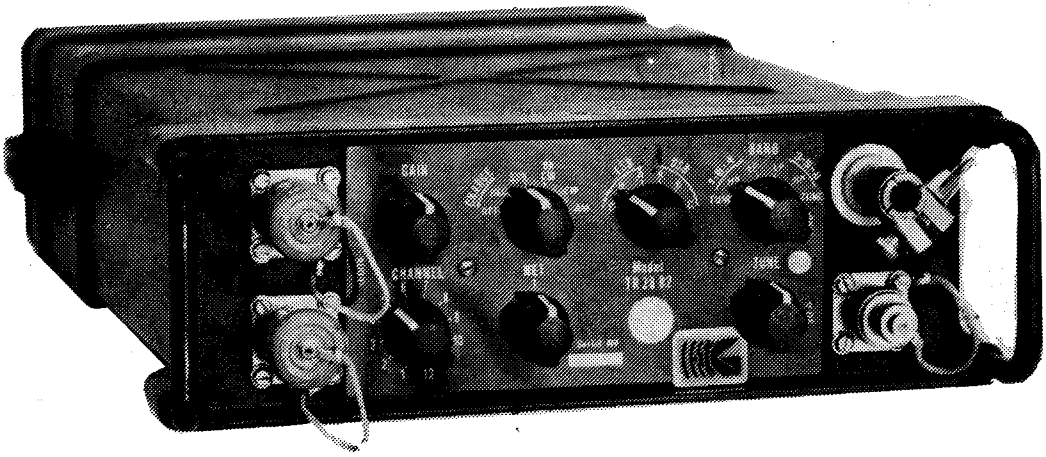
Technical Manual For HF SSB Radiotelephone Type TR28B2



GRINAKER ELECTRONICS (PTY) LTD/(EDMS) BPK

PO BOX 1463 PRETORIA 0001
316 KUIT STREET, WALTLOO, SILVERTON, PRETORIA, REPUBLIC OF SOUTH AFRICA,

TELEPHONE (012) 83 4141 TELEX SA3754

Handbook Prepared and Printed by: GRINAKER ELECTRONICS (PTY) LTD
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GRINEL

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CHAPTER 1

GENERAL DESCRIPTION

INTRODUCTION

1. The TR28B2 is a lightweight, channelised, battery powered transceiver designed primarily as a portable s.s.b. communications set operating in the 1,6MHz to 8MHz band. Up to 36 channels are available, the frequency of each channel being determined by the crystals installed. CW and compatible a.m. facilities are provided and a full range of accessories allow the set to be used under various conditions and environments including fixed and mobile operation.

2. Transmitter power output on s.s.b. is 25W between 2MHz and 8MHz and can be reduced to 5W, by a front panel control, for local operation.

3. Provision is made for various types of antenna to be used with the set: whip, slant wire, dipole etc., each antenna being tuned for the frequency in use by a front panel control. To tune under conditions of radio silence a tuning signal derived from an internal signal generator is fed to the antenna system. It is arranged that maximum sound in the headphones will correspond to the correct antenna coupling for the frequency selected. If radio silence is not required a 1kHz tone generator in the set may be used to tune the transmitter.

4. Two audio sockets, wired in parallel, are provided on the front panel. Audio input and output may be via hand-microphone-telephone (h.m.t.) to either of the sockets or a microphone with a press-to-talk (PTT) switch and separate headphones may be used.

5. The set incorporates an internal battery charging circuit which enables the internal battery to be charged in situ from any convenient 12V d.c. source. If the battery is removed from the set, then a.c. from a suitable source (the RACAL MSU 23 for example) or 12V d.c. may be used for charging.

TECHNICAL SPECIFICATION

6. The following specification is for normal conditions at room temperature and performance figures measured with a 12,6V d.c. supply. Worst case conditions can be supplied by the company on request.

General

7. (a) Frequency Range	-	1,6MHz to 8MHz (36 channels)
(b) Temperature	-	-10^{o} to $+55^{o}C$
(c) Supply Voltage	-	12V to 14V d.c.
(d) Power Supply	-	12V d.c., 5,0AH Nickel-cadmium rechargeable battery 10 cells
(e) Operating Modes	-	SSB Telephony, A3J - USB and LSB Compatable AM, A3 CW Telegraphy, A1
(f) Frequency Stability	-	Better than ±100Hz at 1,6MHz rising linearly to ±200Hz at 8MHz. Internal trimmer range greater than 50ppm.
(g) Netting (TX and RX simultaneously)	-	Range ±100Hz minimum on channel frequency. Channel to be within $\pm 45^{o}$ of mechanical centre.

Transmitter

8. (a) Power output (into 50 ohms)	
(i) SSB (High Power) for 26dB IP relative to PEP	- 1,6MHz to 1,99MHz, 20W p.e.p. ±1dB 2MHz to 8MHz, 25W p.e.p. ±1dB
(ii) AM (High Power)	- 3W minimum
(iii) CW (High Power)	- 1,6MHz to 1,99MHz, 10W r.m.s. ±1dB 2MHz to 8MHz, 12W r.m.s. ±1dB
(iv) CW (Low Power)	- 1,6MHz to 1,99MHz, 1W r.m.s. ±1dB 2MHz to 8MHz, 2,5W r.m.s. ±1dB
(b) Harmonic Emission (Using 2,4m to 3,6m Whip Antenna)	- -40dB relative to the maximum available power out
(c) Spurious Emission	- spurious emissions separated from the carrier by more than 20kHz will be attenuated by at least 40dB relative to the maximum available power out.
(d) Carrier Suppression	- -40dB relative to the maximum available power output.
(e) Unwanted Sideband Suppression	- -40dB relative to 1kHz
(f) Microphone Sensitivity (at 1kHz)	- 1mV p.d. maximum for full output on SSB
(g) Transmitter Current Consumption	- 5,5A maximum

Receiver

9. (a) Sensitivity	
(i) SSB	- A 3µV e.m.f. input from a 50 ohm source produces a minimum output of 320mV r.m.s. into 300 ohms.
(ii) AM	- A 30µV, 30% modulated input from a 50 ohm source produces a minimum output of 60mV r.m.s. into 300 ohms.
(b) Selectivity (relative to 1kHz)	
(i) SSB Bandwidth	- Minimum 2kHz at -6dB Maximum 5,5kHz at -40dB
(ii) AM Bandwidth	- Minimum 6kHz at -6dB
(c) Audio Frequency Response	
(i) Lower limit	- 100Hz to 500Hz at -6dB relative to 1kHz
(ii) Upper limit	- Determined by audio bandwidth
(d) Audio Output	- Factory set for 1mW maximum into 300 ohm headphones.
(e) Signal to Noise Ratio (S+N/N) SSB	- A1µV e.m.f. input gives a minimum of 10dB
(f) AGC	- Threshold between 1µV and 3µV e.m.f. The audio output will change by less than 3dB for 3µV to 1mV e.m.f. input.
(g) Image Rejection	- minimum 75dB
(h) IF Rejection	- minimum 60dB
(j) Receiver Current Consumption	- 90mA maximum

Figure 1.1

FUNCTIONAL DESCRIPTION

10. The transceiver circuits comprise the Receive path and Transmit path, each path using some common circuits, a TX/RX switch and an antenna tuning unit (ATU). Separate power supply regulators

provide the different voltages required. The following description is of the functional block diagram (Figure 1.1). It should be noted that the RX signal path is indicated by closed arrows and the TX signal path is indicated by open arrows.

Receive Path

11. The received signal from the ATU is routed via the TX/RX switch to a r.f. amplifier. The output is fed through the Image Suppression Filter which is a low pass filter suppressing all frequencies above 8MHz. The i.f. of 10,7015MHz is above the signal frequency and therefore the image frequency is very much higher than the signal frequency:

e.g. f_{sig} = 5MHz

fxtal = 15,7015MHz

fim = 20,7015MHz

12. The above technique allows the use of a simple filter to suppress all signals above 8MHz thus avoiding the use of switched coils when changing frequency.

13. The RX signal is mixed with the output of the 36 channel crystal oscillator, which is at f_{sig} + 10,7015MHz, and the resulting signal at 10,7015MHz is fed to a diode switch which routes the i.f. through the appropriate sideband filter (USB or LSB), amplifier. The i.f. signal is then mixed with the output of the carrier oscillator (10,7015MHz) in the demodulator.

