Type 127**

**12.** As indicated in the block diagram, fig. 4, the receiver employs one RF amplifying stage, a frequency changer, three IF amplifiers, a diode detector, which also provides the AGC voltage, and one AF amplifier stage. The oscillator stage serves also as a frequency quadrupler, and is followed by a frequency doubler stage. The AGC voltage derived from the detector stage is applied to the RF, the frequency changer, and the first and second IF stages. AGC delay is provided, and an AGC delay valve is introduced to prevent the possibility of the positive delay voltage appearing in the AGC line. The complete receiver circuit is shown in fig. 10 and reference to the annotated illustrations fig. 7 and 8 will assist in locating any specific component in the receiver.

*RF input*

**13.** The signals received by the aerial are transferred through the send/receive relay to the receiver aerial plug 2PL1, and so to a tapping on an inductor 2L2 which is in the grid circuit of the RF amplifier valve 2V1 (*fig.* 10). This inductor is tuned to the frequency of the incoming signal by a preset capacitor 2C4, and the grid is coupled to this tuned circuit by a capacitor 2C3; the latter capacitor also serves to prevent the AGC voltage which is parallel-fed to the grid of 2V1 from shorting to earth through inductor 2L2. An inductor 2L1 in series with a capacitor 2C1 is connected between the tapping on 2L2 and earth. This combination is tuned to 102·06 Mc/s, and forms an image acceptor circuit to prevent the image frequency from appearing in the receiver.

*RF amplifier*

**14.** The gain of the RF pentode valve is controlled by the AGC voltage which is parallel-fed to its grid through resistor 2R3. To ensure that the valve will always have a certain minimum amount of bias no matter how low the AGC voltage, a small amount of automatic bias is applied by means of resistor 2R7, which is bypassed for RF by 2C7 and 2C10. The screen grid voltage is obtained from a potential divider connected across the HT supply and consisting of two resistors, 2R1 and 2R2; capacitor 2C2

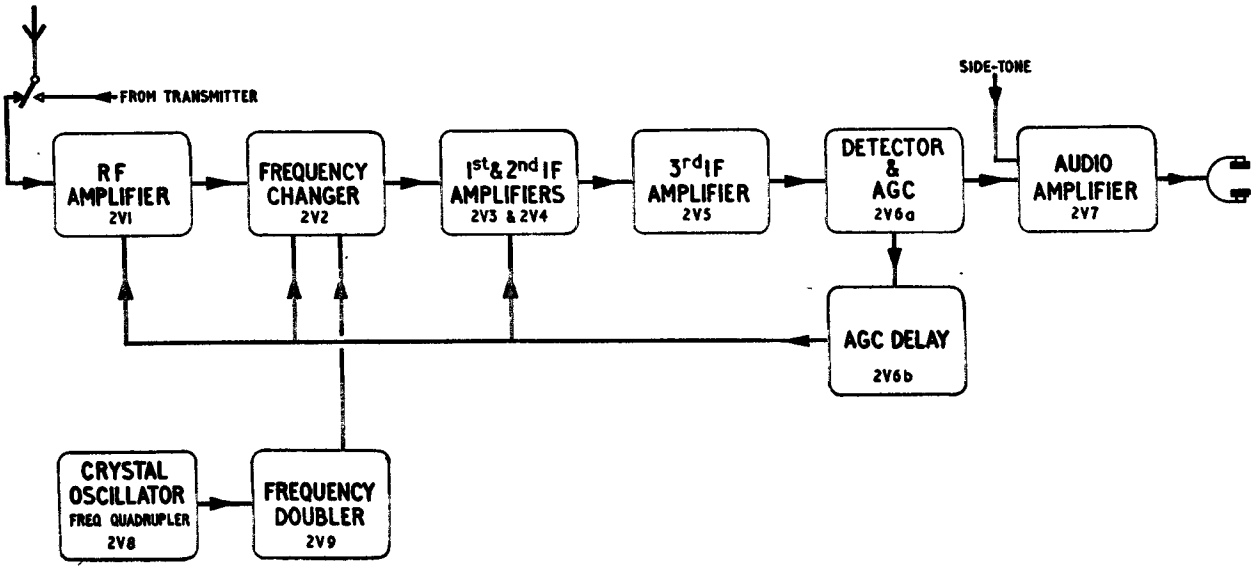



**Fig. 4. Receiver unit Type 127, block diagram**

provides RF bypass for this circuit. The tuned anode circuit comprises inductor 2L3 tuned by preset capacitor 2C5. The anode supply passes through resistor 2R4, and decoupling is provided by capacitor 2C6. A meter plug 2PL2/1 is connected across a resistor 2R6 (2·2K) which forms part of a potential divider (2R5, 2R6) across the cathode bias resistor 2R7. A suitable meter connected to this plug will give an indication of the cathode current of this stage without affecting its stability. Readings taken at this point may be used to check the operation of the AGC system.

*Oscillator and frequency quadrupler*

**15.** The pentode valve 2V8 serves both in the crystal oscillator and in the frequency quadrupler circuits. The circuit used is similar to that used in the transmitter and described in para. 4 to 6, that is, the oscillator circuit is of the Colpitts type, with electron coupling to the frequency-multiplying portion of the circuit. The crystal 1XL1 has a frequency of 13·9725 Mc/s, and positive feedback is applied to the valve from the junction of the phase-splitting capacitors 2C47, 2C48 which are connected across 2XL1. Inductor 2L5 maintains the cathode at RF potential and also provides the cathode DC path to earth. Resistors 2R35, 2R36 connect the grid to earth, and a meter plug 2PL2/2 connected across 2R36 enables an indication of the amplitude of oscillation to be obtained. Energy is transferred within the valve from the oscillatory circuit to the anode circuit by electron coupling and, since the anode is tuned by inductor 2L4 and capacitor 2C49 to the fourth harmonic of the crystal frequency, the output frequency from the anode circuit will be four times that of the crystal, or 55·89 Mc/s.

*Frequency doubler*

**16.** The output of the frequency quadrupler is applied to the grid of the doubler pentode 2V9 through a 100pF capacitor 2C51. A certain amount of grid bias results from the flow of grid current through the resistors 2R39 and 2R40, and a meter socket 2PL2/3 connected across 2R40 enables an indication of this current to be obtained. Inductor 2L6 is tuned by capacitor 2C53 to the second harmonic of the output frequency of the quadrupler stage, with the result that the output frequency of this stage will be eight times the crystal fundamental frequency, or 111·78 Mc/s. This stage, besides acting as frequency doubler, also acts as a buffer stage between the frequency changer and the oscillator.

*Frequency changer*

**17.** The output of the frequency doubler passes through a 1pF capacitor 2C55 and, together with the amplified RF signal from 2V1, is applied through a 100pF capacitor 2C11 to the control grid of the frequency-changer valve 2V2. By reason of the valve characteristics, the sum frequency (233·28 Mc/s) and the difference frequency (9·72 Mc/s) appear at the anode. The anode circuit includes the primary of the first IF transformer 2TR1, and since this primary is tuned to the desired IF frequency of 9·72 Mc/s, it accepts the difference frequency. The primary and secondary windings of all IF transformers in this receiver are each tuned by two capacitors, one of 10pF and one of 55pF connected in parallel; these capacitors have differing temperature coefficients and, when combined, provide temperature correction. The screen voltage is taken through 2R9, and the anode voltage through 2R10, decoupling being by capacitors 2C12 (330pF) and 2C16 (0·01 $\mu$F) respectively. Automatic cathode bias is provided by a resistor 2R11 which is bypassed for RF and IF by capacitors 2C14 and 2C15. AGC voltage is parallel-fed to the grid of 2V2 through resistor 2R8.

*First, second and third IF amplifiers*

**18.** The output from the frequency changer is coupled to the control grid of the first IF amplifier. valve 2V3 by the permeability-tuned IF transformer 2TR1. AGC voltage is series-fed to the control grid through resistor 2R12 and the secondary of 2TR1; this circuit is bypassed for IF by capacitor 2C17. Cathode bias is developed across 2R15, which is bypassed for IF by capacitor 2C21. The screen voltage is taken through 2R13, and in this instance the bypass capacitor 2C19 is connected between the screen and the cathode. The anode voltage is taken through 2R14, and 2C22 provides the normal bypass to earth. Transformer 2TR2 couples the first IF anode to the second IF grid, transformer 2TR3 couples the second IF anode to the third IF grid, and transformer 2TR4 couples the output of the third IF stage to the detector stage. The three IF stages are similar, with the exception that the third IF (2V5) grid is returned to earth through a 470K resistor 2R20 instead of to the AGC line through a 100K resistor as in the first and second IF stages.

*Detector*

**19.** The output developed across the secondary of the last IF transformer 2TR4 is applied to the anode of the detector portion, 2V6a, of a double-diode valve (*fig.* 5), the second portion of which serves to control the AGC voltage. The signal is

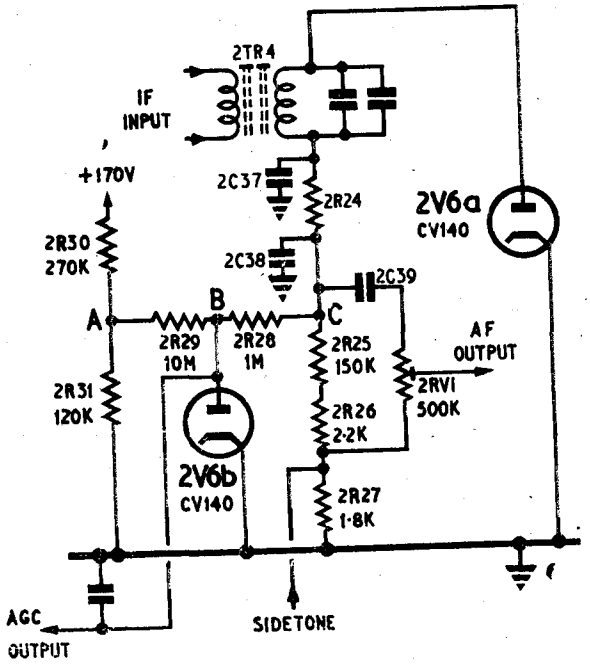



**Fig. 5. Simplified detector and AGC circuit**

rectified in 2V6a, and the resulting AF voltages, plus a DC component due to rectification of the carrier, appear across the diode load resistors 2R24, 2R25, 2R26 and 2R27. The AF output from this stage is taken from the slider of a potentiometer 2VR1 which, in series with a capacitor 2C39, is connected across 2R25 and 2R26 of the diode load. This potentiometer is of the preset type and controls the audio-frequency output to the AF amplifier stage. Capacitor 2C39 serves as a DC stopper. Bypass capacitors 2C37 and 2C38 are connected at the junction of 2R24 with the IF transformer and with 2R25, respectively to form an IF filter. A meter plug 2PL3 connected across resistor 2R26 of the diode load enables an indication of the diode current to be obtained.

*Automatic gain control*

**20.** As noted in para. 19, when a signal is being received a DC voltage proportional to the received signal appears across the diode load resistors 2R24, 2R25, 2R26 and 2R27. By reason of the direction of current flow through the detector diode 2V6a, the anode end of the resistor chain will be negative with regard to the cathode, or earthy end. A proportion of this negative voltage, taken from the junction of 2R24 and 2R25, (the point marked C on fig. 5) is used for automatic gain control (AGC), and is applied through the AGC line to the grids of the RF, frequency-changer, and first and second IF stages. This AGC voltage is parallel-fed to the RF and frequency-changer stages, and series-fed to the first and second IF stages. As the AGC voltage is proportional to the incoming signal, it follows that a strong signal will produce a larger, and a weak signal a smaller, negative bias on the grids of the controlled stages, so providing automatic correction for changes in signal strength by varying the gain of these stages. Suitable bypass capacitors are provided at each of these stages, and capacitor 2C32 in conjunction with resistors 2R3, 2R12, and 2R16 prevent the AF component from affecting the controlled stages.

*AGC delay*

**21.** As noted in the preceding paragraph, the negative voltage appearing at point C is proportional to the strength of the received signal. If this voltage were applied direct to the controlled stages it would reduce the sensitivity of the receiver even on weak signals and it is therefore desirable to "delay" its application until the strength of the received signal exceeds a certain pre-determined level. In this receiver a delay of approximately 4·75V has been introduced, i.e., no AGC bias is applied to the controlled valves until the signal received is of such strength as to develop a DC voltage across 2R25, 2R26, 2R27 in excess of this value.

**22.** Fig. 5 shows the circuitry involved. Resistors 2R30 (270K) and 2R31 (120K) are connected in series between +170V and earth, consequently the junction A of these resistors will be approximately 52·3V positive with regard to earth. A potential divider consisting of 2R29 (10M) and 2R28 (1M) is connected between point A and point C (the point on the detector diode load from which the AGC bias is taken), and the AGC line is connected to point B, the junction of 2R29 and 2R28. Ignore 2V6b for the moment, and assume that the equipment is switched on and that no signal is being received; there will now be no current flow through the detector diode load, and consequently no negative voltage at point C. Under these conditions, point A is connected to earth through resistors 2R29, 2R28, 2R25, 2R26 and 2R27, and consequently the voltage at point B will be approximately 4·75V. This is the delay voltage, and as it is in opposition to the negative AGC voltage which appears at point C when a signal is being received, it follows that no negative AGC voltage can reach the controlled valves until a signal is received of strength sufficient to produce a voltage drop across 2R25, 2R26, 2R27 greater than 4·75V.

**23.** If the circuit were left as described above it would be possible, when no, or weak, signals were being received, for the positive delay voltage to appear in the AGC line. To prevent this from occurring, the second half of the double diode valve, 2V6b, is inserted between point B and earth, the cathode being connected to earth. So long as the normal negative bias is present in the AGC line, valve 2V6b will be in the non-conducting state, and consequently will not affect the circuit. If, however, the signal strength should fall to a level at which the positive delay voltage tends to appear at point B, the diode will conduct, effectively maintaining the AGC line at earth potential.

*AF amplifier*

**24.** The output from the detector to the grid of the AF valve 2V7 may be adjusted by the preset potentiometer 2RV1 (*fig.* 10). As in the other stages, automatic cathode bias is provided, the resistor in this instance being 2R33, and the cathode bypass capacitor being 2C43. The HT supply for the RF, IF and oscillator stages is taken through pin 8 of plug 2PL4, and is controlled by the send/receive relay. As the AF stage is used to amplify not only the received signals but also the transmitter side tone, a separate unswitched HT supply is necessary, and this is obtained through pin 4 of 2PL4. 2R34 is the voltage-dropping resistor for the screen supply, and is bypassed for AF by the capacitor 2C41. Capacitor 2C44 bypasses any RF which may appear in the anode circuit. The output from this stage is coupled to the load through transformer 2TR5, the output impedance being 150 ohms.

**Note . . .**

*The heater circuits of the receiver are described in para.* 11.

**Control and power circuits**

**25.** The control circuits, power circuits and the interconnections between the transmitter and the receiver are indicated in the simplified diagram, fig. 6. This diagram also indicates the external associated items in the simplest terms. In actual

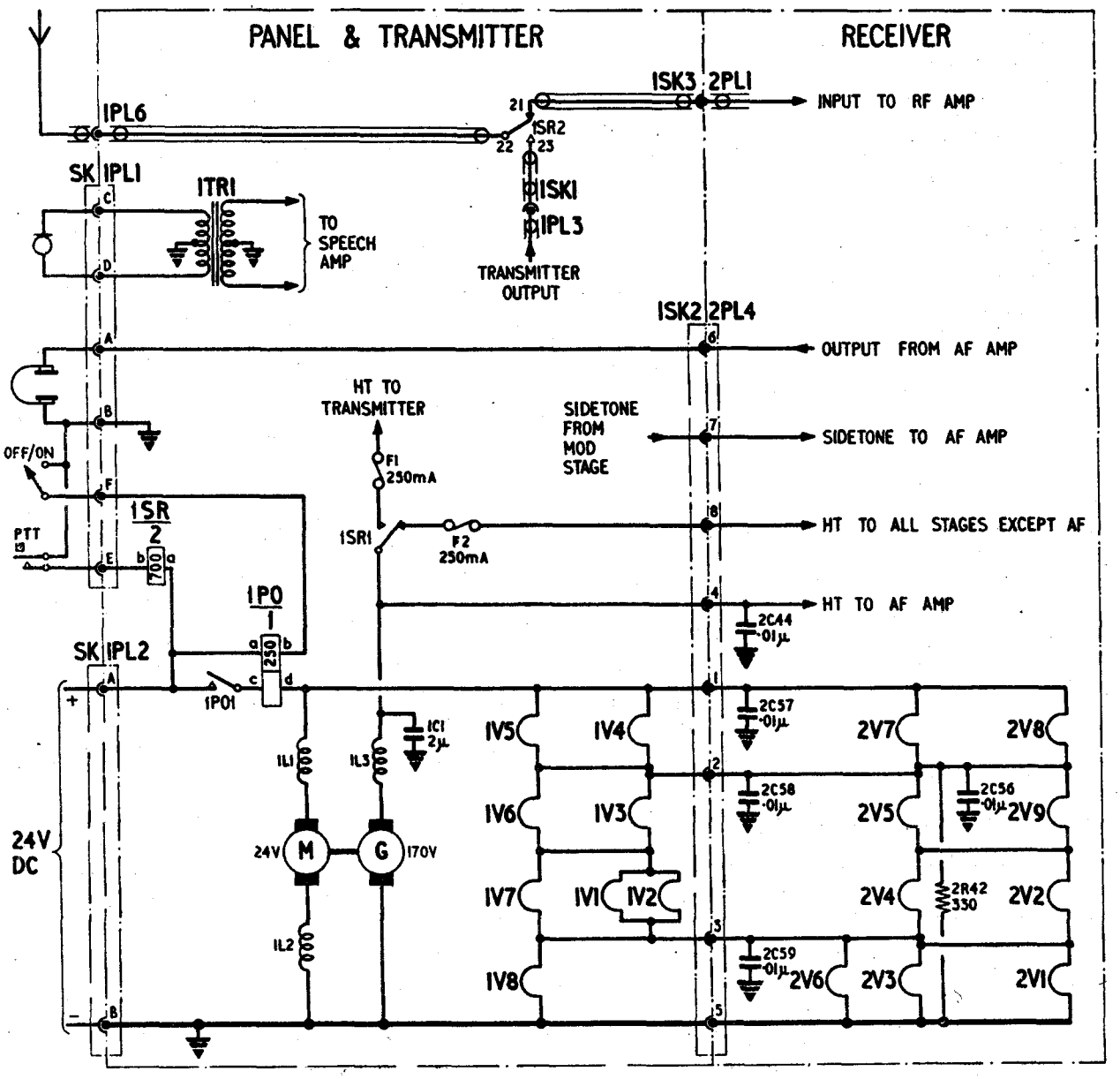



**Fig. 6. Simplified control, interconnection and power supply diagram**

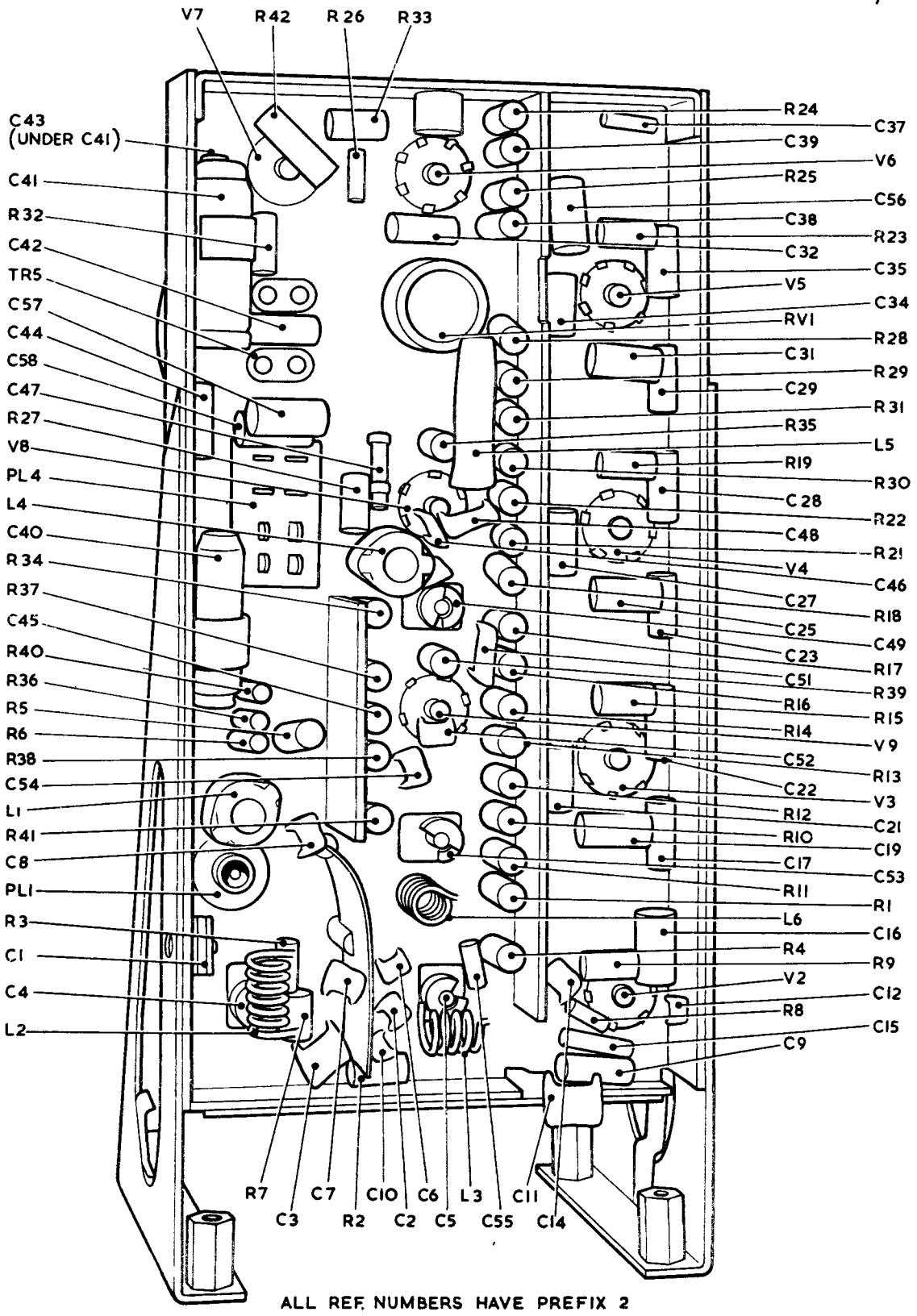
installations the circuitry external to the transmitter-receiver will be more complicated then it is here indicated, but the effects, in-so-far as the transmitter-receiver is concerned, will be the same. For details of the complete installations refer to Chap. 3.

**26.** Referring to fig. 6, it is seen that the 24V DC supply is applied to poles A and B of plug 1PL2, the aerial is connected through the coaxial plug 1PL6 to contacts 1SR2 of the send/receive relay, and the microphone, telephones, power on-off switch and the press-to-transmit switch are connected through plug 1PL1.

**27.** When the power switch is ON, current from the 24V battery flows through the 250 ohm winding of relay 1PO/1, causing contacts 1PO1 to close. This permits the 24V supply to reach the heater circuits of the transmitter and, through socket 1SK2 and plug 2PL4, of the receiver. The 24V supply also passes to the input brushes of the rotary transformer through inductors 1L1 and 1L2, with the result that the 170V HT supply becomes available at the output brushes, and passes through inductor 1L3 to contacts 1SR1 of the send/receive relay. The HT supply is smoothed by the 2 microfarad capacitor 1C1, inductors 1L1, 1L2 and 1L3 are provided to suppress RF interference from the brushes of the rotary transformer, and 0·01 microfarad capacitors are included in the heater circuit to complete the suppression. It will be noted, from the diagram, that the total load current passes through a low-resistance limit-hold winding of relay 1PO/1.

**28.** When the press-to-transmit switch is in the normal (receive) position, the send/receive relay is in the unenergized condition (as shown in the diagram), with the result that the aerial is con-

nected through relay contacts 1SR2, coaxial socket 1SK3 and plug 2PL1 to the receiver circuits, and the HT supply passes through relay contacts 1SR1 and pole 8 of socket 1SK2 and plug 2PL4 to all stages of the receiver with the exception of the AF stage. The AF stage of the receiver serves as side-tone amplifier when the transmitter is in use, and for this reason the HT supply to this stage is fed directly to the receiver through pole 4 of 1SK2 and 2PL4, and is not controlled by the send/receive relay. If the press-to-transmit switch is now set to the transmit position, the send/receive relay will be energized, contacts 1SR2 change the aerial over from the receiver input to the transmitter output circuit, and contacts 1SR1 transfer the HT supply from the receiver (with the exception of the AF stage) to the transmitter circuits.




ALL REF. NUMBERS HAVE PREFIX 2

Fig.7 Bottom view of receiver chassis Fig.7

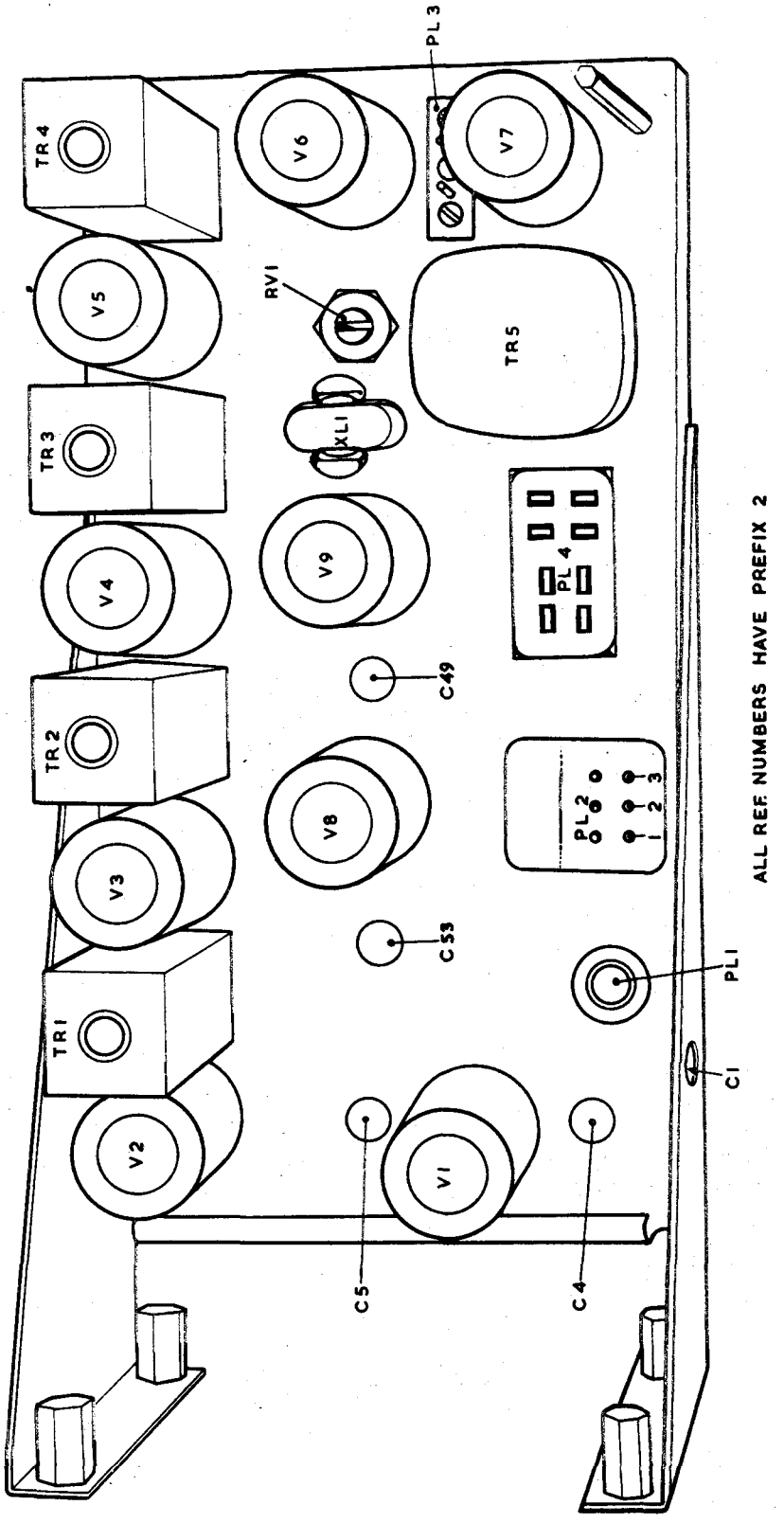



Fig. 8 Top view of receiver chassis Fig. 8

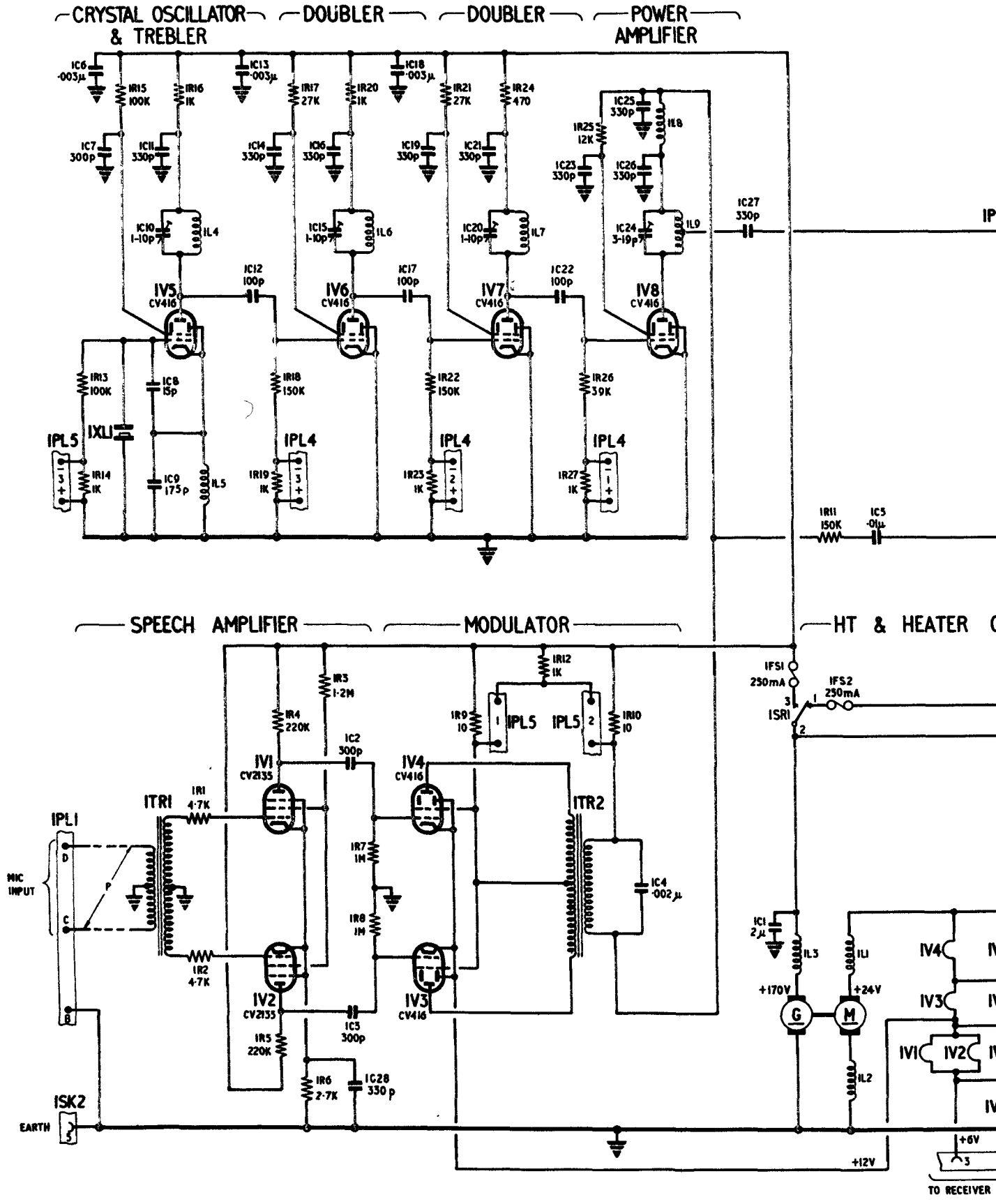



Fig. 9 Transmitter unit Type 98 - circuit

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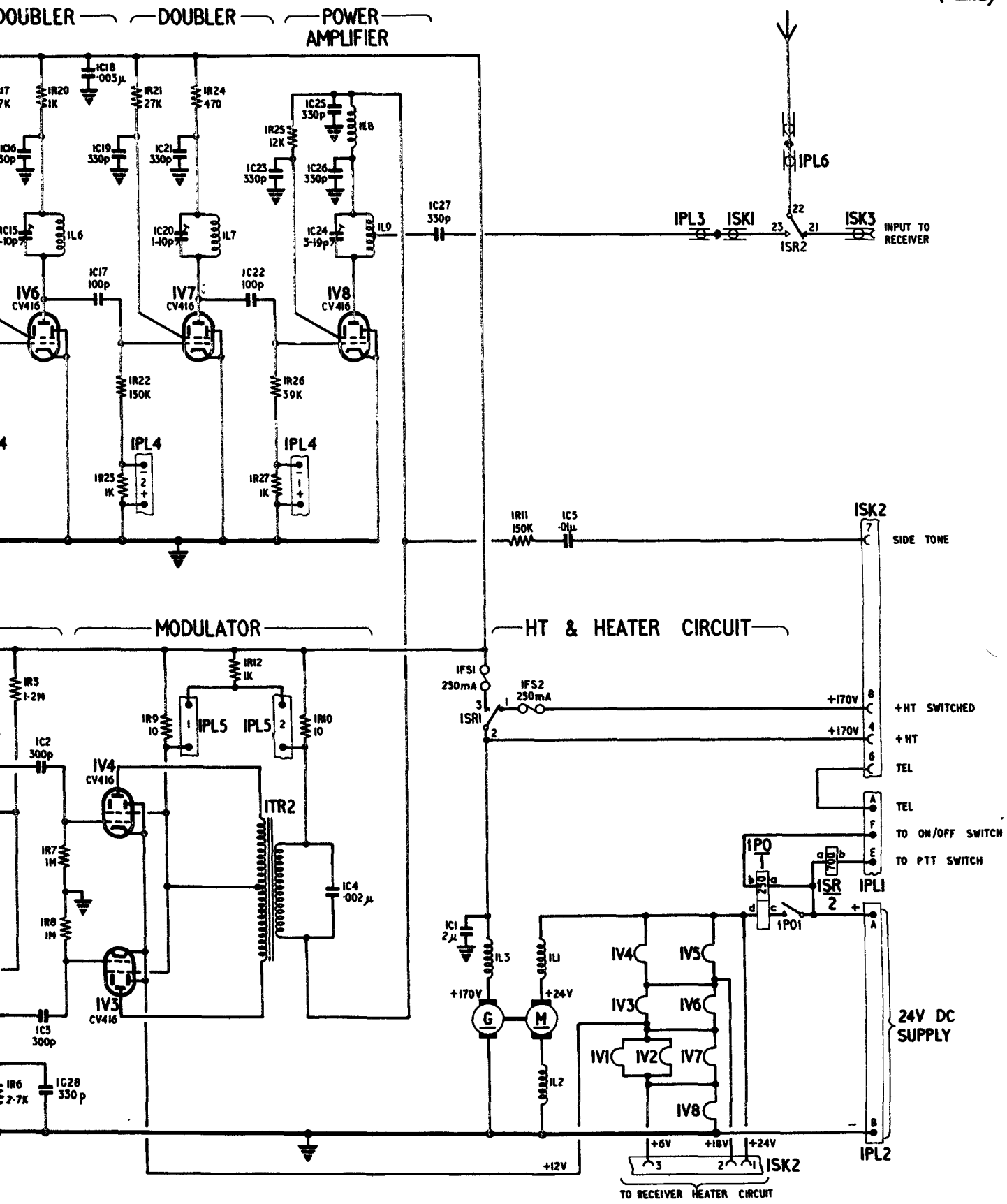