14. The audio output from the demodulator is amplified and fed to an audio power amplifier the output of which drives a pair of headphones.

15. Part of the output of the audio amplifier is fed to the a.g.c. amplifier, its output providing an a.g.c. voltage for the i.f. stages of the receiver.

Transmit Path

16. The microphone input (or 1kHz from tone generator) is amplified and passed to the modulator where it is mixed with the output of the carrier oscillator (10,7015MHz) thus producing a double sideband i.f. This signal is amplified in the a.l.c. controlled TX IF amplifier and routed through the appropriate sideband filter as controlled by the sideband switch.

17. The SSB signal is mixed with the output of the channel oscillator to provide the signal frequency. The r.f. is amplified to 25W p.e.p. in the pre-amplifier, driver amplifier and power amplifier stages and is fed via the TX/RX switch and the ATU to the antenna.

18. Automatic level control (a.l.c.) signals derived from the PA stage are amplified in the a.l.c. amplifier, the output controlling the TX i.f. amplifiers. Overload protection of the PA stage is also provided by a current a.l.c. signal which controls the bias of the pre-amplifier stage.

Antenna Tuning Unit

19. The ATU matches whip or 50 ohm antennas to the TX output and RX input.

Sidetone

20. In the transmit condition, the first RX audio amplifier operates as a diode which passes attenuated speech or keyed tone signals to the audio output stages.

Noise Generator

21. A simple multivibrator circuit generates a low frequency train of pulses with a high harmonic content when in the tune condition. This allows the transceiver to be tuned without using radiated power and therefore breaking radio silence.

PTT

22. Operation of the PTT switch (either microphone or CW key) energises relay RL1. The contacts of this relay perform two functions:-

(a) connects the output of the TX PA stage to the ATU and earths the input to the receiver.

(b) activates the +9V supply to the transmit circuits and de-activates the +9V supply to the receive circuits.

POWER SUPPLIES

23. The primary power source of 12V is provided from nickel-cadmium cells contained in a separate battery box clipped to the base of the transceiver. The batteries are rechargeable in situ from an external 12V supply via d.c. to d.c. converter contained in the transceiver, or, from a 12V d.c. or suitable 13,6V a.c. charging source with the battery box removed.

24. The 12V supply provides inputs to the following:

(a) 9V regulator - provides the main supply for all common TX/RX circuits, and via transistor switches the main supplies (9V TX and 9V RX) to the TX and RX circuits.

(b) DC/DC converter - provides the main supply (36/12V TX) for the PA stage, controlled by relay RL1.

25. The 12V supply also provides the main supply for the transmitter pre-amplifier and driver amplifier stages, also controlled by relay RL1.

MECHANICAL DESCRIPTION

Figure 1.2

General Construction

26. The TR28B2 comprises a cast aluminium front panel on which are mounted the operator controls and input and output connectors. Two carrying handles are integral parts of the casting. A chassis secured to the rear of the front panel contains the main p.c.b., crystal board and the DC converter. Mounted on the side of the chassis are the components comprising the Power Amplifier stage.

27. An antenna tuning unit, comprising a coil in which a ferrite rod is inserted by a lead-screw controlled by the front panel TUNE control, is also secured to the rear of the front panel.

28. A cast aluminium box cover is secured to the rear of the front panel by four screws.

29. A separate battery box containing ten nickel-cadmium cells and a charging circuit is clipped to the bottom of the transceiver by two quick release thumb catches. A socket in the battery box mates with a plug in the bottom of the transceiver when the battery box is clipped in position.

Front Panel Controls

Figure 1.3

30. A list of front panel controls and brief descriptions of their functions appear below. Full operating instructions are given in Chapter 2.

(a) AUDIO sockets SK1 and SK2 - Identical 7 pin sockets connected in parallel. Used to connect h.m.t. or morse key and external charging source.

(b) 50Ω Antenna socket SK3 - Used to connected 50 ohm antenna

(c) LSB/USB switch S1 - Selects required sideband and appropriate crystal bank A, B or C

(d) CHANNEL switch S2 - Selects required channel frequency on crystal bank selected - by S1.

(e) BAND switch S3 - Selects one of three functions, TUNE, HP, LP, in each of the two following bands: 1,6 - 4MHz and 3,5 - 8MHz.

(f) MODE switch S4 - Selects the following modes of operation:

(i) OFF

(ii) REC - reception only
Internal batteries can be charged with S4 in either of the above positions.

(iii) SSB - reception and transmission in voice using PTT switch.

(iv) BK CW - CW transmission and reception

(v) CW - CW transmission only

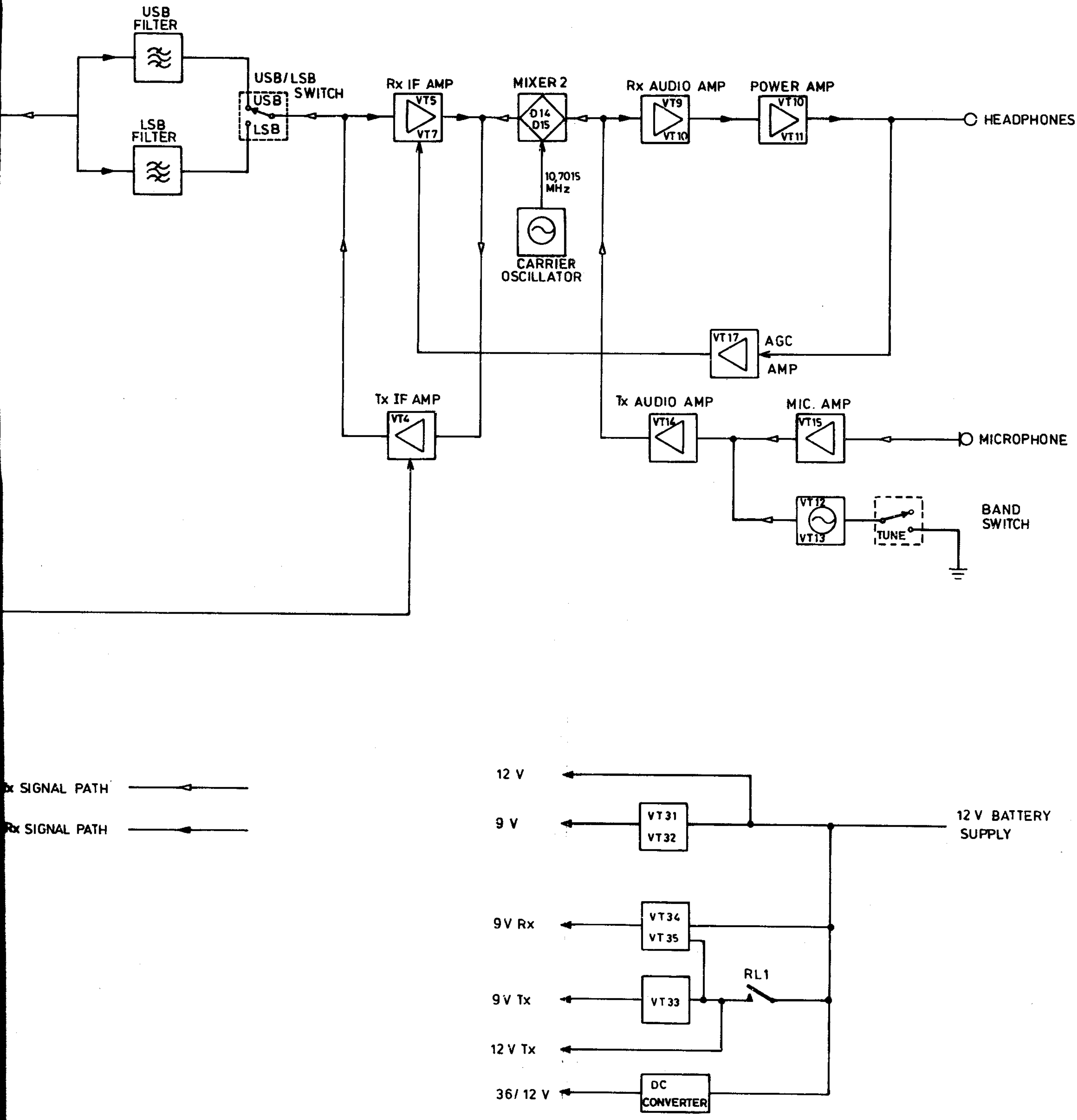
(vi) AM - AM transmission and reception

(g) GAIN control RV6 - Controls IF gain of receiver

(h) NET control RV12 - Allows netting i.e. slight adjustment of transceiver frequency to cope with received frequencies slightly above or below the nominal channel frequency.

(j) TUNE lamp LP1 - TUNE control adjusted for maximum brilliance of LP1

(k) METER M1 - Indicates state of battery charge and received signal strength.



TR28 B2 - Functional Block Diagram

Fig. 1.1

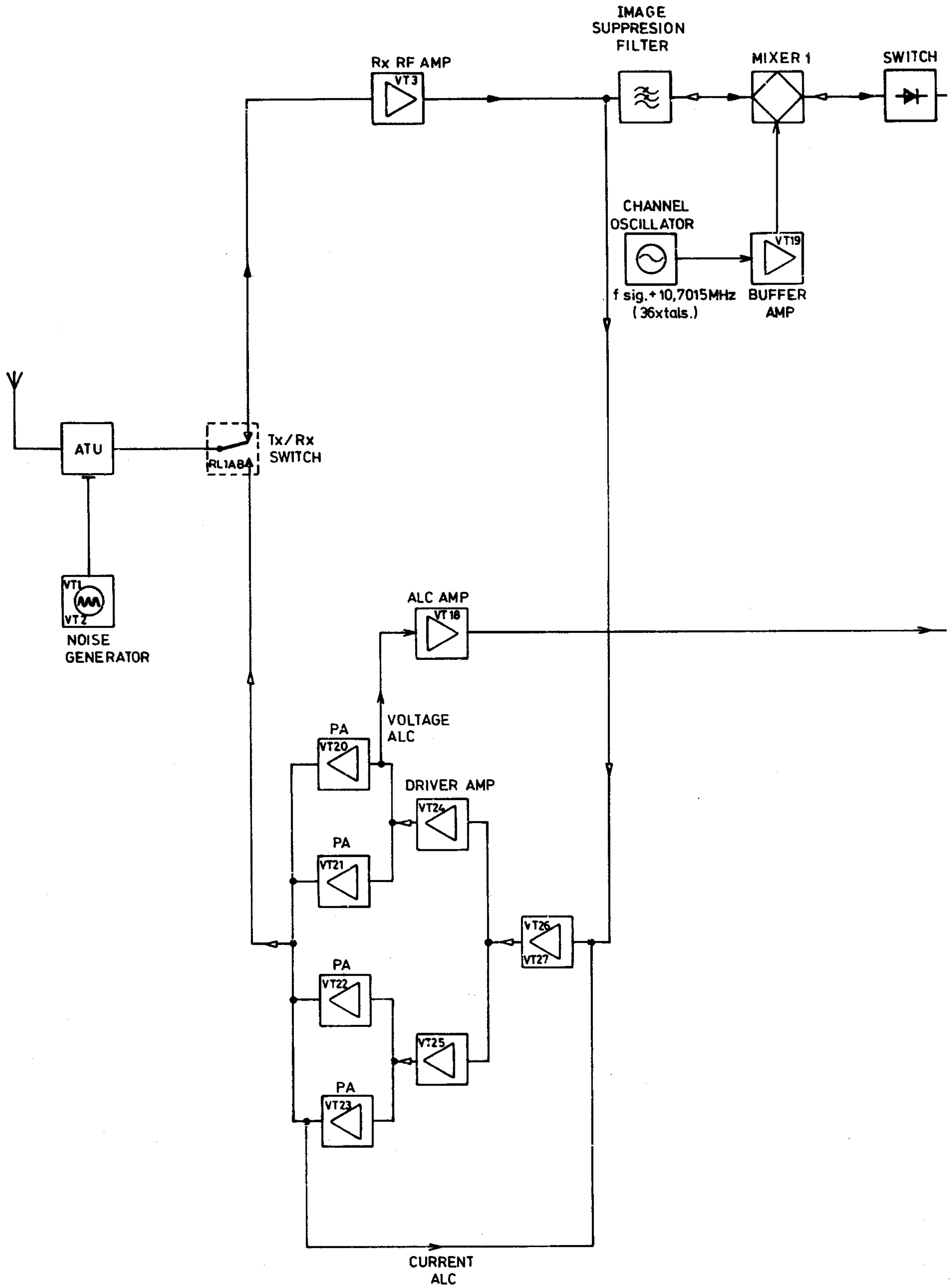


IMAGE
SUPPRESION
FILTER
Rx RF AMP
VT3
MIXER 1
SWITCH
CHANNEL
OSCILLATOR
VT19
f sig.+10,7015MHz
(36xtals.)
BUFFER
AMP
ATU
Tx/Rx
SWITCH
RL1AB
VT1
VT2
NOISE
GENERATOR
ALC AMP
VT18
VOLTAGE
ALC
PA
VT20
DRIVER AMP
VT24
PA
VT21
VT26
VT27
PA
VT22
VT25
PA
VT23
CURRENT
ALC