Transmitter unit Type 98 - circuit

Fig. 9

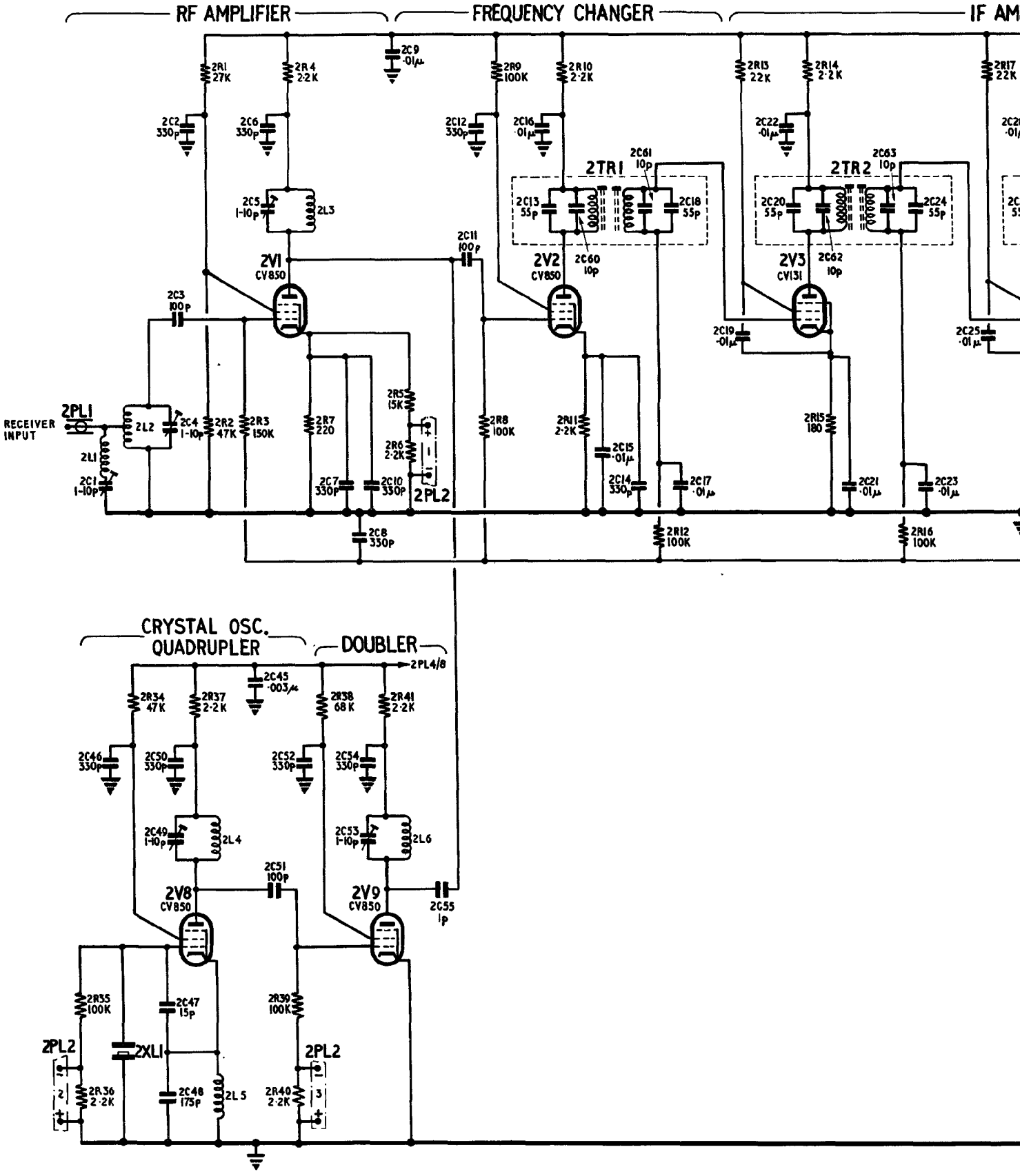


Fig.10

Receiver unit Type

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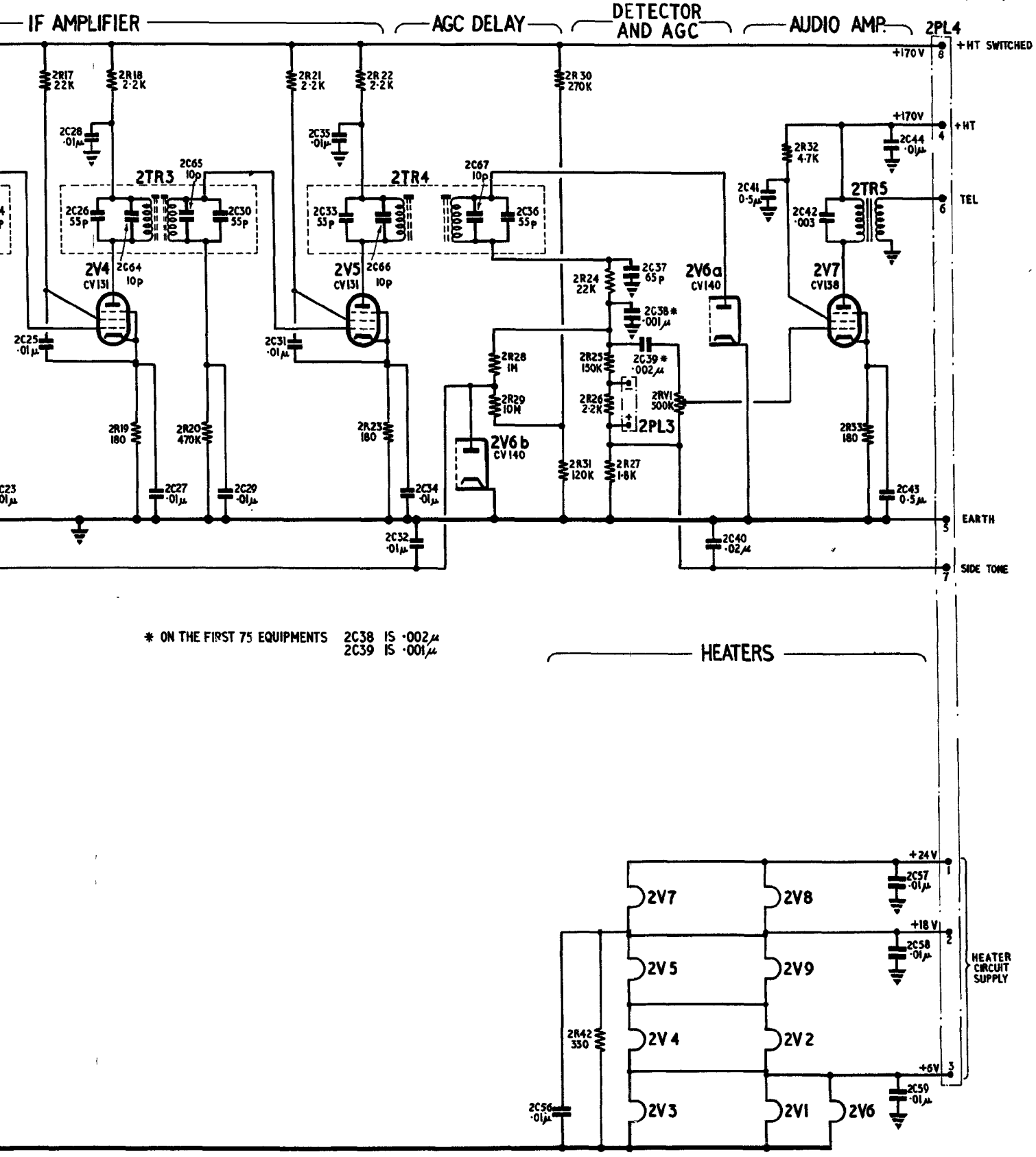


it Type 127 – circuit

Fig. 10

TRICTED

# Chapter 3

# INSTALLATIONS

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### Introduction

**1.** The function of the airborne radio installation ARI.18041 is to provide a stand-by VHF communication channel for use in the event of failure of the normal airborne VHF transmitter-receiver or power supply. The transmitter-receiver used in the stand-by installation is the Type TR.2002 which operates on a spot frequency of 121·5 Mc/s. The TR.2002 is described elsewhere in this volume. The installation is provided with its own aerial, Type 226, and may be operated from the normal 24V DC aircraft supply or, in some installations, from a 24V emergency supply provided by two small 12V accumulators (*Stores Ref.* 5J/3307) which are connected in series and housed in a battery box Type 15. In some installations battery box Type 15 cannot be used, and at the time of writing such installations have no source of emergency supply. Suitable stand-by batteries will, however, be eventually included in all installations.

**Note . . .**

*In no installation can the normal VHF installation be operated from the emergency supply.*

**2.** Details of the actual installation are varied to suit the particular aircraft in which it is fitted, and at the time of writing it is not possible to provide detailed information regarding all variations which may occur. For this reason, the description given in this chapter should be considered as representing a "typical" installation, and for accurate information regarding any specific installation, reference should be made to the appropriate aircraft publication.

### Typical airborne radio installation ARI.18041

**3.** Fig. 1 shows the interconnections of a typical installation ARI.18041, and Table 1 lists the items involved. It must be again emphasized that some installations may differ considerably from that shown, e.g., in some installations the 24V standby power supply is not yet provided, and in others, where carbon microphones are used, a special attenuator unit will be required. The general layout and the method of changing over from main to standby equipment is, however, similar for all installations.

**4.** The principal items of the standby installation are a transmitter-receiver Type TR.2002 (1), an aerial Type 226 (2), a switch, magnetic relay, Type S No. 4 (16), a single-pole change-over VHF switch (15), and a single-pole change-over SUPPLY switch (17). The latter switch is included only in installations with alternative power supplies. The normal pilot's microphone, telephones, and press-to-transmit switch are used both with the main and the standby equipment.

**5.** The aerial Type 226 is used with the standby transmitter-receiver only, and consequently is connected directly to the AERIAL plug (1PL6) of that instrument, no switching being necessary. The pilot's microphone, telephones and press-to-transmit switch (connected to terminal blocks (20), (21), and (22) ) are changed over from the main to the standby transmitter-receiver (or vice-versa) by the relay switch (16). When the main VHF transmitter-receiver is in use, the VHF switch (15) is set to NORMAL, enabling current from the normal 24V aircraft supply to flow through the winding of the relay switch. This energizes the relay (shown unenergized in fig. 1), with the result that the microphone, telephones and press-to-transmit switch are connected to the main VHF transmitter through the terminal blocks (3), (4) and (5).

**Note . . .**

*The input power supply for the main VHF transmitter-receiver is also taken from the normal 24V aircraft power supply, but as the wiring for this does not form part of installation ARI.18041 it is not indicated in the diagram.*

**TABLE 1**

**Principal items of a typical installation ARI.18041**

| Ref. No. in fig. 1 | Description | Stores Ref. |
|---|---|---|
| (1) | Transmitter-receiver Type TR.2002 | 10D/17997 |
| | *with* | |
| | Mounting Type 1028 | 10AJ/209 |
| | *or* | |
| | Mounting Type 1031 | 10AJ/212 |
| (2) | Aerial, aircraft, Type 226 | 10B/16566 |
| | *with* | |
| | Mounting Type 1031 | 10AJ/212 |
| (16) | Switch, magnetic relay, Type S4 | 5C/3945 |
| (15) | Switch, tumbler, Rotax, Type D5406 (VHF switch) | 5C/4179 |
| (17) | Switch, tumbler, Rotax, Type D5406 (SUPPLY switch) | 5C 4179 |
| (6), (8), (11), (13) (18), (19) | Block, terminal, Type B, 2-way | 5C 430 |
| | (*Note.—Terminal blocks* (3), (4), (5), (20) *and* (29) *are part of the main VHF installation*) | |
| — | Battery box Type 15 *with* Mounting Type 1029 } Some installations only | 10AP/189 |
| | | 10AJ/210 |
| General wiring | | |
| (10) | Cable, electric, L.T. Unipren 4 | 5E/3037 |
| (14) | Cable, electric, L.T. Unipren 6 | 5E 3038 |
| (9) | Cable, electric, L.T. Uniprenmet 4 | 5E 3089 |
| (12) | Connector, Type (Duvinmet small, 16, 5E/2932) | |
| (7) | Connector Type (Sextovinmetsmall, 2·5, 5E/2879) | |

# Chapter 4

# TRANSMITTER-RECEIVER TYPE TR2002A

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## LIST OF ILLUSTRATIONS



### Introduction

**1.** In the design of transmitter-receiver Type TR2002 no provision was made for the use of the speech amplifier and modulator for intercommunication (I/C). With the transmitter-receiver Type TR2002A (Ref. No. 10D/122941) this is accomplished by using transmitter-unit Type 98A (Ref. No. 10R/149). This unit enables the speech amplifier and modulator to be used for I/C purposes when the equipment is switched to "receive". The wiring changes between the transmitter units Type 98 and 98A are not great and are simplified by the introduction of a relay unit, having four contacts, which is substituted for the existing changeover relay. The facility of I/C can be switched in or out by transferring the I/C selector screw, located on the panel at the top of the relay box, from one position to a second position. An additional fuse 1FS3 has been fitted for the protection of the h.t. supply to the audio section.

**WARNING...**

**The I/C selector screw on the selector panel is at h.t. potential, and the equipment must be switched off before transferring the screw from the I/C OFF position to the I/C ON position. After adjustment the screw should be locked in position using the approved varnish to prevent it from loosening under vibration.**

### Circuit changes

**2.** The circuit of the transmitter unit Type 98A is similar to that of the transmitter unit Type 98 with the exception of the connections of the h.t. supply to the speech amplifier, modulator, power amplifier and receiver audio amplifier (*fig.* 1). The differences are as follows: —

(1) The h.t. connection from the receiver audio amplifier is removed from the unfused h.t. rail, and is rewired to the rail via fuse 1FS3, which is an additional item in TR2002A.

(2) A connection from the anode of power amplifier valve (1V8) to the modulation transformer (1TR2) is taken via relay contacts 1SR/4; these contacts are open on "receive" and closed on "transmit".

(3) Wired to the centre terminal of the I/C selector panel is the h.t. connection from the speech amplifier and modulator. In the I/C ON position it is connected to the h.t. rail via the I/C selector screw, an outer terminal of the selector panel, and fuse 1FS3. In the I/C OFF position it is connected to the h.t. rail via the I/C selector screw, the other outer terminal of the selector panel, fuse 1FS1 and a pair of contacts (SR3) on relay 1SR/4. These contacts are open on "receive" and closed on "transmit".

(4) The h.t. connection from the screen grids of the modulator valves (1V3 and 1V4) to the modulation transformer centre tap is taken via the 470K resistor 1R28. A pair of contacts (SR1) on relay 1SR/4 are arranged to short-circuit this resistor when the equipment is switched to transmit, maintaining the output of the modulator substantially constant in the receive and transmit conditions.

### Servicing

**3.** In transmitter-receiver Type TR2002 only two fuses 1FS1 and 1FS2 are fitted. With transmitter-receiver Type TR2002A it was found necessary to include an additional fuse 1FS3, and one of the original spare fuse holders was used for this purpose. This fuse safeguards the h.t. supply line to the audio section. Should any of these fuses fail, the cause should be ascertained before a new one is fitted. The fuses used are Type 153 (Ref. 10H/18680) and are housed in the fuseholders Type 102 mounted on the front panel of the transmitter-receiver. To renew a fuse, procedure in Part 2, Chap. 1, para. 14 should be followed.

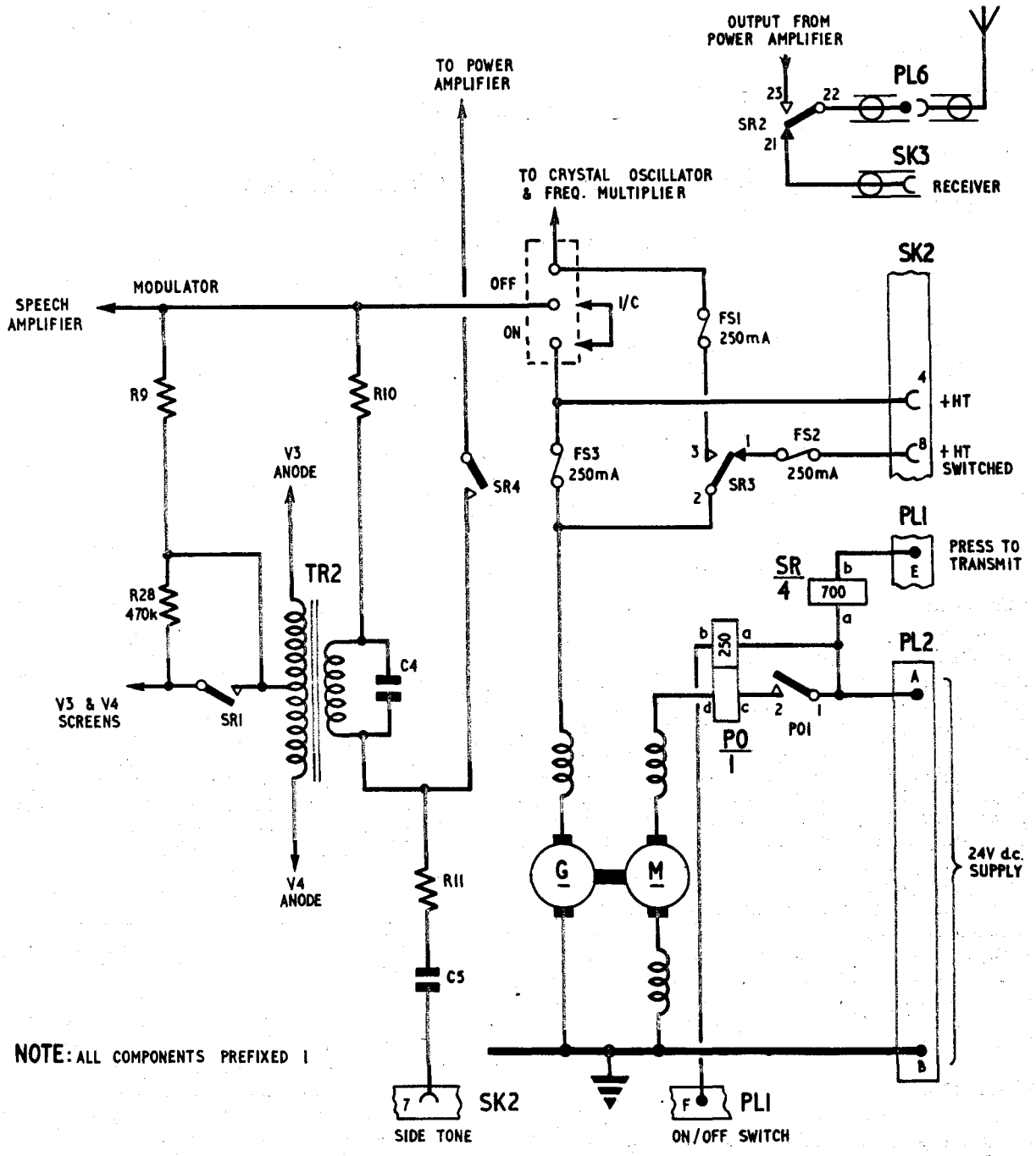


**Fig. 1. Circuit diagram of TR.2002A, showing wiring changes**

**4.** The relay 1SR/4 fitted to transmitter-receiver Type 98A to add the I/C facility should require little servicing, and under normal conditions should not be adjusted; if servicing does become necessary the instructions in Part 2, Chap. 1, para. 17 should be followed.