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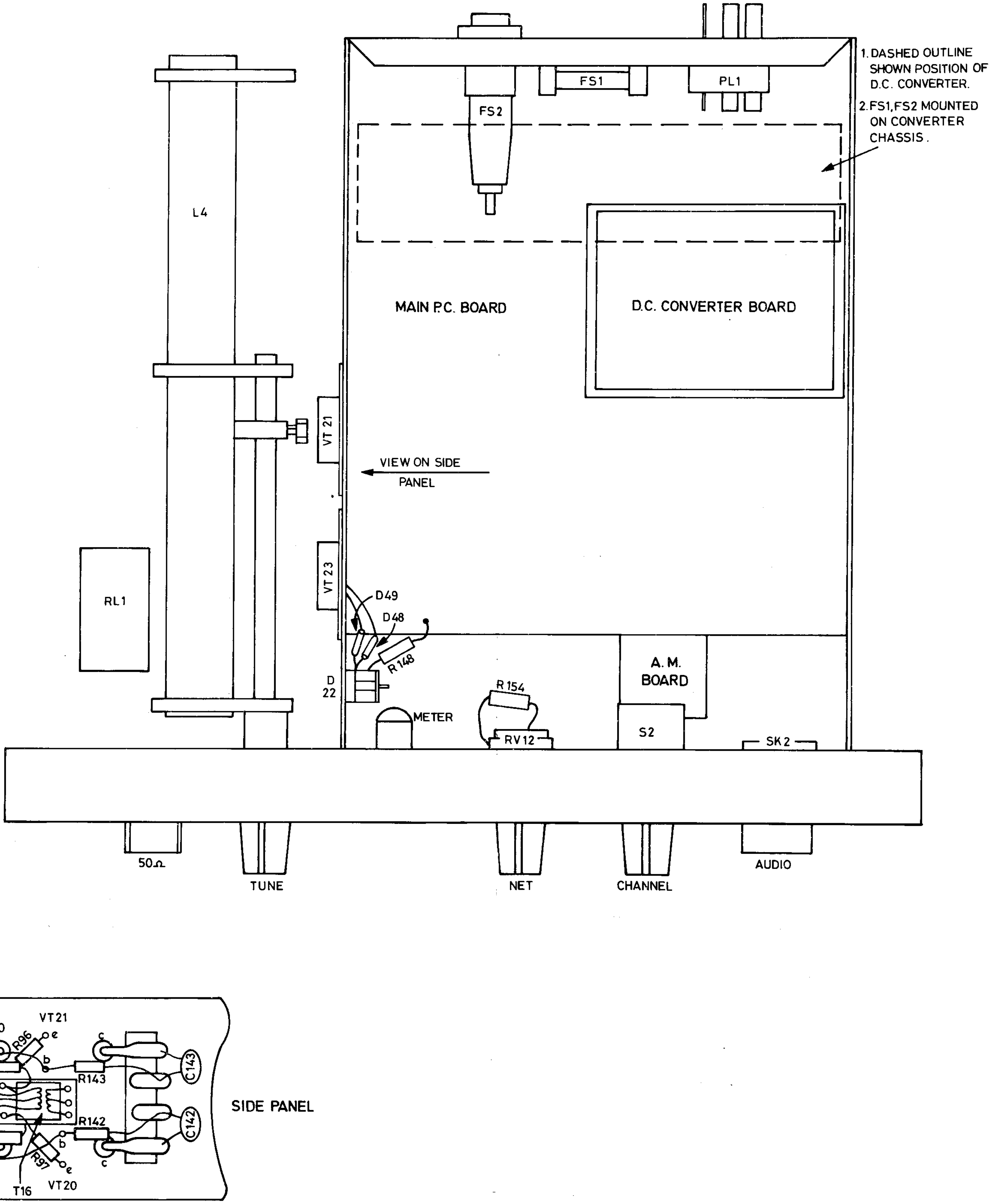
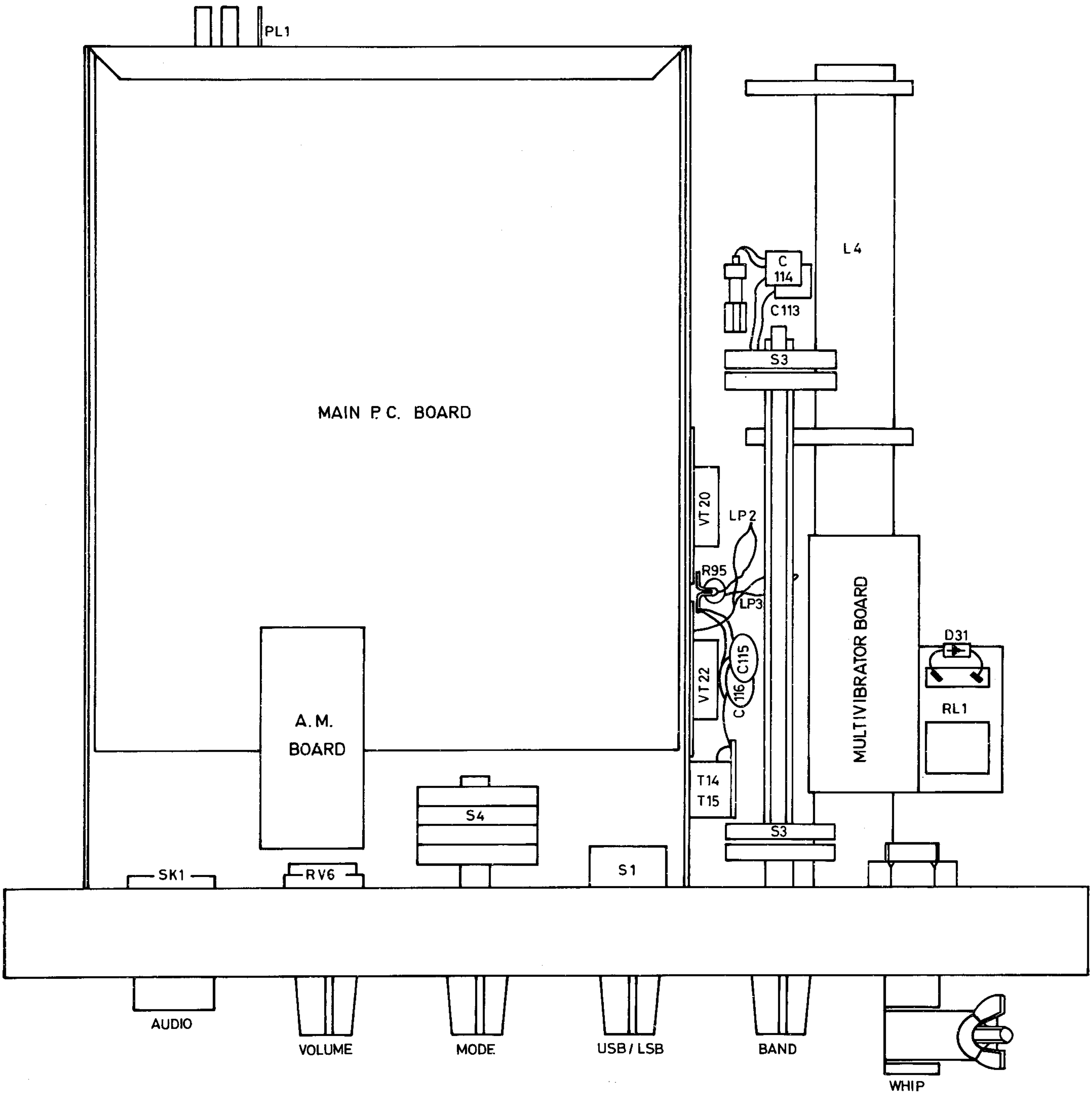
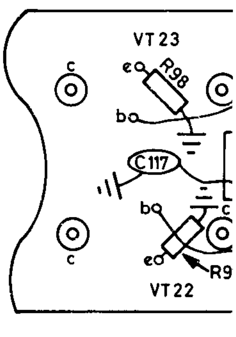


TR 28 B2 - Layout Diagram

Fig. 1.2


PL1
MAIN P.C. BOARD
L4
C 114
C113
S3
VT20
LP2
R95
LP3
VT22
C115
C116
MULTIVIBRATOR BOARD
D31
RL1
A.M. BOARD
S4
T14
T15
S3
S1
SK1
RV6
AUDIO
VOLUME
MODE
USB / LSB
BAND
WHIP


VT23
R98
C117
VT22

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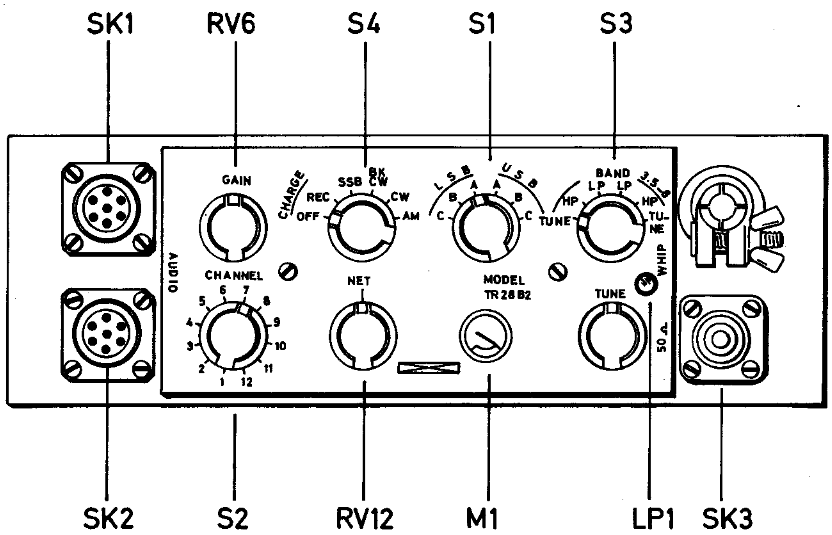

TR 28 B2 Front Panel Controls

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Fig. 1.3

CHAPTER 2

INSTALLATION AND OPERATING INSTRUCTIONS

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CHAPTER 2

INSTALLATION AND OPERATING INSTRUCTIONS

SYSTEM CHECK LIST

1. The following items are supplied with a TR28B2.

Item	Description	Quantity
1	Transceiver TR28B2	1
2	Battery Box	1
3	3,65m (12ft) whip antenna	1
4	Gooseneck	1
5	Carry-bag	1*
6	Capacity wallet	1
7	Hand-microphone-telephone (h.m.t.)	1
8	Charging lead A (with Souriau plug)	1
9	Charging lead C (with Painton plug)	1

*Two carry-bags are provided for certain installations.

The following accessories are optional extras which may be supplied:

Headset, noise excluding, with plug
Morse key and knee strap, with plug
G5RV antenna
Centre - fed dipole antenna
Capacity belt
Field Charger
Ground spike and lead
1 Watt amplifier and speaker unit

SETTING UP

General Inspection

2. Inspect the set as follows:
   (1) Check the desiccator at the bottom of the set: its colour should be blue. If it is pink, dry out the set desiccator with warm air. Replace the desiccator.
   (2) Remove the transceiver cover (four allen screws behind the handles) and check that the correct crystals are fitted. Make a note of the BAND and USB-LSB switch settings for each antenna frequency (antenna frequency = crystal frequency minus 10,7015MHz). Replace cover.
   (3) Set the front panel mode switch to OFF.
   (4) Clip the battery box to the set.

Battery Check

3. Check the battery as follows:
   (1) Connect the antenna to be used, to the set.
   (2) Connect the h.m.t. to either of the front panel AUDIO sockets.