**Fault diagnosis**

**5.** Fault diagnosis for transmitter-receiver Type TR2002A is similar to that for Type TR2002 given in Part 3, Chap. 1. Faults which may occur due to additional relay contacts being added are: —

(1) No h.t. on speech amplifier and modulator causing non-operation of the I/C system; this may be due to relay contact 1SR3 being inoperative.

(2) Output of modulator not substantially constant in the "receive" and "transmit" conditions; this may be due to relay contact 1SR1 being inoperative and hence not short-circuiting resistor 1R28, causing variation in output level of the I/C system in the "transmit" and "receive" positions.

**PART 2**

# SERVICING

**RESTRICTED**

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**PART 2**

SERVICING

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***Note.***—*A list of contents appears at the beginning of each chapter*

# Chapter 1

# GENERAL SERVICING

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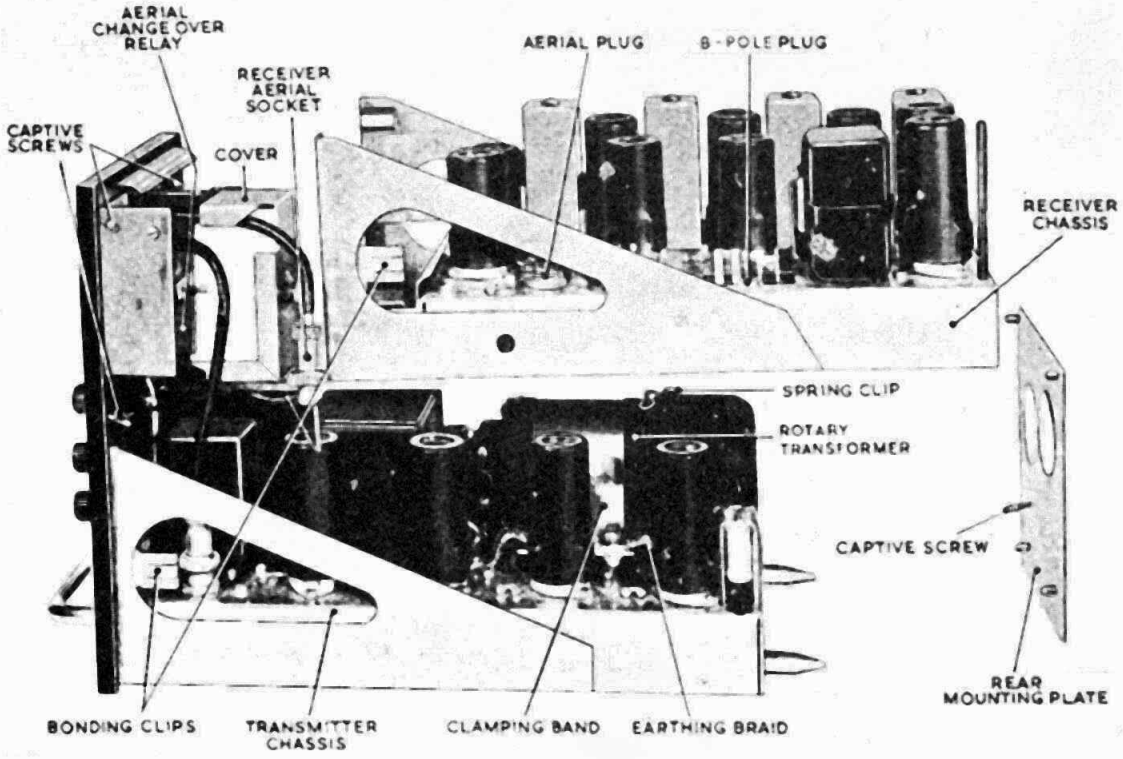


Fig. 1. Transmitter-receiver Type TR.2002, dismantling

#### Introduction

**1.** This chapter is to provide guidance regarding the general servicing of transmitter-receiver Type TR.2002. Instructions regarding the tuning and alignment of the equipment are given in Chapter 2 and 3, respectively, of this Part, and the locating of possible faults in the equipment are dealt with in Part 3.

#### Precautions

**2.** For the majority of servicing operations the case must be removed from the transmitter-receiver. Normally the power supply should be switched off or (preferably) disconnected while the equipment is in this condition, but for some operations and tests it is necessary to operate the equipment with the case removed. In these instances, due care must be exercised to avoid the risk of electrical shock, and also to avoid the possibility of the exposed wiring being short-circuited.

**3.** If the equipment is to be switched on for test purposes, first ensure that the transmitter and receiver are electrically interconnected through the normal plugs and sockets, and that all valves are in place. This is necessitated by the series parallel type of heater circuit employed. Where additional freedom is required for handling the units separately on the bench, the six-inch extension leads of connector set Type ARI.18041, bench testing (if available) may be interposed between the normal plugs and sockets.

**4.** Even minor items of servicing, such as changing valves, may affect the alignment of the equipment, and consequently, unless good reason exists to the contrary (*e.g.* need for renewal) any valves which are removed for testing or similar purposes should be returned to their original positions in the transmitter-receiver. Para. 37 and 38 provide an indication of the extent of retuning or re-alignment necessary subsequent to certain servicing operations.

#### Test bench connectors and junction box

*Connector set ARI.18041, bench testing*

**5.** The above connector set (Res. W.T.42854) has been designed to facilitate the servicing of transmitter-receiver Type TR.2002. It consists of five connectors as listed below, and is used in conjunction with a box, junction, Type 170 (*para.* 6).

*Junction box Type 170*

**6.** Junction box Type 170 (*Stores Ref. 10D 19216*) is used in conjunction with the above connector set for the bench-testing of transmitter-receiver Type TR.2002. It consists of a case approximately $3\frac{5}{8}$ in. × $1\frac{7}{8}$ in. × $2\frac{3}{4}$ in., one six-pole plug, one mic./tel. jack, two toggle switches, and the appropriate wiring. The six-pole plug is mounted on the back of the case and, when in use, is connected by item 1 of the above connector set to the CONTROL plug on the front panel of the transmitter-receiver. The jack is mounted on the centre front of the case, and serves to connect the microphone and telephones to the transmitter and receiver units. The toggle switches are mounted on the front of the case, one on either side of the jack, and function as starting switch and send/receive switch, respectively. Fig. 3 shows the internal wiring of the box, and its general appearance is indicated in fig. 2.

#### Renewing the batteries

**7.** The batteries are housed in a battery box Type 15 (*fig.* 4). To change the battery, unscrew the large knurled captive nut visible on the top

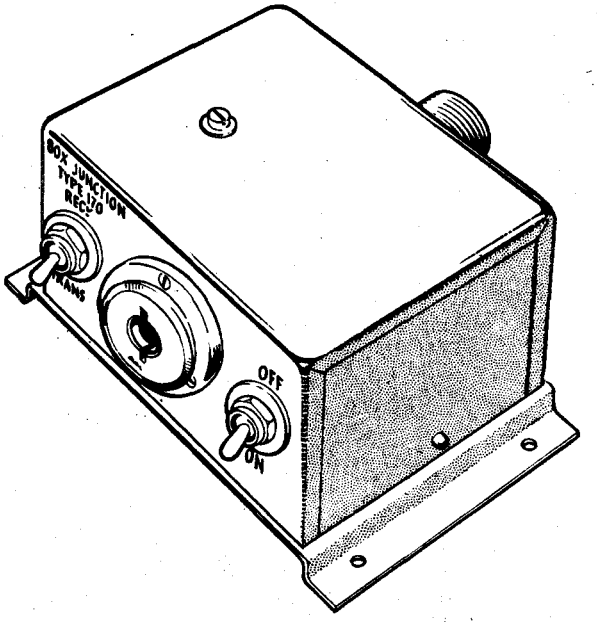


**Fig. 2. Junction box Type 170, general view**

**TABLE I**

**Connector set ARI.18041, bench testing**

| Item No. | Type No. | Stores Ref. No. 10HA/ | Length ft. | Length in. | Type of cable | Sleeve markings End "A" | Sleeve markings End "B" | No. off |
|---|---|---|---|---|---|---|---|---|
| 1 | B23/30A/6 | 13058 | 5 | 0 | — | Control TR.2002 | Mic/tel | 1 |
| 2 | B2/50E/1 | 13059 | 5 | 0 | — | TR.2002 | Supply | 1 |
| | | | 0 | 3 | | Supply | | |
| 3 | D243/51E/3 | 14566 | 0 | 6 | Uniradio 43 | 1SK3 | 2PL1 | 1 |
| 4 | 10104 | 14567 | 0 | 6 | — | 1SK2 | 2PL4 | 1 |
| 5 | D267/31A/1 | 13061 | 5 | 0 | Uniradio 67 | 1PL6 | Wattmeter | 1 |

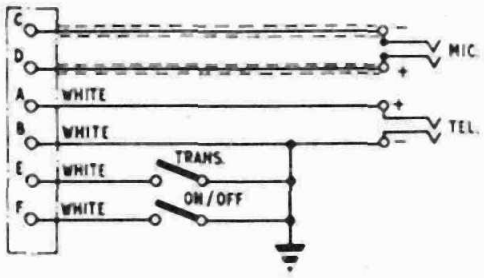


**Fig. 3. Junction box Type 170, circuit**

of the box and lift off the lid. The case will be seen to contain two 12-volt accumulators (*Stores Ref. 5J/3307*) connected in series, and each provided with a simple carrier. Unscrew the accumulator terminals and remove the two leads which connect to the output socket at the front of the box, also the short link which provides the series connection between the accumulators. Lift the accumulators from the box by means of the carriers, then transfer the carriers to the replacement accumulators. Insert the replacement accumulators in the box with the terminals towards the centre, connect them in series by means of the short link provided, and connect the red and black output leads to the appropriate terminals of the accumulators. Re-install the lid, and secure it with the large knurled nut. If it is desired to check the voltage of the accumulators without opening the box, this may be done at the terminal block mounted beside the output plug on the box front.

#### Dismantling and assembling the transmitter-receiver

**8.** In most instances the equipment is assembled by essentially a reversal of the dismantling procedure, and consequently no separate instructions are given.

*To remove the transmitter-receiver from the case*

**9.** With the power supply switched off or disconnected, unscrew the two coin-slotted captive screws at the rear of the case; then hold the case and withdraw the transmitter-receiver by means of the handle on the front panel.

*To remove the receiver unit from the transmitter unit (fig. 1)*

**10.** (1) Unscrew the locking ring of the receiver coaxial socket 1SK3 and withdraw it from the plug 2PL1 on the receiver chassis.

(2) Disconnect the 8-pole socket 1SK2 from the plug 2PL4 on the receiver chassis.

(3) Loosen the single captive screw which secures the rear mounting plate.

(4) While supporting the receiver chassis, unscrew the four captive screws on the front panel (the four screws nearest the top of the panel).

(5) Disengage the rear mounting plate from the transmitter and receiver chassis, and remove the receiver chassis, being careful to avoid damaging the components on its under side by contact with the transmitter chassis or other objects.

**Note . . .**

*When reassembling the transmitter-receiver, ensure that the opening in the rear mounting plate is in line with the air intake of the rotary transformer.*

*Transmitter unit*

**11.** It is unnecessary to detach the transmitter chassis from the front panel, as all components are readily accessible when the receiver chassis is removed.

#### Component location

**12.** By reason of the small size of the components used in the transmitter-receiver, it has not proved possible to provide all components with identification markings. The larger components are so marked, and reference to the circuit and component-location diagrams in Part 1, Chap. 2 should facilitate the location of the smaller items.

#### Cleaning

**13.** As noted earlier, care is necessary to avoid damage to the components, or movement of components or wiring which might affect the performance or alignment of the units. For this reason it is usually best to restrict cleaning of the chassis to the careful use of an air blower.

#### Fuses

**14.** Only two fuses, 1FS1 and 1FS2 are included in the actual transmitter-receiver. Fuse 1FS1 is connected in the transmitter, and fuse 1FS2 in the receiver HT supply circuits, both fuses being rated at 250mA. Should either of these fuses fail, the cause should be ascertained before a new one is fitted (Part 3, Chap. 1 suggests possible causes). The fuses used are Type 153 (*Stores Ref. 10H/18680*) and are housed in two fuseholders Type 102 mounted on the front panel of the transmitter-receiver. Two similar fuseholders are provided on the front panel to contain spare

**Fig. 4. Battery box Type 15**

fuses. To renew a fuse, unscrew the fuseholder cap, withdraw the expended fuse, insert the new one, and screw the cap home.

#### Valves

**15.** The valves fitted in this transmitter-receiver are of the miniature, glass-based type. They are each enclosed in a screening can which is secured by a bayonet catch. To remove a valve, press the can downward, turn it counterclockwise and lift it off, then withdraw the valve from its holder preferably using extracting tool Ref. Z970289. The valve should be drawn straight from the holder, as rocking the valve will result in the valve pins being distorted, and could produce air leakage at the pins. If the screening cans are to be removed, note that the cans fitted to the CV850 valves (2V1, 2V2, 2V8 and 2V9) are shorter than those fitted to the remainder of the receiver valves, and are not interchangeable with them. Note also that the cans for the CV2135 valves (1V1 and 1V2) are larger in diameter than those for the remainder of the transmitter valves.

**16.** Table 2 lists the valves to be used in transmitter-receiver Type TR.2002. Before installing any valve, make certain that the pins are in correct alignment, using the special valve pin adjusting tools as necessary.

**TABLE 2**

**Valves used in transmitter-receiver Type TR.2002**

| Valve number on circuit diagrams | Function | CV No |
|---|---|---|
| 1V1, 1V2 | Speech amplifier | 2135 |
| 1V3, 1V4 | Modulators | 416 |
| 1V5 | Oscillator and frequency trebler | 416 |
| 1V6, 1V7 | 1st and 2nd frequency doublers | 416 |
| 1V8 | Power amplifier | 416 |
| 2V1 | RF amplifier | 850 |
| 2V2 | Frequency changer | 850 |
| 2V3, 2V4, 2V5 | 1st, 2nd, 3rd IF amplifiers | 131 |
| 2V6 | Detector and AGC delay | 140 |
| 2V7 | AF amplifier | 138 |
| 2V8 | Oscillator and frequency quadrupler | 850 |
| 2V9 | Frequency doubler | 850 |

**Note . . .**

*When certain valves are changed it will be necessary to retune or re-align the unit affected. An indication of the action necessary is given under the heading "Effect of servicing on the tuning and alignment of TR.2002".*

#### Relays

**17.** The relays used in this transmitter-receiver should require little servicing, and by reason of the easily-damaged nature of the contacts and the difficulty of making accurate adjustments without special equipment, these items should not normally be interfered with. If it becomes necessary to clean the contacts this may be done using a small amount of carbon-tetrachloride, but any required servicing in excess of this should be considered as being third-line.

**18.** The send/receive relay is mounted on the back of the front panel, immediately below the aerial plug. The rear end of the plug and the relay are each enclosed in a separate compartment of a small screening box Access is by unscrewing a knurled captive nut and pulling the cover straight off (*fig. 1*).

**19.** The starter relay, which controls the power supply to the valve heaters and the rotary transformer, is mounted in the transmitter chassis immediately below the front end of the rotary transformer. It is enclosed in a plastic cover which cannot be removed while the relay is in the transmitter. The relay is secured to the chassis by two screws and locknuts, the screw heads being visible below the choke located at the forward end of the rotary transformer; it may be necessary to remove the choke to obtain access to these screws.

#### Preset controls

**20.** The preset capacitor 1C24 which tunes the power amplifier stage of the transmitter is locked by a small screw located near the capacitor spindle and visible on the top of the chassis. This screw must be loosened before adjusting the capacitor and tightened after adjustment. The remainder of the preset controls of the transmitter and receiver units have friction sufficient to prevent their accidental movement, while at the same time permitting the necessary adjustments to be made. As a result of this, no locking or unlocking action is necessary either before or after adjustment of these controls. Note in particular that the large conical nut on the receiver preset gain control must not be interfered with, as it serves to secure the control to the chassis. The fact that the friction device is housed in this nut is purely incidental; no provision is made for the adjustment of the degree of friction. The tuning slugs of the IF transformers are secured against accidental movement by an initial application of a silicone sealing compound (Admiralty Pattern 7003). This compound, while being adequate to prevent the accidental movement of the slugs, is non-setting, and consequently requires no softening treatment before the adjustment is made. The application of additional compound should not be necessary except in special circumstances, *e.g.* when a new tuning slug is fitted. If a new slug is to be fitted, the compound should be worked well into the threads of the slug, and a little applied to the interior of the coil former so that it will be carried well into the threads when the slug is inserted.

#### Rotary transformer

**21.** The rotary transformer used with this equipment is Type 119 (*Stores Ref. 5UB/5908*). It operates on an input power supply of 21 to 29 volts. At the rated input of 26 volts it provides an HT output of 170 volts while supplying a current of approximately 90mA. As illustrated in fig. 5, it is installed on an anti-vibration mounting at the rear of the transmitter chassis.

##### *Access to commutators and brush gear*

**22.** For access to the rotary transformer, first remove the receiver chassis, as described in para. 10. It will now be seen that no cover is

provided at the front (or output) end of the rotary transformer. The cover at the rear (or input) end is secured by two hairpin-type clips, one at the top and one at the bottom of the cover, which engage with studs on the body of the machine.* To remove the cover, release both clips, making certain that the lower one does not foul the wiring, then draw the cover straight off. When refitting the cover, ensure that the input leads to the brush boxes are accommodated in the two small slots in the lower half of the cover, that both clips are properly engaged, and that the cover is correctly seated against the flange of the rotary transformer, so that it does not foul the impeller vanes. This is important, as even a slight interference between the impeller and its cover could result in damage to the impeller, damage to the bearings, and overloading of the rotary transformer with consequent sparking at the brushes and the production of RF interference. If brushes are to be renewed it will be necessary to remove the rotary transformer from the chassis.