(3) Set the front panel controls as follows:

GAIN control : fully clockwise
USB-LSB switch : USB or LSB and
CHANNEL switch : channel required
BAND switch : LP on appropriate range
NET control : Central
TUNE control : Immaterial
Mode switch : SSB

(4) Operate the PTT switch and check the battery voltage. For a fully charged battery the front panel meter should read half to full-scale deflection. If the meter reading is below the half-scale the battery needs recharging. (See paragraph 8 for charging procedure). Release the PTT switch.

Tuning

4. The set may be tuned by either of two methods. Generally, the most accurate method and the one which must be used if radio silence is imposed is by tuning the receiver. This method is given in paragraph 5. If radio silence is not required the aerial may be tuned by the method given in paragraph 6 which is quite accurate for whips and reasonably accurate for other types of antenna.

5. Tuning by the receiver method

(1) Set the front panel controls as follows:

GAIN control : fully clockwise
USB-LSB switch : USB or LSB as required
CHANNEL switch : channel required
BAND switch : TUNE
NET control : Central
TUNE control : Immaterial
Mode switch : SSB

(2) Adjust the TUNE control for maximum noise on the h.m.t. At this stage noise will be found over a wide range of TUNE control adjustment. Set the TUNE control to about the centre of this range.

(3) Reduce the GAIN control until the noise can just be heard.

(4) Readjust the TUNE control for maximum noise.

(5) Repeat (3) and (4) until a sharply defined maximum is achieved. The set is then tuned for both transmission and reception.

6. Tuning by the transmitter method.

(1) Set the front panel controls as follows:

GAIN control : fully clockwise
USB-LSB switch : USB or LSB as required
CHANNEL switch : channel required
BAND switch : LP on appropriate range
NET control : Central
TUNE control : Immaterial
Mode switch : BK CW

(2) Operate the PTT switch and adjust the TUNE control for maximum brilliance of the lamp between the BAND switch and TUNE control.

(3) Release the PTT switch.

OPERATION

7. The equipment is now set up to transmit and receive on the channel set by the CHANNEL and USB-LSB switches. If the channel is changed, the tuning procedure must be carried out with the switches set to the new channel. The front panel mode switch should now be set for the transmission and reception mode required:

(a) OFF - In this position the set is switched off and there is no current drain on the battery.

(b) REC - This position is for reception only. Operating the p.t.t. switch has no effect on the set, transmission is not possible.

(c) SSB - The set will receive and transmit SSB signals, upper or lower sideband depending on the position of the USB-LSB switch.

(d) BK CW - With the key connected to one of the front panel AUDIO sockets transmission and reception of morse is available. The set will transmit while the key is down and receive while the key is up.

(e) CW - In this position the set is permanently in a transmit condition. However, no transmission will be made until the key is down. Reception is not possible whether the key is up or down.
CAUTION: if the h.m.t. is also connected, the microphone is 'live' and extraneous noise will be broadcast.

(f) AM - In this position, AM signals can be transmitted and received. It is intended for communications between the TR28 and some other type of set using AM. Generally, AM operation between two TR28's is not recommended and should only be attempted if no other mode is available.

BATTERY CHARGING

Introduction

8. To charge the battery using the field charger (Battery Charger type BC28F) see handbook reference RE018.374.

9. The battery may be charged without using the field charger by one of two methods: with the Battery Box in situ or with the Battery Box removed from the transceiver. Before charging is attempted it is recommended that the operator first reads Appendix A: Nickel Cadmium Batteries - Technical Notes.

10. Whichever method is used first determine the source from which the battery is to be charged. This may be:

(a) A 12V vehicle battery.
WARNING: THE VEHICLE ENGINE MUST NOT BE RUNNING WHILE CHARGING FROM THIS SOURCE.

(b) An a.c. supply from a unit such as the mains powered Racal MSU28.
This must only be used for charging when the battery box is removed from the transceiver.

(c) A regulated d.c. power supply capable of giving an output of 12V at 1,0A.

(d) An unregulated 12V d.c. source such as a charger for lead-acid batteries.
WARNING: IF THIS TYPE OF CHARGING SOURCE IS USED, A BALLAST SUCH AS A 12V VEHICLE BATTERY MUST BE CONNECTED BETWEEN THE CHARGING SOURCE AND THE TR28 BATTERY BOX.

11. Figure 2.1 shows the general method of connecting the charging source to the TR28.

12. Check the state of charge of the battery while the Battery Box is still clipped to the transceiver:

(1) Connect the h.m.t. to either of the AUDIO sockets.

(2) Set the front panel switches as follows:

BAND switch : LP on either range

Mode switch : SSB

Other controls : Immaterial

(3) Operate the PTT switch and check meter reading:

(i) No deflection indicates a fully discharged battery which will required a 14-hour charge.

(ii) A centre scale reading may indicate a fully charged or near fully charged battery for which a charge of a few hours will be sufficient.

(iii) A reading between zero and half scale shows a partly discharged battery for which a pro rata charging time is required.

(4) Estimate and make a note of the charging time required.

Charging with the Battery Box in Situ

13. To charge the battery:

(1) Connect charging lead A (with Souriau plug) to either of the front panel AUDIO sockets.

(2) Connect the croc. clips on the other end of the charging lead directly to the terminals of the charging source listed under paragraph 10(a) or (c). If the charging source listed in paragraph 10(d) is to be used, connect the croc. clips to the ballast battery, select another pair of leads (40,0076 minimum) and connect between the charging source and the ballast battery. Ensure that polarity is observed: red charging lead to charging source or ballast battery positive.

(3) Set the MODE switch to OFF and listen for a 7kHz whine from the transceiver. This indicates that the battery is being charged.

(4) Leave the battery on charge for the period estimated above and then recheck and make a note of the state of charge as in paragraph 12 above.

(5) Return to the charge condition for one hour and then recheck the state of charge. If this is the same as noted in (4) the battery is fully charged. If not, return to the charge condition and repeat until there is no noticeable difference in the readings taken over a one hour period.

NOTE: Whatever the original state of charge, the battery may be left on charge for a period of up to 24 hours without damage.

14. If required, the h.m.t. may be plugged into the vacant AUDIO socket and the mode switch set to REC while charging. A listening watch may then be kept although a fair amount of background noise can be expected.