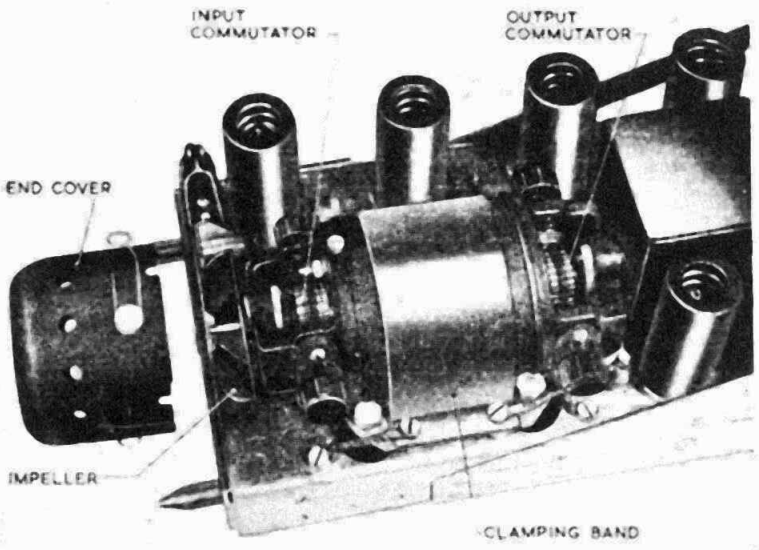


**Fig. 5. Rotary transformer Type 119**

*To remove the rotary transformer from the chassis*

**23.** To remove the rotary transformer from the chassis, first remove the four screws which secure the earthing braid and the rotary transformer clamping band to the anti-vibration mounting (*fig. 5*); then move aside the earthing braid while holding the rotary transformer to avoid risk of damage to the wiring. The rotary transformer may now be gently raised a little, the end cover taken off, and the screws securing the wiring tags to the terminal extension lugs (below the brushes) removed. The terminal extension lugs must be supported when disconnecting the leads, as unsupported pressure may cause permanent damage. The rotary transformer is now entirely free of the chassis and may be removed. The wiring tag screws should be replaced in position to avoid loss. With the possible exceptions of the renewal of brushes or impellers, the machine may not, on any account, be further dismantled at second-line servicing.

*Examination of the rotary transformer*

**24.** When servicing the rotary transformer, both commutators should be examined for traces of arcing, burning or discolouration. The track portion of each commutator should be of a uniform colour between light chocolate and dark grey, the brush track on the output commutator being normally slightly darker than that on the input commutator. If there are traces of local burning, or if blackened segments occur at regular or irregular intervals, reference should be made to Part 3, Chap. 1, Table 3 which indicates possible causes of these symptoms. If the damage is in excess of that dealt with in the subsequent paragraphs, or if a rotary transformer requires servicing in excess of the facilities available at the user unit, a replacement machine should be fitted and the removed one returned to the appropriate Maintenance Unit.

* On later rotary transformers the cover may be secured by four screws.

*Commutators*

**25.** Commutators which are dirty (as distinct from worn, pitted or burnt) may be cleaned using a piece of clean cloth moistened with unleaded petrol. Care should be taken to restrict the petrol to the area being cleaned, and time should be allowed for all petrol to evaporate before the machine is again switched on. No grease or oil of any kind may be permitted on the commutator or brushes, and contamination of the surface with the fingers must also be avoided. In no instance may abrasives of any kind be used for cleaning the commutators. Should the commutators require servicing in excess of the above, the machine must be returned for third-line servicing.

*Brushes*

**26.** When re-installing a brush which has been removed for examination or any other reason, it is essential that it be returned to its original holder and to its original orientation in the holder. If this is not done the brush will not bed properly on the commutator.

**27.** If excessive sparking occurs at the brushes they should be removed and examined for wear, for freeness in the holder, and for satisfactory bedding on the commutator. In this machine the brushes should normally be renewed when worn for more than one quarter of their length, as continued use after this stage has been reached may result in unsatisfactory operation due to the reduced spring pressure.

**28.** If a brush shows signs of sticking in its holder, the holder should be cleaned with unleaded petrol. If this does not produce the desired result, the sides of the brush may be carefully smoothed with grade 000 glasspaper, being careful to remove the

# Chapter 2

# TUNING THE TRANSMITTER AND RECEIVER

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### Introduction

**1.** The transmitter and receiver are normally correctly aligned and tuned when received from the factory, and should require no adjustment before being put into service. A few units may be supplied without crystals, but these units are also pretuned, and it should only be necessary to insert the correct crystals. Should it be found necessary to retune any unit, the methods detailed in the subsequent paragraphs may be applied.

**Note . . .**

*The operations described in this chapter should be performed only by authorized personnel, and where suitable test equipment is available. Specific test equipment is listed in the following paragraphs, but the methods described may be applied using approved alternative equipment. The meter readings quoted in this chapter assume an input power supply of exactly 24V.*

### Preliminary operations

**2.** (1) With the power supply switched off or disconnected, unscrew the two coin-slotted screws at the rear of the case, and remove the case.

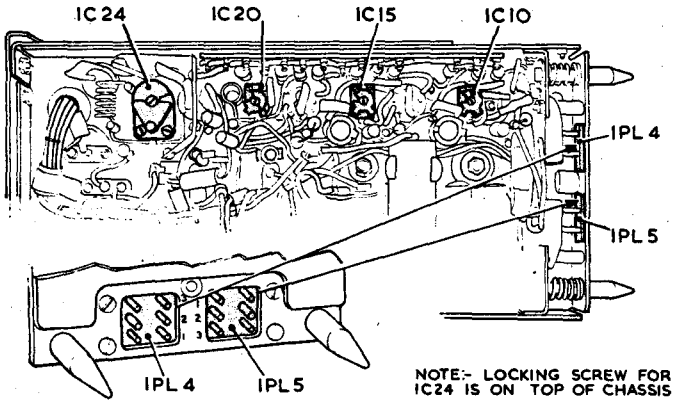


**Fig. 1. Transmitter tuning controls**

(2) Place the transmitter-receiver in a position where the trimming capacitors are accessible and there is no risk of the exposed wiring being accidentally short-circuited. The receiver unit may be tuned when installed on the transmitter unit, but must be removed to provide access to the power amplifier tuning capacitor locking screw if the transmitter is being tuned.

### WARNING

*When operating the equipment with the case removed, care must be taken to avoid the possibility of electrical shock from the exposed wiring.*

### Tuning transmitter unit Type 98

**3.** The following equipment is required:—

| | Stores Ref. |
|---|---|
| Milliammeter 0–1 (75 ohms) | 5Q/11843 |
| *or* | |
| Testmeter Type 26 | 10S/16401 |
| Wattmeters, VHF, CT87 | 10S/16415 |
| *or* | |
| Test set X740A (*when available*) | |
| Connector set ARI.18041, bench testing (*Chap. 1*) | |
| Box, junction, Type 170 | 10D/19216 |

**4.** Proceed as follows:—

(1) Connect wattmeter, VHF, CT87 to the AERIAL plug on the front panel (connector, 10HA/13061), the power supply to the BATTERY plug (connector 10HA/13059), and the other associated items of equipment, (junction box, telephones and microphone) to the CONTROL plug (connector 10HA/13058). Insert the correct crystal (10X/ZDH/10125 Kc/s) if this has not already been done.

(2) Switch on the power supply and permit the equipment to warm up. Set the TRANSMIT/RECEIVE switch on the junction box to TRANSMIT.

(3) Check the RF voltage across the crystal by connecting the 0–1 milliammeter to test plug 1PL5/3. The voltage should not exceed 15V RMS, as indicated by a meter indication of 150 microamp. Should a reading in excess of this be obtained, try changing valve 1V5 and/or the crystal.

(4) Connect the meter to test plug 1PL4/3 (in the grid circuit of the first frequency-doubler valve, 1V6) and, using a non-metallic tool, adjust trimming capacitor 1C10 for maximum meter indication.

(5) Connect the meter to test plug 1PL4/2 (in the grid circuit of the second frequency-doubler valve, 1V7) and adjust trimming capacitor 1C15 for maximum meter indication.

(6) Connect the meter to test plug 1PL4/1 (in the grid circuit of the power amplifier valve, 1V8) and adjust trimming capacitor 1C20 for maximum meter indication.

(7) Loosen the small locking screw visible on top of the chassis adjacent to the spindle of the trimming capacitor 1C24, then adjust the capacitor for maximum output as indicated by wattmeter CT87, and tighten the locking screw.

(8) The unmodulated output, as indicated by the wattmeter CT87 connected to the AERIAL socket, should exceed 1W (i.e., 1W into a 45-ohm resistive load).

(9) The modulation may be checked by speaking into the microphone; sidetone should be audible in the telephones.

**Note . . .**

*Table 1 shows typical readings as obtained at the test plugs.*

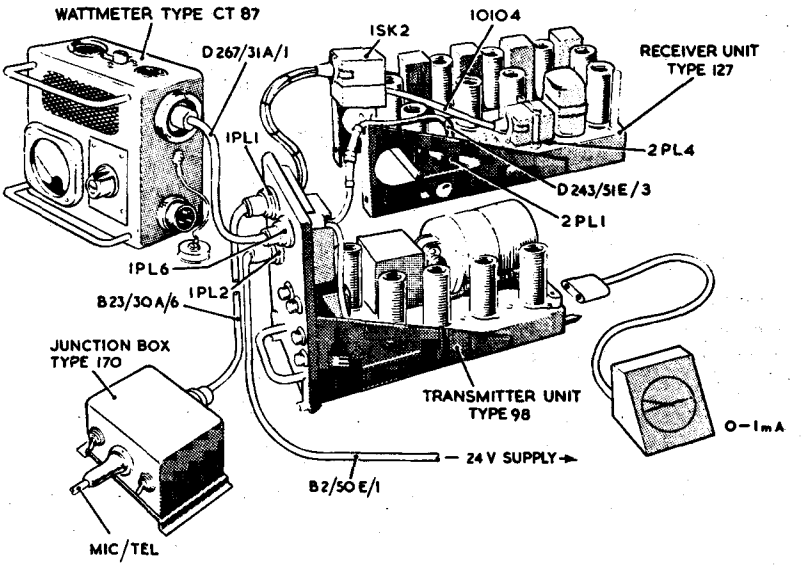


**Fig. 2. Test bench layout for transmitter tuning**

**Tuning receiver unit Type 127**

**5.** The following equipment is required:—

| | *Stores Ref.* |
|---|---|
| Signal generator Type 62 | 10S/16318 |
| *or* | |
| *Signal generator Type 31 | 10S/66 |
| Microammeter 0–100 | 5Q/19854 |
| *or* | |
| Testmeter Type Y | 10S/16379 |
| Connector set, Type ARI.18041, bench testing (*Chap. 1*) | |
| Box, junction, Type 170 | 10D/19216 |

**Note . . .**

**If the signal generator Type 31 is used, the output terminating unit should be modified by connecting a 33-ohm ±10 per cent, ½ watt resistor, insulated, grade II, between the 14 ohms insulated terminal and the centre pin of the end portion only of socket ref. Z56044. Also, a connection should be made from the earth terminal to the outer of the socket. It is essential that the connecting wires shall not exceed ½ in. in length.*

**6.** Proceed as follows:—

(1) With the transmitter-receiver removed from the case and the power supply, junction box, and telephones connected as in para. 4, insert the crystal (10X/ZDH/13972·5 Kc/s) if this has not already been done, then switch the equipment ON, set the TRANSMIT/RECEIVE switch to RECEIVE, and permit the set to warm up.

(2) Check the RF voltage developed across the crystal by connecting the microammeter to test plug 2PL2/2. The voltage should not exceed 10V RMS, as indicated by a meter reading of 85 microamps. Should a reading in excess of this figure be obtained, try changing the oscillator valve (2V8) and/or the crystal.

(3) Connect the microammeter to test plug 2PL2/3 (in the grid circuit of the frequency-doubler valve, 2V9) and adjust trimming capacitor 2C49 for maximum meter indication.

(4) Adjust the signal generator for an output frequency of 121·5 Mc/s modulated to a depth of 30 per cent at 1,000 c/s.

(5) Apply the output of the signal generator to the AERIAL plug of the transmitter-receiver (connector 10HA/13061 of the connector set may be used), and connect the microammeter to test plug 2PL3 (in the detector diode circuit).

**Note . . .**

*While the undernoted tuning operations are being performed, the signal generator output should be adjusted to keep the diode current, as indicated by the microammeter, below 30 microamps, ensuring at the same time that the signal generator is tuned to give a peak diode current at each stage of alignment. This is necessary, as a number of factors, including the necessity for adjusting the signal generator attenuator, may slightly affect the output frequency of the signal generator.*

(8) Adjust the signal generator to 102·06 Mc/s.

(9) With the above frequency applied to the aerial plug, adjust trimming capacitor 2C1 (the second-channel rejection trimmer) for maximum dip, increasing the signal generator output as necessary while doing so. To produce a 30 microamp indication on the meter, the signal generator output required should be at least 50dB greater than that required at operation (7).

(10) When tuning has been satisfactorily performed, switch off the transmitter-receiver, disconnect the test equipment, and re-install the transmitter-receiver in its case.

**Note . . .**

*Table 1 shows typical meter readings as obtained at the test plugs.*

**Adjustment of receiver AF gain control**

**7.** Equipment required:—

| | *Stores Ref.* |
|---|---|
| Signal generator Type 62 | 10S/16318 |
| Microammeter 0–100 | 5Q/19854 |
| *or* | |
| Test meter Type Y | 10S/16379 |
| Output meter Type 2 | 10S/11934 |
| Connector set Type ARI.18041, bench testing (*Chap. 1*) | |
| Box, junction, Type 170 | 10D/19216 |

**8.** Proceed as follows:—

(1) With the transmitter-receiver removed from the case and connected to the bench installation as in para. 6, connect the microammeter to plug 2PL3 (in the detector diode circuit), and connect the output meter Type 2 across the ± leads of a mic/tel connector plugged into the junction box Type 170.

(2) Adjust the signal generator for an output at 121·5 Mc/s with 70 per cent modulation at 1,000 c/s. Apply this output to the aerial socket of the transmitter-receiver, and adjust the signal generator attenuator to produce a diode current indication of 30 micro-amp.

(3) Adjust the preset AF gain control of the receiver to produce an output of 50 milliwatt into 150 ohms, as indicated on the output meter Type 2.

**Note . . .**

*The gain control is self-locking, consequently no locking or unlocking action is necessary before or after adjustment.*

**Typical meter readings**

**9.**

**TABLE I**

**Typical meter readings at test plugs**

| Test plug | Circuit | Typical reading (microamps) | Remarks |
|---|---|---|---|
| Transmitter | | | |
| 1PL4/1 | 1V8, grid circuit | 750 | |
| 1PL4/2 | 1V7, grid circuit | 550 | |
| 1PL4/3 | 1V6, grid circuit | 250 | |
| 1PL5/1 | 1V3, 1V4, anode circuit | 120 | |
| 1PL5/2 | 1V8, anode circuit | 200 | |
| 1PL5/3 | 1V5, grid circuit | 120 | This represents 12V RMS across the crystal. Reading is not to exceed 150 microamp. |
| Receiver | | | |
| 2PL2/1 | 2V1, cathode circuit | 75 | With no signal applied |
| 2PL2/2 | 2V8, grid circuit | 80 | Must not exceed 85 microamp |
| 2PL2/3 | 2V9, grid circuit | 50 | |
| 2PL3 | 2V6A, detector diode circuit | — | A diode current of 30 microamp should be obtained with a RF input of not greater than 10 microvolt |

**Note . . .**

*The above readings were taken with an input power supply of exactly 24V, and using the specified 0–1 milliammeter for all transmitter measurements and the 0–100 microammeter for all receiver measurements. Changes in the input voltage applied or in the test equipment used may cause differences in the readings. Except where limits are given in the above table, the figures quoted should be regarded as being for guidance only, as the readings will vary in different equipments.*

# Chapter 3

# IF ALIGNM NT

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## LIST OF ILLUSTRATIONS



### Introduction

**1.** The IF alignment and bandwidth adjustment operations detailed below will normally be performed at third-line servicing only. The incremental scale of the signal generator must be calibrated before it is used for the bandwidth measurements; para. 3 provides instructions for this operation. Once performed, the calibration should hold good for a considerable time; it should, however, be checked at reasonable intervals, say, once per month, to ensure that accuracy is maintained.

### Equipment required

**2.** The following equipment is required:—

| | *Stores Ref.* |
|---|---|
| Signal generator Type 56 | 10S/647 |
| *or* | |
| Signal generator Type 57 | 10S/695 |
| Microammeter 0–100 | 5Q/19854 |
| *or* | |
| Test meter Type Y | 10S/16379 |
| Frequency meter set SCR–211–M (or one of the SCR–211 series) | |
| Connector set Type ARI.18041, bench testing (*Chap. 1*) | |
| Box, junction, Type 170 | 10D/19216 |

### Calibration of signal generator incremental scale

**3.** To obtain accurate bandwidth measurements it is necessary to calibrate the incremental scale of the signal generator. This may be done, using frequency meter SCR–211–M as described below:—

(1) Set up the frequency meter, then set the FREQUENCY control of signal generator Type 56 to 9·72 Mc/s with the INCREMENTAL TUNING control at zero, and connect its output to the frequency meter as described in A.P.2538HA, Vol. 6, Part 2, Sect. 2, Chap. 3.

(2) Rotate the INCREMENTAL TUNING control of the signal generator clockwise to +5 divisions, then rotate the tuning control of the frequency meter clockwise until a zero beat is obtained in the telephones (plugged into the frequency meter), and note the frequency meter dial reading. Proceed in this manner for every five divisions of the INCREMENTAL TUNING control, i.e., for +10, +15, +20, and so on to +50 divisions.

(3) Return the INCREMENTAL TUNING control of the signal generator to the zero position.

(4) Rotate the INCREMENTAL TUNING control of the signal generator counter-clockwise to −5 divisions, then rotate the tuning control of the frequency meter counter-clockwise until a zero beat is obtained, and note the dial reading. Proceed in this manner for every five divisions of the INCREMENTAL TUNING control, i.e., −10, −15, −20, −25 and so on to −50 divisions.

(5) Convert the frequency meter dial readings obtained to frequencies, using the calibration charts provided with the frequency meter. It will be necessary to interpolate if the dial readings fall between two calibration points on the chart. List the frequencies in terms of

| INCREMENTAL SCALE SETTING (DIVS) | -20 | -15 | -10 | -5 | 0 | +5 | +10 | +15 | +20 |
|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY (Kc/s) | -72 | -54 | -36 | -18 | 0 | +18 | +36 | +54 | +72 |

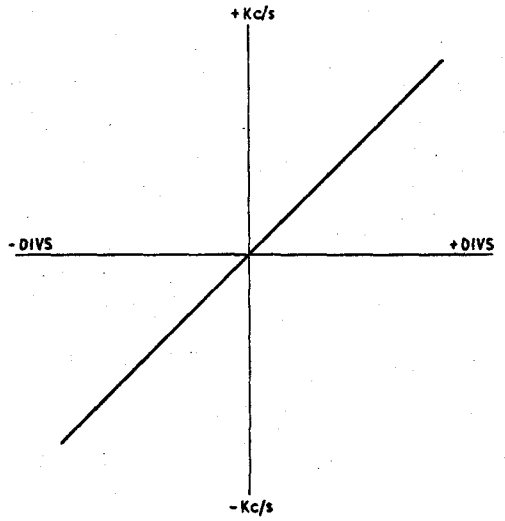


**Fig. 1. Typical form of calibration diagram for signal generator incremental tuning control**

kilocycles above and below 9·72 Mc/s, as indicated in fig. 1.

(6) Plot a graph of ± kc/s against divisions of the INCREMENTAL TUNING scale in the form indicated in fig. 1.

(7) The signal generator INCREMENTAL TUNING scale having been calibrated, proceed with the IF alignment as follows:—

**IF alignment and bandwidth adjustment** *(fig. 3)*

**4.** (1) With the input power supply switched off or disconnected, remove the transmitter-receiver from the case.

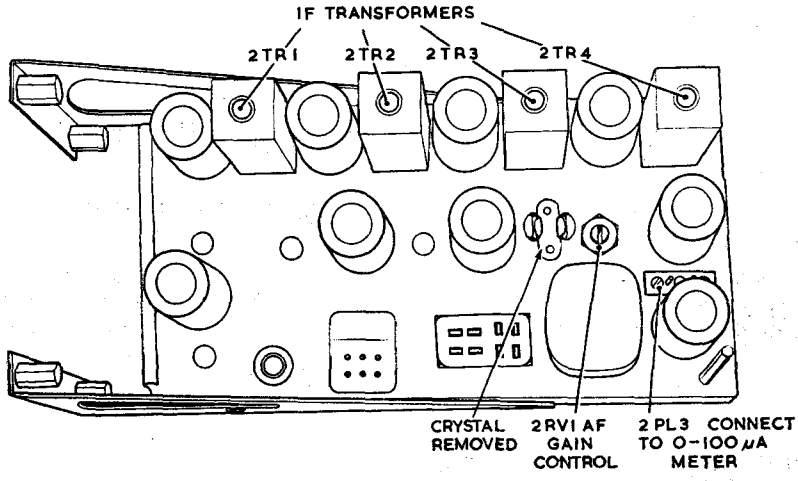


**Fig. 2. Receiver unit Type 127, tuning and test points for IF alignment**

(2) Remove the receiver from the front panel (*Chap. 1, para. 10*).

(3) Position the receiver chassis so that both sides are accessible, and connect sockets 1SK2 and 1SK3 of the transmitter to plugs 2PL4 and 2PL1 of the receiver by means of the six-inch extension leads of the connector set (Ref. 10HA/14567 and 10HA/14566, respectively).

(4) Connect the 24V supply to the BATTERY plug using connector Ref. 10HA/13059, and the remaining items of the bench installation (junction box Type 170, telephones, and microphone) to the CONTROL plug on the front panel by means of connector Ref. 10HA/13058).

(5) Remove the receiver crystal, and connect the microammeter to plug 2PL3 at the rear of the receiver chassis (*fig. 2*). When connected in this position the meter provides an indication of the detector diode current.

(6) Adjust the signal generator to produce an unmodulated output at 9·72 Mc/s frequency with the INCREMENTAL TUNING control at zero.

(7) Connect the earthy side of the signal generator output to the receiver chassis, and the other side to the grid of the frequency-changer valve 2V2 through a 0·1 microfarad shielded capacitor. A length of Uniradio 42 and the spare cable connector (10A/17695) from the signal generator should be used as the signal generator output connector.

(8) Switch on the transmitter-receiver and the signal generator, and permit them to warm up. Set the TRANSMIT/RECEIVE switch on the junction box Type 170 to RECEIVE.

(9) Adjust the signal generator output to produce a 30 microamp indication on the meter connected to 2PL3.

(10) Using a non-metallic tool, adjust the primary and secondary tuning slugs of the IF transformers for maximum output, and at the same time adjust the signal generator output as necessary to maintain the meter indication at the 30 microamp level.

**Note . . .**
*The tuning slugs are secured against accidental movement by an application of a silicone sealing compound (Admiralty Pattern 7603) This compound is non-setting, and consequently no action is necessary before adjusting the slugs. Unless a slug is to be renewed no additional sealing should be necessary on completion of tuning.*

(11) Increase the signal generator output by 6dB (i.e., by two times); the microammeter will now indicate, say, 40 microamp.

(12) Increase the *frequency* of the signal generator output (using the INCREMENTAL TUNING control) until the microammeter again indicates 30 microamp, and note the frequency setting of the control.

(13) Decrease the signal generator output frequency below 9·72 Mc/s by means of the INCREMENTAL TUNING control until the meter again indicates 30 microamp, and note the frequency setting. Convert the incremental scale readings obtained at (12) and (13) to Kc/s by means of the calibration graph. The difference between the two settings gives the bandwidth at 6dB down.

(14) The bandwidth as ascertained above should be not less than 70 kc/s (35 kc/s above, and 35 kc/s below 9·72 Mc/s).

(15) Should the bandwidth at 6dB down be unsymmetrical to the extent that the conditions at (14) are not met, it should be corrected by detuning the primary of the first IF transformer 2TR1 (the primary tuning slug is at the top end of the transformer). If the bandwidth is wide on the +ve side, screw the slug in; if wide on the −ve side, screw the slug out.

(16) Set the signal generator for an output frequency of 9·72 Mc/s with the incremental tuning control at zero, and adjust the output to produce a 30 microamp indication on the meter connected to 2PL3. Note the signal generator output required, and increase it by 40dB (i.e., by 100 times). This will produce a meter indication of about 80 microamp.

(17) Using the INCREMENTAL TUNING control, increase the signal generator frequency until the meter indication falls to 30 microamp, and note the reading on the incremental scale. Decrease the frequency below 9·72

Mc/s until the meter again indicates 30 microamp, and again note the reading on the incremental scale. The difference between the two readings (when converted to kc/s) will be the bandwidth at 40dB down; it should not exceed 260 kc/s, i.e., 130 kc/s above and below 9·72 Mc/s.

**Adjustment of the audio gain control**

**5.** The following equipment is required:—

| | *Stores Ref.* |
|---|---|
| Signal generator Type 56 | 10S/647 |
| *or* | |
| Signal generator Type 57 | 10S/695 |
| Microammeter 0–100 | 5Q/19854 |
| *or* | |
| Testmeter Type Y | 10S/16379 |
| Output meter Type 2 | 10S/11934 |
| *or* | |
| Multimeter electronic CT38 | 10S/16308 |
| Connector set Type ARI.18041, bench testing (*Chap. 1*) | |
| Box, junction, Type 170 | 10D/19216 |

**6.** With the transmitter, receiver, microammeter, signal generator and junction box arranged as for IF alignment, proceed as follows:—

(1) Connect the output meter across the Tel± leads of a mic-tel connector plugged into the junction box Type 170 (*fig. 3*).

(2) Adjust the signal generator to give an output at 9·72 Mc/s with 70 per cent modulation at 1,000 c/s.

(3) Adjust the signal generator output to produce a diode current indication of 30 microamp. If the equipment is in order and correctly aligned the signal generator output required should not exceed 300 microvolt.

(4) Adjust the preset gain control of the receiver to produce an output of 50 milliwatt into 150 ohms, as indicated on the output meter.

**Note . . .**

*An alternative method of adjusting the AF gain control is given in Chapter 2. This method makes use of a signal generator Type 62 or Type 61, the signal generator output (at 121·5 Mc/s with 70 per cent modulation at 1,000c/s) being applied to the* AERIAL *plug of the transmitter-receiver. This output is adjusted by means of the signal generator attenuator to produce a detector diode current indication of 30 microamp, and the receiver AF gain control is then adjusted to produce an output of 50 milliwatt into a 150 ohm load, as indicated on the output meter Type 2. If this method is to be applied, the crystal must first be inserted.*

**Operations after alignment**

**7.** On completion of the adjustments, switch off, disconnect the test equipment, install the crystal, assemble the receiver unit on the transmitter unit, and install the complete transmitter-receiver in the case.

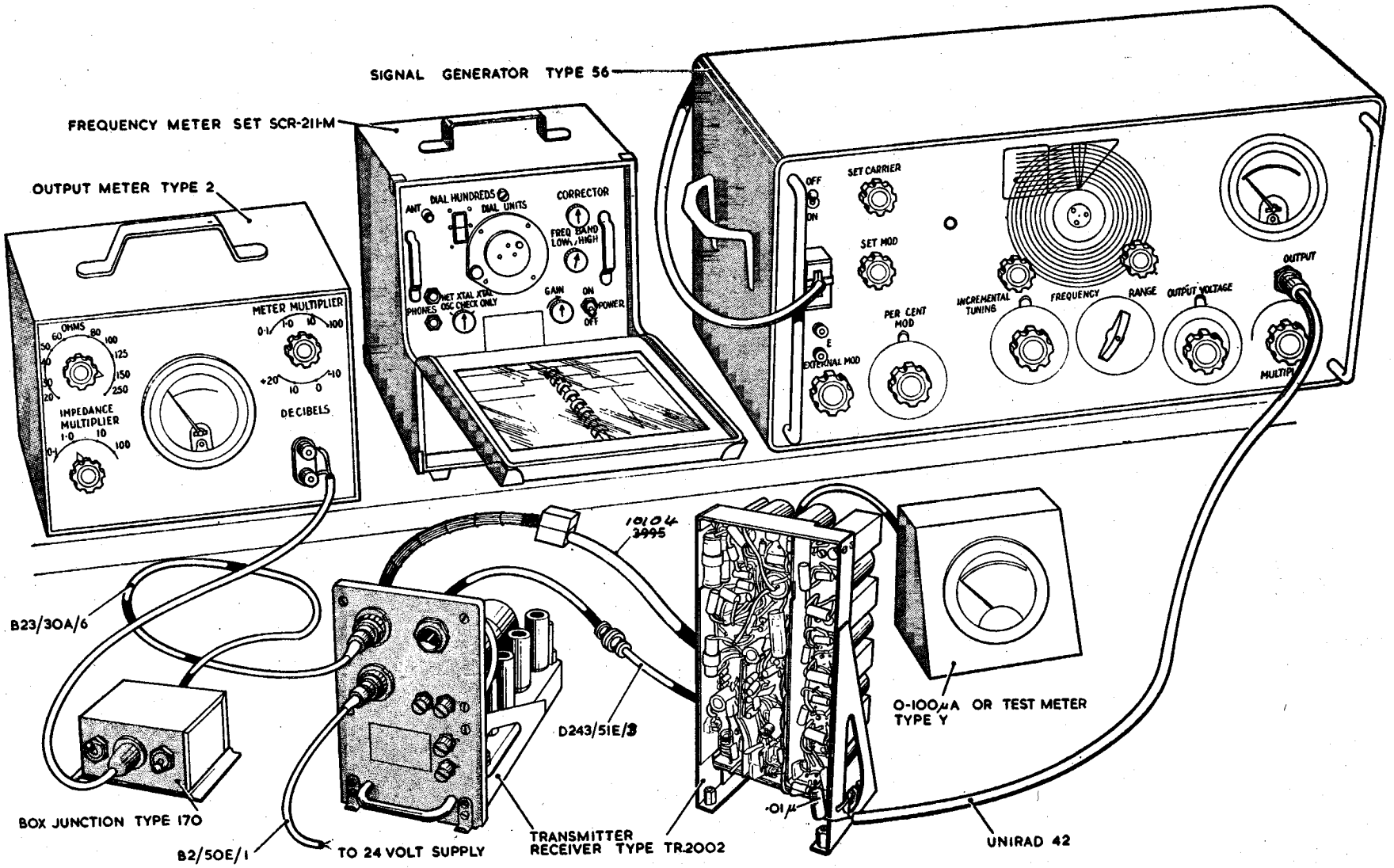


**Fig. 3. Test bench layout for IF alignment**

**PART 3**

# FAULT DIAGNOSIS

**RESTRICTED**

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**PART 3**

FAULT DIAGNOSIS

# LIST OF CHAPTERS

***Note.***—*A list of contents appears at the beginning of the chapter*

# Chapter 1

# FAULT DIAGNOSIS FOR TRANSMITTER-RECEIVER TYPE TR.2002

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## LIST OF ILLUSTRATIONS



### Introduction

**1.** This chapter provides information regarding the locating of faults which may occur in transmitter-receiver Type TR.2002. The circuit and component location diagrams appearing in Part 1, Chap. 2 should be referred to when performing the various tests suggested.

### WARNING

*For some tests it may be necessary to operate the equipment with the cover removed, and due care must be exercised to avoid the possibility of electrical shocks to the operator. The input power supply should be switched off or disconnected at all times except when the actual tests are being performed.*

### Preliminary operations

**2.** In the tables of defects and possible causes provided in this chapter it is generally assumed that the items of the installation external to the transmitter-receiver are in satisfactory condition, but before commencing to dismantle the equipment it is advisable to make a preliminary check, ensuring first of all that a suitable input supply is in fact available at the BATTERY plug on the front panel. If the motor generator fails to operate, the defect must be somewhere in the power input circuits of the transmitter (this includes the primary circuit of the rotary transformer) or in the starting circuit, which includes the ON–OFF switch, relay 1PO/1, and the associated wiring. If the motor generator operates, but the transmitter, the receiver, or both fail to operate, check first the 250mA fuses on the front panel. An overload in the transmitter unit is indicated if fuse 1FS1 has failed, and failure of fuse 1FS2 indicates an overload in the receiver unit. Should a fuse fail, the circuitry of the associated unit should be examined and the cause ascertained before a new one is fitted.

**3.** When the transmitter-receiver is removed from the case for further investigation it is usually advisable to make a rapid visual examination of the units for traces of mechanical damage, loose connections, valves, crystals or plugs incorrectly seated in their holders, gassy valves, and any other obvious signs of damage. If a unit is known to have been defective but appears to be in order when tested, tapping or gentle jarring of the chassis may reveal an intermittent or loose connection.

**4.** Even after the cover has been removed, access to many of the components is impossible so long as the transmitter and receiver are assembled together, and for any but the most obvious faults the receiver unit must be separated from the transmitter unit as described in Part 2, Chap. 1. The leads (terminated by sockets 1SK2 and 1SK3) which normally connect the transmitter to the receiver are of sufficient length to permit these two units to be connected when placed side-by side on the bench. If greater freedom of access is desired, suitably terminated extension leads may be interposed between the transmitter and the receiver. The 6-in. extension leads (10HA/13060 and 10HA/13064) of connector set ARI.18041, bench testing, should be used if available.

**Note . . .**

*It must be emphasized that, by reason of the series-parallel heater system used in this transmitter-receiver, it must not be switched on when the receiver unit is electrically disconnected from the transmitter unit, or when any of the valves are removed (the former restriction may not apply if special rigs become available for testing the units). Failure to observe these restrictions may result in damage to the equipment. Similarly, if valves are to be tested by substitution, the equipment should be switched off before making the changes.*

**TABLE 1**

**Fault diagnosis for transmitter-receiver Type TR.2002**

| Symptom | Probable cause |
|---|---|
| Equipment does not operate | Open-circuit in external power supply circuit (check voltage at the BATTERY plug) |
| Power supply is available at the BATTERY plug, but equipment does not operate | Defective relay 1PO/1 |
| Valve heaters glow, but rotary transformer does not operate | Defective rotary transformer (Table 4), or defective choke 1L1, 1L2 |
| Rotary transformer operates, but no HT on either transmitter or receiver | Fuses 1FS1 and 1FS2 failed. Defective rotary transformer, defective relay 1SR/2, choke 1L3, or capacitor 1C1 |
| HT on transmitter, but not on receiver (or vice versa) | Defective relay 1SR/2. Fuse 1FS1 (transmitter) or fuse 1FS2 (receiver) failed. Possibly defect in the send-receive switch or the associated wiring |
| Low transmitter output<br>Low receiver sensitivity | Defective valves. Contacts of relay 1SR1 damaged or misaligned |
| HT and LT supply to both units in order, but:— | |
| No reading on one or more test points | Check the associated circuit for continuity |
| No readings on test point 2PL2/3 | Short-circuit, or foreign matter between vanes of 2C49 |
| No readings on test point 1PL4/1 | Short-circuit between vanes of 1C20 |
| No readings on test point 1PL4/2 | Short-circuit between vanes of 1C15 |
| No readings on test points 1PL4/3 | Short-circuit between vanes of 1C10 |
| No carrier sound from receiver, and no sidetone audible in phones | Fuse 1FS2 failed. Defective AF valve 2V7. Defective resistor, capacitor or wiring associated with the AF stage. Defective transformer 2TR5 |
| No transmitter sidetone or output to aerial, but receiver functions normally | Fuse 1FS1 failed. If HT supply is reaching the transmitter, and the receiver is in order, absence of sidetone would indicate a failure in the transmitter speech amplifier or modulator stages |
| No transmitter output to the aerial, but receiver functions normally and sidetone is audible | Defective send/receive relay 1SR/2. Defective choke 1L5 or 1L6. Removed or defective transmitter crystal. Grid end of 1R13, 1R18, 1R22 or 1R26 may be shorting to the chassis. If sidetone is audible at the normal level, the indication is that the AF and modulator portions of the transmitter are in order. Check the oscillator, doubler and power amplifier stages at 1PL4/1, 2, 3 and at 1PL5/3; this should provide an indication of the defective stage |
| Severe modulation distortion in transmitter (distortion in sidetone) | Defective capacitor 1C28. Defective transformer 1TR2. Check the cathode potential of 1V1 and 1V2 for bias |
| No sidetone audible but receiver functions normally and there is output from transmitter to aerial | Examine 1C5 for broken or loose wire terminations 2C40 shorted |
| No signals received, but sidetone audible | This indicates that the AF portion of the receiver is in order, and consequently the defect must be in the earlier stages. Check that the crystal is installed. Readings taken at the test points 2PL2/1, 2, 3 and 2PL3 will assist in locating the defect. See above for reasons for zero reading at these points. Check RF trimming capacitors for short-circuits or wrong adjustment |
| Intermittent output from receiver | Defective contacts on relay 1SR/2. Defective AF gain control 2RV1. Defective plug and socket connections |
| Receiver instability | This is usually caused by defective decoupling in the RF or IF portions of the receiver. If the instability ceases when the grid of the frequency-changer valve is earthed, the trouble lies in the RF portion, and all the associated 330 picofarad capacitors should be examined for loose or broken wire terminations. Similarly, if the fault appears to be in the IF portion examine the terminations of all the 0·01 microfarad capacitors in the IF strip |

**TABLE 1—*contd.***

| Symptoms | Probable cause |
|---|---|
| Receiver operates only on very strong signals | Defect in RF portion of receiver. Check valves and tuning |
| Excessive RF interference from rotary transformer | Defective earthing of rotary transformer case. Commutator or brush trouble (Table 4). Defective capacitors 2C44, 2C56, 2C57, 2C58, or 2C59. |
| Crackling noise in 'phones occurring only when the case is fitted | Defective case-earthing contacts on transmitter and or receiver chassis |
| Troubles not included in the above | Check the transmitter and receiver valve voltages (Table 3). Make continuity tests as necessary |

**Checking at test points**

**6.** Where the fault is not immediately obvious, a rapid check of the meter indications obtained at the built-in test points, plugs 1PL4/1, 2, 3 and 1PL5/1, 2, 3 on the transmitter, and at plugs 2PL2/1, 2, 3 and 2PL3 on the receiver (*fig.* 1), and a comparison of the resulting readings with those given in Table 2 will provide an indication of the stage in which the fault occurs (the table indicates the circuits in which the various test points are inserted). A milliammeter 0–1 (Stores Ref. 5Q/11843) or a testmeter Type 26 (Stores Ref. 10S/16401) should be used for the transmitter, and a microammeter 0–100 (Stores Ref. 5Q/19854) or testmeter Type Y (Stores Ref. 10S/16379) for the receiver tests. Table 1 provides some conclusions which may be drawn from the meter readings, but it must be borne in mind that the readings may vary considerably from set to set.