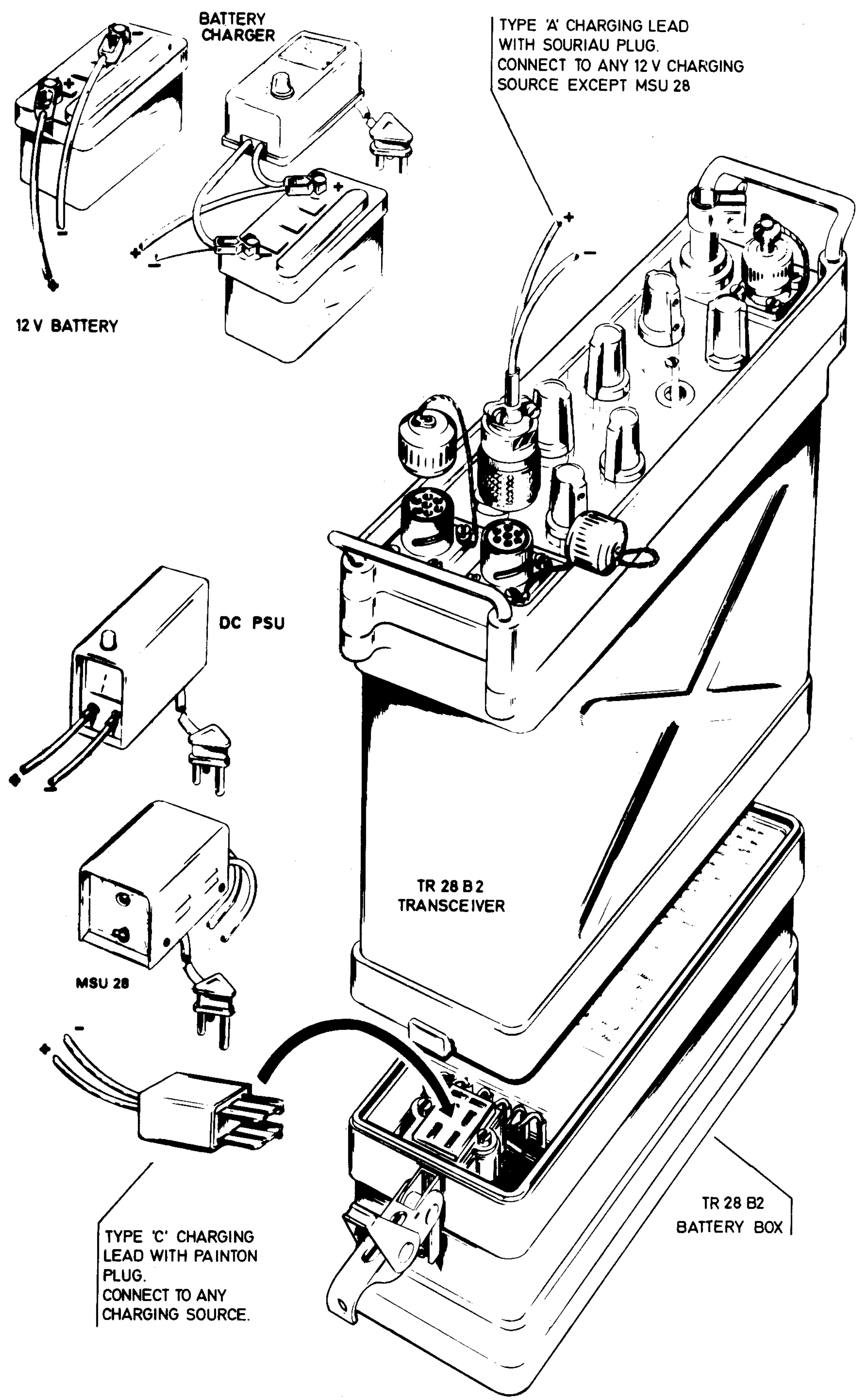
Charging with the Battery Box Removed

15. With the Battery Box removed from the transceiver the charging procedure is similar, the only differences being:

(a) Charging lead C (with a Painton plug) is connected to the socket on the Battery Box, the other end of the charging lead being connected to the charging source or ballast battery.

(b) The two lamps, one on either side of the socket, light to indicate that the battery is being charged.

(c) The mains powered a.c. unit may be used.



TR 28 B2 Charging Connections

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Fig. 2.1

CHAPTER 3

CIRCUIT DESCRIPTION

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CHAPTER 3

CIRCUIT DESCRIPTION

INTRODUCTION

1. To assist in the understanding of the following circuit description the functional description and block diagram given in Chapter 1 should be read first.

2. The circuit diagram comprises Figures 3.1, 3.2 and 3.3. Figure 3.1 shows the switch functions and p.c.b. interconnections with the main p.c.b. shown in functional form. Figures 3.2 and 3.3 show the circuit of the main p.c.b., power amplifier and DC/DC converter. In the following description the receive path is considered first followed by the transmit path.

3. The d.c. supply to most circuits, except the transmitter output stages, is +9V. As some circuits are common to both RX and TX paths the inputs and outputs to these circuits must be from the RX path when the equipment is in the RX mode and from the TX path when in the TX mode. This is achieved by applying 9V RX to the RX circuits during reception and by applying 9V TX to the TX circuits during transmission, these voltages being switched by the PTT switch.

RECEIVE PATH

Radio Frequency Stage

4. The received signal is routed from the 50 ohm or whip antenna connector via the bandswitch S3, the antenna tuning unit (L4), the antenna changeover relay contact RL1/1, the passband filter and main p.c.b. pins 28 and 29 to the primary of the broadband ferrite transformer T1, which matches the signal to the base of the r.f. amplifier VT3.

5. The cross-connected silicon diodes D1 and D2 protect the r.f. amplifier against high energy electrostatic or r.f. voltages.

6. The collector load of VT3 is the transformer T2. The output of T2 (4 turn winding) is applied to the image suppression filter (ISF) which suppresses all frequencies above 8MHz. Added attenuation at the i.f. is provided by a notch filter in the ISF which is factory adjusted by C9. R7 in the primary circuit of T2 ensures a flat response up to 8MHz.

Balanced Mixer

7. Output from the image suppression filter is matched to the primary of transformer T3, the secondary of which is connected to the balanced diode bridge D20 and D21 in the centre tapped secondary of transformer T13. High level output from the channel oscillator buffer amplifier VT19 is fed to the primary of T13 at a frequency equal to the channel frequency plus the i.f. frequency. The diode bridge mixer balances out the oscillator signal and the mixer difference signal at the i.f. frequency is fed to the primary of tuned transformer T4.

Sideband Filters

8. The output from transformer T4 is fed via capacitive divider C15 and C16, to the switching diodes D5 and D6 at the input of the sideband filters F1 and F2. With the USB/LSB switch S1B set to USB, 9V positive is applied to diodes D5 and D7 which conduct and open the signal path to the USB filter. With the USB/LSB switch set to LSB, 9V positive is applied to diodes D6 and D8 which conduct, and open the signal path to the LSB filter. The wanted sideband is fed to the junction of capacitors C24 and C25 connected across the primary of T5. It should be noted that because of frequency inversion the u.s.b. filter has l.s.b. characteristics and vice versa.

10,7MHz IF Amplifier

9. I.F. amplifiers VT5 and VT6 operate in the common emitter mode with audomatic gain control while VT7 operates at a fixed gain. Tuned transformers T6, T7 and T8 provide interstage matching and selectivity, and T9 is a broadband matching transformer.

10. The emitter current of VT6 is fed via R32 to the metering circuit.

Balanced Demodulator

11. The secondary winding of T9 matches the i.f. signal to the balanced diode demodulator D14 and D15. High level excitation at 10,7015MHz from carrier crystal oscillator VT16 is applied to the demodulator via T10. Balancing of the mixer is effected by RV4 and C69. Audio voltage is fed via decoupling network C40, C41 and R39, to the input of the first audio amplifier VT8.

Audio Amplifiers

12. The audio pre-amplifier VT8 operates in common emitter mode and feeds VT9, which drives the complementary push-pull class B stage VT10 and VT11. The quiescent current of the class B stage is controlled by diodes D10, D11 and RV1. Audio output is developed across preset level control RV2, the slider of which is connected to pin 2 on both front panel audio sockets, via pin 27 of the main p.c.b.

Automatic Gain Control

13. The audio output appearing at the junction of R56, R57 and C49 is fed via R74 and C70 to diode detector circuit D16 and D17 in the base circuit of VT17. Under no signal conditions, VT17 draws no current, and the gain of the i.f. stages VT5 and VT6 is controlled by the setting of the pre-set potentiometer RV5 and the receiver manual gain control RV6. Under signal conditions, the a.f. signal is rectified in diodes D16 and D17 and a positive voltage proportional to the audio output is developed across R75. This positive voltage, filtered by C71, R76 and C72, is applied to the base of VT17 and its collector current increases. The resulting voltage drop across R77 is applied to the bases of i.f. amplifiers VT5 and VT6, resulting in a reduction of the combined gain of the controlled stages.

AM Reception

14. With the MODE switch S4 set to AM, h.t. is removed from the 10,7MHz oscillator VT16. The 9V supply is applied via switch S4H contact 6 to switching diodes D3 and D4 in the sideband filter circuit. These diodes conduct to connect both filters in parallel and provide the a.m. characteristics for the incoming i.f. signal. During reception the 9V RX supply is applied to the anode of D42 and resistor R120 is earthed through contact 6 of S4B. The resulting positive voltage at the cathode of

D42 reverse biasses D18 and D19 to hold the filter bypass link open circuited. (This link is in circuit during a.m. transmission - see paragraph 24).

15. The 9V at S4H is also fed through R40, R39 and T9 secondary to the slider of RV4. This causes the modulator to be unbalanced and to operate as an a.m. detector circuit.

TRANSMIT PATH

Microphone Amplifier and Balanced Modulator

16. Audio voltages from the microphone at pins 1 of both audio sockets are fed via pin 18 of the main p.c.b. to the two-stage amplifier VT15 and VT14. Diode D12 conducts when the 9V TX supply is applied to R68. The amplified audio from VT14 is fed via C54 and the distribution transformer T9, to the input of the balanced modulator D14 and D15, where it is heterodyned with the 10,7MHz signal from carrier oscillator VT16. The carrier is balanced out and the double sideband signal is fed to the 10,7MHz d.s.b. line via the distribution transformer T9.

DSB Amplifier and Sideband Filter

17. Input from the d.s.b. line is fed via diode D9 to the common emitter amplifier VT4 and matched to the input of the sideband filters by the primary of the tuned transformer T5. The unwanted sideband is rejected and the wanted sideband is matched to the input of the balanced mixer by the tuned transformer T4.