**TABLE 2**

**Typical meter readings at test plugs**

| Test plug | Circuit | Typical reading (Microamps) | Remarks |
|---|---|---|---|
| **Transmitter** | | | |
| 1PL4/1 | 1V8, grid circuit | 750 | |
| 1PL4/2 | 1V7, grid circuit | 550 | |
| 1PL4/3 | 1V6, grid circuit | 250 | |
| 1PL5/1 | 1V3, 1V4, anode circuit | 120 | |
| 1PL5/2 | 1V8, anode circuit | 200 | |
| 1PL5/3 | 1V5, grid circuit | 120 | This represents 12V RMS across the crystal. Reading is not to exceed 150 microamp. |
| **Receiver** | | | |
| 2PL2/1 | 2V1, cathode circuit | 75 | With no signal applied |
| 2PL2/2 | 2V8, grid circuit | 80 | Must not exceed 85 microamp |
| 2PL2/3 | 2V9, grid circuit | 50 | |
| 2PL3 | 2V6a, detector diode circuit | — | A diode current of 30 microamp. should be obtained with an RF input at the AERIAL socket of not greater than 10 microvolt (for second line servicing the equipment may be accepted provided the RF input required does not exceed 20 microvolt) |

**Note . . .**

*The above readings were taken with an input power supply of exactly 24V, and using the test equipment specified in para. 6. Changes in the input voltage or in the test equipment used may cause differences in the readings. Except where limits are specified in the table, the figures quoted should be regarded as being for guidance only, as they may vary in different equipments.*

**Valve-base voltages**

**7.** A check of the valve-base voltages and comparison with the typical values given in Table 3 will also be of assistance in locating the source of trouble. This series of measurements may be taken using the appropriate ranges of a test meter Type F. If the meter indication at any point is found to vary from the specified value by more than 10 per cent, the components involved in that portion of the circuitry should be investigated. When taking the measurements it must be borne in mind that the use of a meter of different sensitivity from that specified may produce readings differing considerably from those quoted. The voltage drop across the heater pins of any valve will be approximately one fourth of the input power supply voltage. If

the voltage drop across the heater pins of any valve is unexpectedly high or low, it is possible that one or more of the heaters is defective. If an excessive voltage drop is found across the heater pins of a valve, the probability is that that heater, or one of those in parallel with it, is defective. Conversely, a lower than normal voltage drop would suggest a defective heater in one of the valves which are in *series* with that measured. The combined transmitter and receiver heater circuit is shown in Part 1, Chap. 2, Fig. 6.

**TABLE 3**

**Typical valve-base voltage measurements**

| Valve reference on diagrams | CV. No. | Function | Pin No. | Element | Voltage |
|---|---|---|---|---|---|
| **Transmitter** | | | | | |
| 1V1, 1V2 | 2135 | Speech amplifiers | 3 | Cathode | 1·2 |
| | | | 8 | Second grid | 30 |
| | | | 7 | Anode | 85 |
| 1V3, 1V4 | 416 | Modulators | 2 | Cathode | 12·4 |
| | | | 7 | Second grid | 158 |
| | | | 5 | Anode | 155 |
| 1V5 | 416 | Crystal oscillator and frequency trebler | 2 | Cathode | 0 |
| | | | 7 | Second grid | 65 |
| | | | 5 | Anode | 155 |
| 1V6 | 416 | 1st frequency doubler | 2 | Cathode | 0 |
| | | | 7 | Second grid | 100 |
| | | | 5 | Anode | 155 |
| 1V7 | 416 | 2nd frequency doubler | 2 | Cathode | 0 |
| | | | 7 | Second grid | 110 |
| | | | 5 | Anode | 155 |
| 1V8 | 416 | Power amplifier | 2 | Cathode | 0 |
| | | | 7 | Second grid | 115 |
| | | | 5 | Anode | 152 |
| **Receiver** | | | | | |
| 2V1 | 850 | RF amplifier | 2 | Cathode | 1·2 |
| | | | 6 | Second grid | 80 |
| | | | 5 | Anode | 150 |
| 2V2 | 850 | Frequency changer | 2 | Cathode | 4·0 |
| | | | 6 | Second grid | 100 |
| | | | 5 | Anode | 150 |
| 2V3, 2V4 | 131 | 1st and 2nd IF amplifiers | 2 | Cathode | 1·3 |
| | | | 7 | Second grid | 130 |
| | | | 5 | Anode | 150 |
| 2V5 | 131 | 3rd IF amplifier | 2 | Cathode | 1·5 |
| | | | 7 | Second grid | 145 |
| | | | 5 | Anode | 145 |
| 2V6 | 140 | Detector and AGC | 1 and 5 | Cathodes | 0 |
| 2V7 | 138 | Audio amplifier | 2 | Cathode | 1·3 |
| | | | 7 | Second grid | 150 |
| | | | 5 | Anode | 145 |
| 2V8 | 850 | Oscillator and quadrupler | 2 | Cathode | 0 |
| | | | 6 | Second grid | 80 |
| | | | 5 | Anode | 150 |
| 2V9 | 850 | Frequency doubler | 2 | Cathode | 0 |
| | | | 6 | Second grid | 80 |
| | | | 5 | Anode | 150 |

**Note . . .**

*Conditions of measurements:—Input 24V exactly, measured at* BATTERY *plug. All measurements taken between the points specified and the chassis, using testmeter Type F.*

**Defects in the rotary transformer**

**8.** Where the symptoms appear to indicate a defective rotary transformer, an examination of the commutators may conform the diagnosis. If the transformer is in good condition the brush tracks on the commutator should be of a uniform colour between light chocolate and dark grey, the brush track on the output commutator being normally slightly darker than that on the input commutator. It will be noted that the mica of the output commutator is flush with the segments, and not undercut as in the input commutator.

**9.** Traces of local burning, or blackened segments occurring at regular or irregular intervals, indicate defects in the rotary transformer. Table 4 lists some of the symptoms which may occur, and suggests probable causes of the same. The majority of the defects listed will necessitate the fitting of a replacement rotary transformer and the return of the defective one for third-line servicing. This course will be necessary for all defects listed in the table with the possible exception of those indicated by an asterisk. Instructions for the rectification of the latter defects are given in Part 2, Chap. 1 of this publication. If further information regarding the general servicing of rotary transformers is required, reference should be made to A.P.1186D, Vol. 1, Sect. 3.

**TABLE 4**

**Rotary transformer defects**

| Symptom | Possible cause | Action |
|---|---|---|
| Burnt traces on trailing edges of commutator segments | Axis of brushes set to wrong position | Fit replacement machine |
| Sparking at commutator (RF interference) | Dirty commutators or brushes | *Clean |
| | Worn or badly-bedded brushes | *Re-bed, or fit new brushes |
| | Brushes sticking in holder | *Clean brush and holder |
| | Insufficient brush pressure | *Usually due to worn brushes |
| | Overload (mechanical or electrical) | *Check for short-circuit in TR.2002 and for freedom of rotation of armature |
| | Excessive speed (due to field circuit breakdown) | Fit replacement machine |
| | Incorrectly set brush axis | Fit replacement machine |
| | Defective armature | Fit replacement machine |
| | Bad dynamic balance | Fit replacement machine |
| | Defective bearings | Fit replacement machine |
| | Defective commutator | Fit replacement machine |
| Overheating | Low insulation resistance, or short-circuit in windings | Fit replacement machine |
| Failure to start | Brush sticking in holder | *Clean brush and holder |
| | Defective windings | Fit replacement machine |
| Low output voltage | Dirty commutator | *Clean |
| | High resistance face on brushes | *As for bedding of brushes |
| Excessive mechanical vibration | Damaged impeller | *Fit new impeller |

* Refer to Part 2, Chap. 1

RESTRICTED

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VOL 4 PART 6
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*Superseding 2nd Edition*

# T.R.2002
# (A.R.I. 18041)

## BAY SERVICING SCHEDULES

BY COMMAND OF THE DEFENCE COUNCIL

(Ministry of Defence)

FOR USE IN THE

ROYAL AIR FORCE

RESTRICTED

## AMENDMENT RECORD CERTIFICATE

1. This certificate is for Ministry of Defence (Air) A.L.'s only.
2. Amendments are to be inserted in numerical sequence except where Non-Availability slips for particular A.L.s are issued.

| A.L. No | A.L. MONTH AND YEAR OF ISSUE | AMENDMENT INCORPORATED SIGNATURE | DATE OF INCORPORATION |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
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| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| 18 | | | |
| 19 | | | |
| 20 | | | |

# LIST OF SECTIONS

# GENERAL

## List of Contents

## Introduction

1. This schedule has been written to a new pattern which details the minimum amount of servicing necessary to ensure serviceability of the equipment. It is to be used.

a. For functional testing after defect rectification.

b. To confirm serviceability after incorporation of modifications or STIs.

c. To carry out acceptance checks.

2. Servicing is to commence at the 1st. Level, as indicated by 'X' in Column 1, and is to continue at this level unless otherwise directed by the schedule. Similarly, after a change to the 2nd. Level is called for in the schedule, servicing is to continue at this level until reversion to the 1st. Level is indicated.

3. At each point in the 1st. Level procedure where an adjustment is available, the letters 'P' for PASS and 'F' for FAIL indicate the appropriate level at which servicing is to continue.

4. At each complete step in the 2nd. Level checks and tests, the letter 'P' is used to indicate the level at which servicing is to continue if a PASS is obtained. Normally, a failure indicates that a fault is present, but in those rare cases where a further 2nd. Level adjustment may bring the equipment within specification, this is indicated by 'F' in column 2.

## Safety Precautions and Servicing Notes

5. The second channel rejection trimmer 2C1 on the chassis side of the receiver unit is not to be adjusted.

6. Alignment of I.F. transformers is not to be attempted.

7. Before T.S.740 is used, 28V supply connector B2/50F/12 is to be terminated as follows:-

Red core to pin 'E' on sealed plug 10H/9560360.

Blue core to pin 'K' on sealed plug 10H/9560360.

8. T.S.740 is to be functionally checked against a known serviceable T.S.740, and is to be used in the horizontal position.

## Glossary

9. The servicing operations detailed in this schedule have the meaning given in the Concise Oxford Dictionary except for the following:-

a. Check - Make a comparison of a measurement of time, pressure, temperature, resistance, dimension or other quantity with a known figure for that measurement.


Continued overleaf

9. (Contd)

b. Test - Ascertain, by using the appropriate test equipment, that a component or system functions correctly.

c. Examine - Carry out survey of the condition of an item. For example the condition of an item may be impaired by one or more of the following:-

(1) Insecurity of attachment.
(2) Cracks or fractures.
(3) Corrosion, contamination or deterioration.
(4) Distortion.
(5) Loose or missing rivets.
(6) Chafing, fraying, scoring, or wear.
(7) Faulty or broken locking devices.
(8) Loose clips or packing, obstruction of, or leaks from pipelines.
(9) External damage due to birds, vehicles, stones, wind, etc.
(10) Discolouration due to overheating, or leaking of fluids, etc.

d. Refit - Fit an item which has previously been removed.

e. Clean - Remove loose dust by Air blast, and clean the whole item including plugs, chassis, wiring, relays, switches etc. using White cotton rag and gasoline, no lead.

| Sect/Ref | Nomenclature | NATO Code | Qty |
|---|---|---|---|
| - | Kits, tool, Air Wireless Fitter to scale A.20, A.P.830, Vol 3, Pt 'A'. | | 1 |
| 10A/14381 | Microphone assembly Type 48. | | 1 |
| 10AH/14 | Headset Type 9. | | 1 |
| 5QP/17447 | Multimeter Type C.T.498. | | 1 |
| or | | | |
| 5QP/17001 | Multimeter Type 9980. | | 1 |
| or | | | |
| 5QP/16411 | Multimeter Type 1. | | 1 |
| 10AG/20 | Adjuster Type 35. | | 1 |
| 10AG/21 | Adjuster Type 36. | | 1 |
| 10D/19216 | Junction box Type 170. | | 1 |
| 10HA/13058 | Connector Type B23/30A/6. | | 1 |
| 10HA/13059 | Connector Type B2/50E/1. | | 1 |
| 10HA/14566 | Connector Type D243/51E/3. | | 1 |
| 10HA/14567 | Connector Type 10104. | | 1 |
| 10S/16400 | Test set Type 193A. | | 1 |
| 10S/16486 | Test set Type 740 | | 1 |
| 10H/9560360 | Plug, sealed, Type M.4. (For use with T.S.740). | | 1 |
| 10S/16379 | Testmeter, Type Y. | | 1 |
| 10S/16401 | Testmeter, Type 26. | | 1 |
| | Power adapter comprising:- | | |
| | 5E/3767 Cable dunyprensheath 12. | | As required |
| | 10H/9560050 Plug, fixed, 2 pole. | | 1 |
| | 10H/9560090 Socket, sealed, M.4. | | 1 |
| | 10H/9560330 Socket, 12-way fixed, medium. | | 1 |
| | Aerial adapter comprising:- | | |
| | 5E/100280 Cable, uniradio 43. | | As required |
| | 10H/18589 Plug/socket Type 3. | | 1 |
| | 10H/9560044 Socket, free. | | 1 |

## MATERIALS

| | | |
|---|---|---|
| 32B/520 | Rags, cleaning, best White. | As required |
| 33H/9424829 | Grease, XG-250 | " |
| 34C/9100454 | Gasoline, no lead. | " |

## POWER SUPPLIES

28V plus 0.5V or minus 1.0V. d.c.

## ASSOCIATED PUBLICATIONS

A.P.2528M Vol 1. A.R.I. 18041 Single channel V.H.F. equipment.
A.P.2536C Vol 1 Common Test Gear for Radio Equipment.

# BAY SERVICING

## List of Contents

# BAY SERVICING
# TRANSMITTER RECEIVER
# SUPPLEMENTARY SERVICING

| LEVEL 1 | LEVEL 2 | Item No | Item | Operation |
|---|---|---|---|---|

| LEVEL 1 | LEVEL 2 | Item No | Item | Operation |
|---|---|---|---|---|
| X | | 1. | Section 1 Chapter 1. | Read. |
| X | | 2. | Servicing forms. | Record details of unit, |
| X | | 3. | Preparation | |
| X | | 3.1 | Transmitter - receiver. | |
| | | 3.1.1<br>3.1.2 | Cover. )<br>Rear mounting )<br>plate. ) | (i) Remove.<br>(ii) Stow. |
| | | 3.1.3 | Receiver unit. | (i) Separate from transmitter unit as detailed in A.P.2528M Vol 1 Pt 2 Chap 1.<br>(ii) Clean.<br>(iii) Examine.<br>(iv) Connect to test bench. (Fig 3 refers). |
| | | 3.1.4 | Rotary transformer. | (i) Clean.<br>(ii) Examine. |
| | | 3.1.5 | Transmitter unit. | (i) Clean.<br>(ii) Examine.<br>(iii) Lubricate front panel plugs lightly with grease XG-250.<br>(iv) Connect to test bench. (Fig 3 refers). |
| X | | 3.2 | Test set Type 740. | |
| | | 3.2.1 | Test set. | Connect to 28V d.c. |
| | | 3.2.2 | Upper meter zero control. | Adjust for reading at junction of Red/Green sectors. |
| | | 3.2.3 | On/Off switch. | Set to 'ON' and allow 5 minute warm up period. |
| | | 3.2.4 | Lower meter. | Check reading is between the limits 27 to 28.5 volts. |



Continued overleaf

| LEVEL 1 | LEVEL 2 | Item No | Item | Operation |
|---|---|---|---|---|
| | | 3.2.5 | Service Selector switch. | Set to position listed below and check upper meter needle indicates appropriate reading:- |
| P | F | | | SWTCH POS'N / UPPER METER READING<br>A — Reject 50 PLUS OR MINUS 4 Divs<br>B — Central PLUS OR MINUS 2 Divs<br>C — Central PLUS OR MINUS ½ Divs<br>D — Reject 50 PLUS OR MINUS 4 Divs<br>E — Reject 50 PLUS OR MINUS 4 Divs<br>F — Pass 50 PLUS OR MINUS 4 Divs<br>G — Central PLUS OR MINUS ½ Divs<br>H — Central PLUS OR MINUS ½ Divs<br>J — Reject 50 PLUS OR MINUS 4 Divs<br>K — Reject 50 PLUS OR MINUS 4 Divs |
| | X | 4 | Test Set Calibration | |
| | X | 4.1 | Test set Type 740. | |
| | | 4.1.1 | Front and rear securing screws. | Slacken off, and hinge back covers. |
| | | 4.1.2 | Service Selector switch. | (i) Set to 'H' and adjust R.V.8 until needle is in centre of upper meter.<br>(ii) Set to 'A' and adjust R.V.1 for meter reading of Reject 50.<br>(iii) Set to 'J' and adjust R.V.12 for meter reading of Reject 50.<br>(iv) Set to 'F' and check reading is Pass 50 PLUS OR MINUS 1 division repeating Operations (1) to (iii) as necessary. |
| | | 4.1.3 | Rear panel. | Close, and tighten securing screws. |
| | | 4.1.4 | Controls R.V.3 and R.V.4. | Using calibration chart in test set lid, set controls to pass levels of 1 watt and 60 per cent modulation depth respectively. |
| P | | 4.1.5 | Front panel. | Close, and tighten securing screws. |



Continued

| LEVEL 1 | LEVEL 2 | Item No | Item | Operation |
|---|---|---|---|---|
| X | | 5. | Transmitter Tuning and Power Output Checks | |
| X | | 5.1 | J.B.170. | |
| | | 5.1.1 | On/Off switch. | Set to 'ON'. |
| | | 5.1.2 | Recv/Trans switch. | Set to 'RECV'. |
| X | | 5.2 | Bench power supply. | Switch on and allow a 5 minute warm-up period. |
| X | | 5.3 | T.S.740 Service Selector switch. | Set to 'A'. |
| X | | 5.4 | J.B.170 Recv/Trans switch. | Set to 'TRANS' and check T.S.740 lower meter reading is between the limits 27 to 28.5 volts. |
| X | | 5.5 | Testmeter Type 26. | (i) Connect to test point IPL5/3 on transmitter unit, and check meter reading does not exceed 150 microA.<br>(ii) Transfer to test point IPL4/3 and adjust capacitor 1C10 for maximum meter reading.<br>(iii) Transfer to test point IPL4/2 and adjust capacitor 1C15 for maximum meter reading.<br>(iv) Transfer to test point IPL4/1 and tune 1C20 for maximum meter reading.<br>(v) Disconnect. |
| X | | 5.6 | Capacitor 1C24. (Transmitter unit). | Adjust for maximum reading in T.S.740 upper meter Green sector. |
| X | | 6. | Transmitter Modulation Depth and Noise Level | |
| X | | 6.1 | T.S.740 Service Selector switch. | Set to 'B' and 'C' in turn checking upper meter reading is in Green sector in each case. |
| X | | 7. | Transmitter Sidetone Check | |
| X | | 7.1 | J.B.170. | Disconnect jack plug and insert headset. |



Continued overleaf

| LEVEL 1 | LEVEL 2 | Item No | Item | Operation |
|---|---|---|---|---|
| X | | 7.2 | Headset. | (i) Speak into microphone and ensure sidetone output is clearly audible.<br>(ii) Disconnect, and reconnect jack plug to J.B.170. |
| X | | 7.3 | J.B.170 Recv/Trans switch. | Set to 'RECV'. |
| X | | 8. | <u>Receiver Local Oscillator Tuning</u> | |
| X | | 8.1 | Testmeter Type Y. | (i) Connect to test point 2PL2/2 on receiver unit, and check meter reading does not exceed 85 microA.<br>(ii) Transfer to test point 2PL2/3 and adjust capacitor 2C49 for maximum meter reading.<br>(iii) Tune 2C53 for minimum meter reading.<br>Note:- Meter reading variation is very small.<br>(iv) Disconnect. |
| X | | 9. | <u>Receiver Tuning</u> | |
| X | | 9.1 | T.S.740. | |
| | | 9.1.1 | Service Selector switch. | Set to 'E'. |
| | | 9.1.2 | Frequency control. | Set to 121.5 Mc/s. |
| | | 9.1.3 | Set R.F. control. | Adjust for scale reading designated Set R.F. in lower meter. |
| | | 9.1.4 | Press-for-High Level button. | Depress. |
| | | 9.1.5 | Frequency control. | Adjust for maximum reading in upper meter Green sector. |
| | | 9.1.6 | Press-for-High Level button. | Release. |
| | | 9.1.7 | Frequency control. ) | Adjust for maximum reading in |
| X | | 9.2 | Capacitors 2C4 and ) | test set upper meter |
| | | | 2C5 (Receiver ) | Green sector. |
| | | | unit) ) | |
| X | | 9.3 | T.S.740 Set R.F. control. | Adjust for scale reading of Set R.F. in lower meter. |
| X | | 9.4 | R.V.1 on receiver unit. | Adjust for reading of 25 in lower meter Green Sector. |

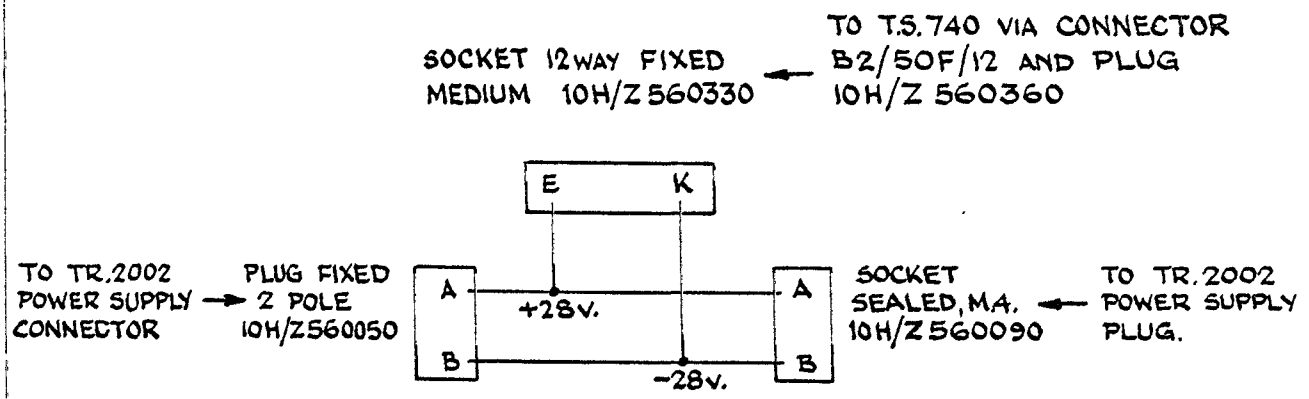
| LEVEL 1 | LEVEL 2 | Item No | Item | Operation |
|---|---|---|---|---|
| X | | 10. | Assistance will be required to carry out this Item. Receiver and Transmitter Quality Checks | |
| X | | 10.1 | T.S.740. | |
| | | 10.1.1. | Sockets JK.1 and JK.2. | Plug in headsets. |
| | | 10.1.2 | Service Selector switch. | Set to 'G'. |
| X | | 10.2 | Headsets. | (i) Speak into microphone at JK.1 and adjust T.S.740 Frequency control for maximum audio output at JK.2.<br>(ii) Ensure availability of good quality audio output at JK.2.<br>Note:- Audio output will be lower than normal. |
| X | | 10.3 | T.S.740 Service Selector switch. | Set to 'H'. |
| X | | 10.4 | J.B.170 Recv/Trans switch. | Set to 'TRANS'. |
| X. | | 10.5 | Headsets. | Speak into microphone at JK.2 and ensure availability of good quality audio output at JK.1. |
| X | | 10.6 | J.B.170 Recv/Trans switch. | Set to 'RECV'. |
| X | | 11. | General | |
| X | | 11.1 | J.B.170 On/Off switch. | |
| X | | 11.2 | T.S.740 On/Off switch. | Set to 'OFF'. |
| X | | 11.3 | Bench power supply. | |
| X | | 11.4 | Headsets. | Disconnect. |
| X | | 11.5 | T.S.740. | Disconnect from 28V. d.c. supply. |
| X | | 11.6 | Transmitter - receiver. | Disconnect from test bench installation. |



Continued overleaf

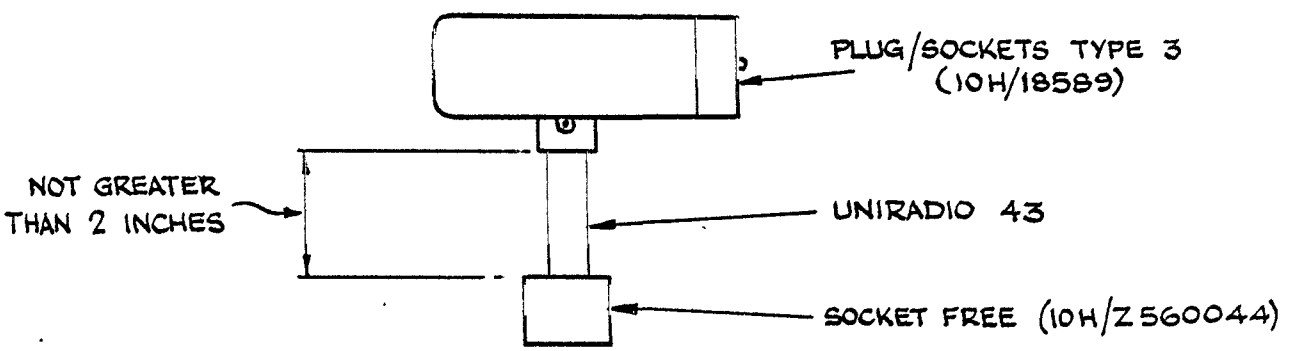
| LEVEL 1 | LEVEL 2 | Item No | Item | Operation |
|---|---|---|---|---|
| | | 11.6.1 | Receiver unit. | Refit to transmitter unit. |
| | | 11.6.2 | Rear mounting plate. | Refit. |
| | | 11.6.3 | Main cover. | Refit. |
| | | 11.7 | Servicing forms. | Sign. |

## List of Contents



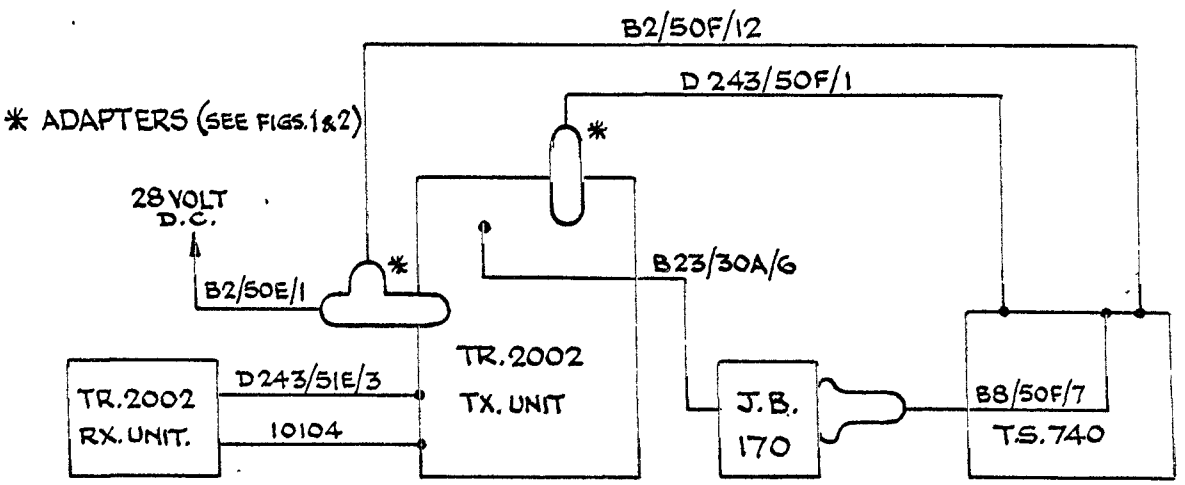

POWER ADAPTER

FIG. 1.




AERIAL ADAPTER

FIG. 2.




TEST BENCH INSTALLATION

FIG.3.

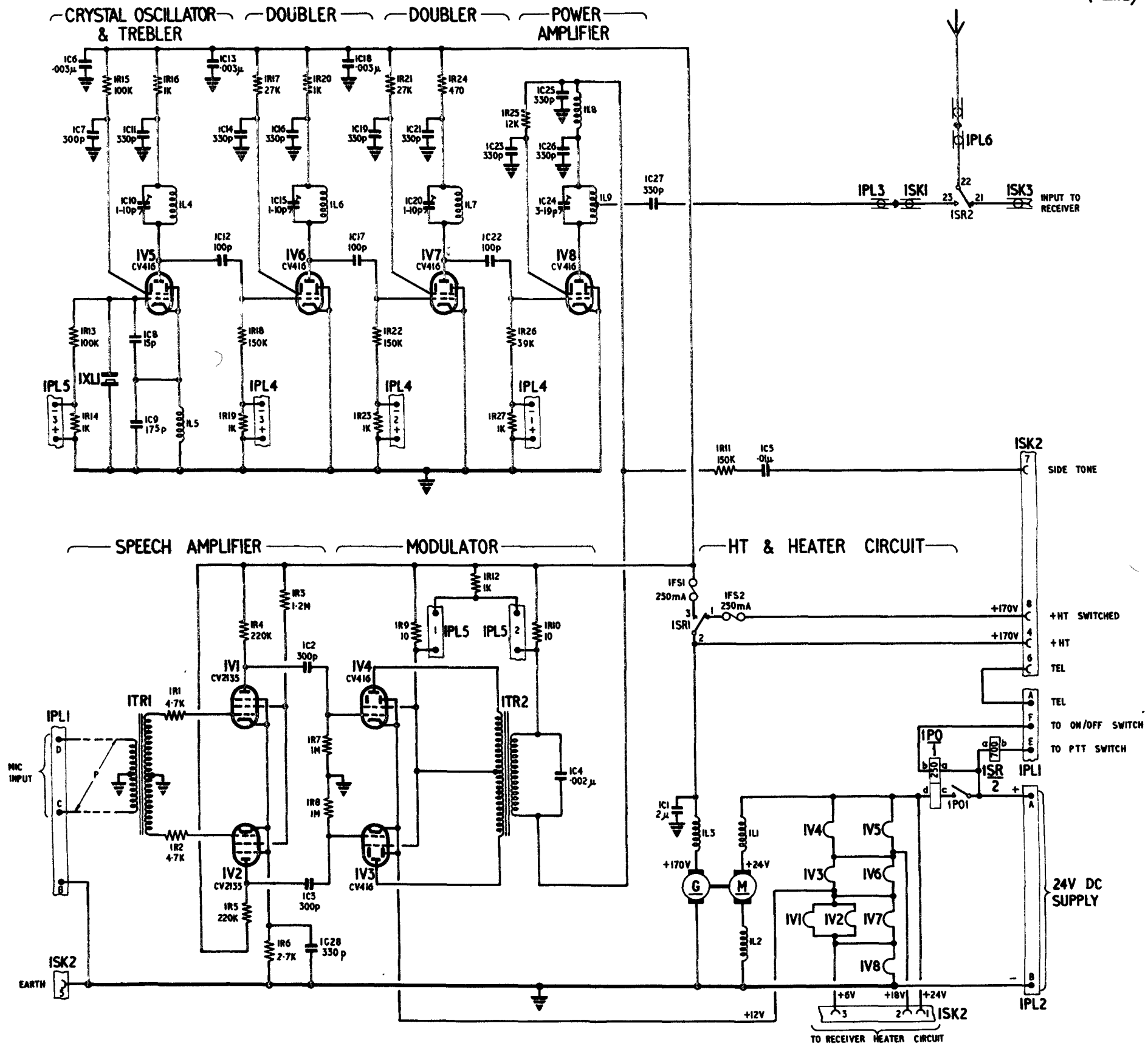



Fig. 9 Transmitter unit Type 98 - circuit Fig. 9

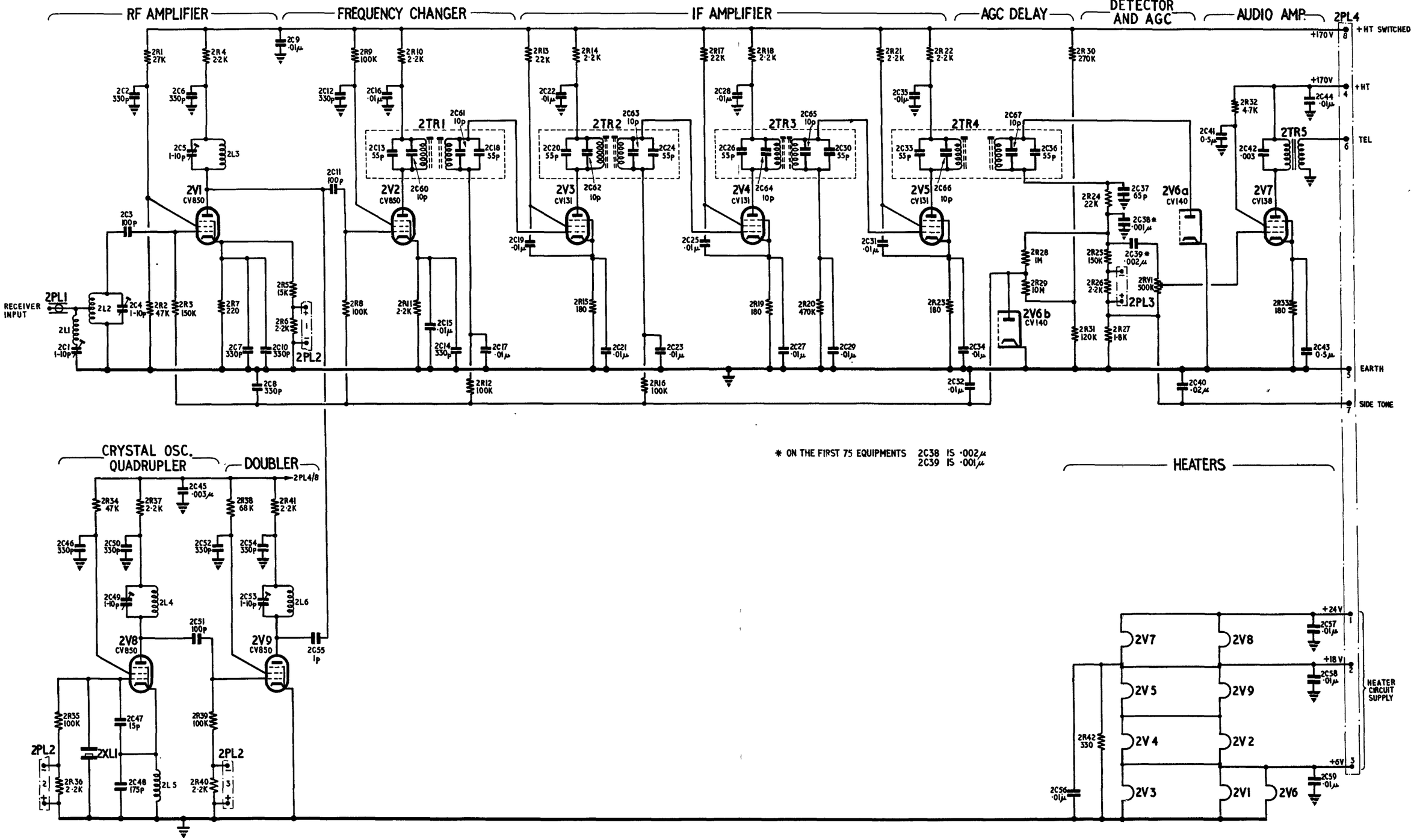



Fig. 10

Receiver unit Type 127 – circuit

Fig. 10

PP9087 250827/6677 9/62 125 C&P Gp. 924 (4)