Balanced Mixer

18. The 10,7MHz sideband is fed to the balanced mixer diodes D20 and D21, and mixed with the output of the channel r.f. amplifier, VT19. The channel oscillator signal is balanced out and the output from the mixer, consisting of the radiated frequency plus an image signal and breakthrough of the 10,7MHz signal, is matched by transformer T3 to the input of the image suppression filter.

Image Suppression Filter

19. The filter has lowpass characteristics, with a cut-off at 8MHz and a rejection notch at the i.f. of 10,7MHz. Output from the filter is matched by transformer T2 to the base circuit of the pre-amplifier VT27.

Pre-Amplifiers

20. Pre-amplifiers VT27 and VT26 operate in broadband configuration, resistors R115 and R109 across the collector loads T19 and T18 enhancing the broadband characteristics. VT27 and VT26 operate in class A, and the output of VT26 is matched by transformer T18 to the input of the driver stage.

Driver Stage

21. VT24 and VT25 operate in common emitter, class B push-pull, the quiescent current being set by RV9 and held by diode D23. The amplified signal appearing in the collector loads T16 and T17, is matched to the bases of the parallel push-pull combination VT20, VT21, VT22 and VT23.

Linear Power Amplifier

22. This stage is operated in class B with the quiescent current held by diode D22 and resistors R106, R101 and R102. The paralleled outputs from pairs VT20/VT21 and VT22/VT23 are matched via transformers T15 and T14 to the 50 ohm line. The 50 ohm line is connected to the antenna tuning unit via changeover relay contact RL1/1.

Antenna Tuning Unit

23. This unit is switched for high or low band operation (4-8MHz and 2-4MHz) and will tune whip antenna connected to the WHIP socket and dipoles and slant wire antenna connected to the 50 ohm socket SK3. The antenna tuning unit supplies the necessary inductance to tune capacitive antenna of less than one quarter wave in length.

AM Transmission

24. When the controls are set for a.m. transmission the 9V TX supply is fed through MODE switch S4G contact 6 to the carrier oscillator circuit. This circuit feeds a 10,7MHz signal to the unbalanced modulator circuit where it is mixed with the audio to form a double sideband plus carrier signal.

25. In the sideband filter circuit the 9V RX supply to D42 anode is not available when the PTT switch is operated. Resistor R120 is earthed as before (paragraph 14) but the 9V RX supply is not available at D42 anode. Thus the 9V supply at the anode of D3 and D4 causes current flow via diodes D5 to D8, diodes D18 and D19 to earth through R120. D18 and D19 are forward biassed and provide a short circuit link across the filters for the a.m. signal from T5.

Overload Protection

26. To protect the p.a. transistor against bottoming, due to causes such as antenna mistuning, an overload protection stage is incorporated. Diodes D48 and D49 are forward biassed to about 5V via potential divider R118, R131, R117. Should the collector potential of the p.a. transistors tend to fall below 5V, the 5V at the anodes of D48 and D49 will be connected to the collectors. During reception the junction of R128 and R129 is earthed by one contact of the transmit-receive relay to prevent any damaging transients being effective.

Automatic Level Control (ALC)

27. Under conditions of no modulation, the collector voltage of the ALC control transistor VT18 is approximately 2,7V and consequently the current through diode D9 is maximum. In this condition diode D9 presents a low resistance to the r.f. drive applied to VT4 base.

28. When drive is applied to the transmitter, the resulting voltage at the emitter of VT20 is applied, via RV7, R81 and R80, to the base of VT18 where it progressively reduces the collector voltage and hence reduces the current through D9. This reduction of current effectively increases the resistance of D9 to the r.f. drive applied to VT4 base, and serves to control the drive level. RV7 is normally adjusted so that when transmitting on 'Tune' an output of 12,5 watts is obtained.

Break-in CW

29. With the mode switch set to BKCW, the key is connected across the PTT switch via S4A, contact 4, and the emitter of the tone oscillator VT13 is connected to battery negative via switch S4B, contact 4. Operating the key energises the transmit/receive changeover relay. Thus the tone oscillator runs continuously and transmission is obtained by keying the relay.

CW

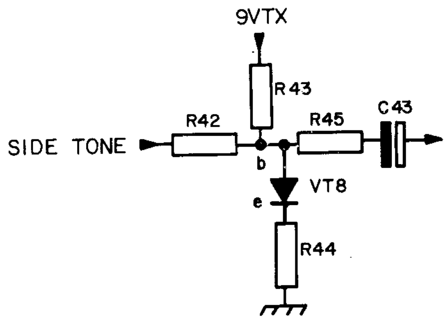
30. With the mode switch set to CW the PTT relay is connected to battery negative via switch S4E, contact 5. The relay is energised and the resulting changeover switching holds the set in a transmitting condition. At the same time the key is connected between the emitter of VT13 and earth via S4A contact 5. The transmitter is thus switched on and the tone oscillator, VT13, is energised by the key.

Tone Oscillator

31. VT12 and VT13 comprise a simple RC-coupled oscillator operating at approximately 1kHz. Audio signals developed across R58 are fed via C53 and R62 to the base of the second microphone amplifier VT14. From this point on, the transmitter operates as described previously. Thus it is possible to operate CW on u.s.b. or l.s.b.

Side tone

32. In the transmit condition the 9V RX line is de-energised and the voltage is removed from the collector of VT8. The base-emitter circuit of VT8 can now be regarded as a diode which is forward biased by the 9V TX through R43 (see sketch). Thus R42 and R44 form a potential divider to the incoming sidetone and an attenuated signal will be fed through R45, C43 to the base of VT9. The audio stages operate as before and sidetone will appear in the headphones.



TUNING CIRCUITS

Tuning the Receiver

33. With the BAND switch S3 set to TUNE, 9V regulated is applied via switch S3E, contacts 1 or 6, to the multivibrator VT1 and VT2. Output from the multivibrator is a pulse train of relatively low frequency with a high harmonic content which is loosely coupled to the coil of the antenna tuning unit via an open-turn link. The spectrum is monitored in the earphones during tuning.

Tuning the Transmitter

34. As an alternative method of tuning the set the BAND switch may be set to HP or LP with the mode switch at BK CW. Under these conditions the tone oscillator is energised and operating the PTT switch will bring the set into a transmit condition. Maximum power to the antenna will now coincide with maximum brilliance of the front panel neon lamp, LP1. While this method of tuning is accurate for whip antennas it is advisable to use the receiver tuning method when antennas other than whips are used.

Metering

35. The front panel meter performs two functions: It gives an indication of the strength of the received signal, and indicates the battery volts on transmit.

36. In the receive position the meter is connected in the emitter of VT6 and will thus become operative at the automatic gain control threshold.

37. In the transmit position the meter is connected in a bridge network with the zener diode D50 connected to the 12V TX supply via relay contact RL113. The zener diode only starts conducting at 9V and the meter will begin to read; at 14V the meter is reading full scale. The meter set potentiometer RV10 is adjusted such that the meter reads half scale at 12V. The effect of connecting the zener diode in series with the meter is to amplify the meter movement, thus enabling small changes in the battery voltage to be readily seen.

38. The crystal board comprises three banks of 12 crystals. Each bank has its own oscillator and any one of the 12 crystals in a bank can be switched into the oscillator circuit using BAND switch S3.

39. Consider the case where the USB/LSB switch, S1, is set to 'A' (either u.s.b. or l.s.b.) and the channel switch, S2, is set to '1'. In this case the 9V supply at the wiper of S1 is fed only to the oscillator and circuits in bank A. There is no supply to banks B and C so that the oscillators in these two banks cannot operate. The cathode of diodes D1A, D1B and D1C are connected through switch S2 and R22 to earth.

40. Current will now flow through VT1A, D2A, D1A and R22 to earth. The two diodes will be forward biased, D2A providing virtually a short circuit between crystal XL1A and the emitter circuit of VT1A. The other end of the crystal is connected through two capacitive circuits to the emitter of VT2A in accordance with the requirements of the Butler type oscillator circuit used in this set. The circuit will now oscillate at the frequency of XL1A. The output from the emitter of VT2A is taken through emitter follower VT3A to the mixing circuits of the transceiver.

41. Only the two diodes D1A and D2A will conduct with the switches set as in paragraph 39. No other diode is forward biased either because there is no supply to the anode (D1B, D2B, D1C, D2C) or because there is no earth to the cathode (all other diodes). Thus only one crystal (XL1A in this case) can be selected for any combination of the setting of the two switches.

42. The frequency of each crystal can be pre-adjusted to a limited extent by the parallel connected fixed and variable capacitors (C4A and C16A for XL1A) in series with the crystal. The fixed capacitor and varicap diode which are common to each bank of crystals also allow the frequency of the selected crystal to be varied. The effective capacitance of the varicap depends on the voltage across it, the higher the voltage the lower the capacitance. The control voltage for the varicap is taken from the NET control potentiometer RV12 on the front panel. Adjusting this control allows antenna frequencies slightly above or below the nominal frequency to be received (netted) by shifting the mixing frequency to a value which gives optimum clarity.

POWER SUPPLIES

General

43. The power supply circuits can be conveniently divided into two parts:

(a) The voltage regulator and switching circuits housed on the main pcb which provide the power supplies for the receiver circuits and for the level transmitter circuits.

(b) The DC Converter which has two functions:

(i) To provide the power for the transmitter power amplifiers

(ii) To connect an external charging source to the internal battery.

Voltage Regulator and Switching Circuits

44. The 12V supply from the internal battery is switched by mode switch S4C to the voltage regulator comprising series transistor VT32, error amplifier VT31 and reference diode D29. VT32 emitter output is the 9V supply which is fed to circuits common to both transmitter and receiver. Should the level of this supply tend to rise above 9V, the potential at the slider of RV11 and hence at the base of VT31 will also rise. Conduction through VT31 will increase and give a greater voltage drop across its collector load resistor R125. The base of VT32 will go more negative to increase the effective resistance of the series regulator.

45. The regulated 9V supply also feeds the collector of switching transistor VT34. The base of the transistor is connected through R135 to the 12V input line and the transistor normally conducts to feed the 9V supply (9V RX) to the circuits used exclusively by the receiver.

46. When the PTT switch is operated, RL1/3 contact changes over to connect the 12V supply to the base of VT33. This transistor conducts and feeds the regulated 9V at its collector as the 9V TX supply to the transmitter low level circuits. At the same time the base of VT35 is also connected to the 12V line through R136. VT35 conducts and holds the base of VT34 at earth potential. VT34 is cut off and there is no 9V RX supply to the receiver circuits. When the PTT switch is released the 9V TX supply is cut off and the 9V RX supply restored.

47. The 9V TX supply is also fed to S4G, contact 6. When a.m. working is selected the resulting 9V TX to the collector of VT16 energises the crystal oscillator to provide the 10,7015MHz signal used as the carrier on a.m. transmission.

DC Converter

48. The unit provides the power supply for the power amplifier transistors VT20 to VT23. The supply is at either 12V when the front panel BAND switch S3 is set for low power (LP), or 36V when high power (HP) or TUNE is selected.

49. For low power working the battery input at PL1 pin 2 is routed as follows:

FS1
p.c.b. pin 1
T20 secondary centre tap
D25 and D28
T14 and T15 primary centre taps
VT20 and VT23 collectors

This collector supply is not switched: it is present at the collectors whenever the battery is connected and whether the set is switched on or not. Transmission is not, of course, available until the set is switched to the appropriate mode and the PTT switch operated.

50. High power operation is only available when the BAND switch is set to HP and the mode switch is set to the required operating mode. The battery input is then fed through S4C to normally open contact RL1/3 on the transmit/receive changeover relay. When the PTT switch is operated the supply is fed through BAND switch S3H and mode switch S4F to the centre tap on the primary of T20. It is also fed through R134 to the centre tap of T20 feedback winding. In the normal manner, conduction will start in one of the Darlington pairs and will increase until the transformer is saturated. The other Darlington pair will then start to conduct and so on. A fast switching action between the two pairs will induce a square wave into T20 secondary. This square wave is rectified by D25 and D28 and is fed at 36V d.c. to the collectors of VT20 to VT23.

51. Diode D24 is a protective device between the bases of the Darlington pairs and earth. The diode will conduct if the base potential of either pair falls to below about -0,7V during the switching action.

Charging from an External Supply

52. Charging may be carried out with the battery box in situ or removed from the transceiver. See paragraph 61 for the latter method of charging.

53. Charging the set with the battery box connected may be from any convenient 12V supply although if an unregulated charging source is used it is essential that an external ballast battery is connected between the charging source and the TR28.

54. The battery may be charged with the receiver switched on or off, that is, in either of the first two positions of the mode switch. With the switch set to CHARGE/REC. reception will be available. The transmitter cannot be energised while the set is being charged.

55. The external source is connected to either of the front panel AUDIO sockets (SK1 or SK2). The positive input at pin 7 is routed through FS2, D30 (reverse polarity protection) MODE switch S4F p.c.b. pin 3 to the centre tap on the primary of T20. This brings the oscillatory circuit formed by the two Darlington pairs into operation in the manner described in paragraph 50. T20 secondary output is rectified by D26, D27 and a negative charging voltage of about -20V is fed through p.c.b. pin 2 and PL1 pin 4 to the battery box (see circuit diagram Fig. 3.5). In the box, the charging current is through current regulator LP4 to PL1 pin 3. This pin is connected to earth through MODE switch S4B while the battery negative is connected directly to earth at PL1 pin 1. There is now a negative current flow through the battery to PL1 pin 4 and through FS1 back to the centre tap of T20 secondary. The battery will now charge and the receiver may be used if required.

TRANSMIT-RECEIVE SWITCHING

56. With the mode switch set to SSB or AM the relevant contact on S4C connects the coil of relay RL1 and the PTT switch in series between the internal battery positive and earth. Operating the switch energises RL1 the contacts of which change over to give the following:

(a) RL1/1 transfers the antenna from the receiver to the output from the transmitter power amplifiers.

(b) RL1/2 short circuits the receiver input and at the same time removes the earth from the overload protection circuit (paragraph 26).

(c) RL1/3 feeds the internal battery input to:

   (i) The d.c. converter oscillatory circuit when the BAND switch is set to HP.

   (ii) The base of VT33 to switch the 9V regulated supply to the transmitter circuits. (9V TX)

   (iii) The base of VT35 to disable the 9V RX power supply circuit.

57. With the mode switch set to BK CW the PTT switch is still in circuit but the transmit-receive relay is energised by the key. In addition the emitter of VT13 is earthed through S4B and the tone oscillator runs continuously.

58. When CW is selected on the MODE switch the transmit-receive relay coil is permanently earthed through mode switch S4E. The relay is energised and the contacts maintain the transceiver in a transmit condition. The morse key, in this case, is connected directly to the emitter of VT13 in the tone oscillator.

BATTERY BOX

Figure 3.5

Battery Interconnections

59. The battery box contains the ten nickel-cadmium cells which comprise the 12V battery, together with protective diodes and the components required for the charging circuit. The cells are electrically connected in two banks of five. Under normal operating conditions a link between pins 5 and 6 of PL1 on the transceiver connect the negative end of one bank to the positive end of the second bank thus giving a single battery of ten cells. When the battery box is removed from the transceiver the two banks of cells are separate.

Charging

60. Charging with the battery connected to the transceiver has been described in paragraph 52 to 55.

61. When the battery box is removed from the transceiver it may be charged from any 12V d.c. source although if the source is unregulated a ballast battery must be connected between the source and the battery box. The battery may also be charged from a suitable 13,6V a.c. source. A mains operated unit, the RACAL MSU28 has been designed for this purpose.

62. When charging from either source the input to pins 5 (.d.c. positive) and 6 of SK5. Diodes D45 and D46 isolate the two banks of the battery from each other, prevent the application of a reverse polarity charge when charging from a d.c. source and act as half wave rectifiers when charging from an a.c. source. Lamps LP5 and LP6 limit the charging current to 500mA in each bank and at the same time indicate that charging is taking place.

DESICCATOR

63. A desiccator is fitted through the bottom of the transceiver case to keep the interior of the set dry. The window in the desiccator is normally blue but becomes pink when the desiccator is saturated. When this occurs it should be taken out and dried with warm air until the blue colour re-appears. It may then be replaced.

ANTENNAS AND EARTHING ARRANGEMENTS

64. The general earth for the set is the outer of the 50 ohm antenna socket. A special cover for this socket is attached to the set and incorporates a threaded stem with a knurled nut. When the cover is screwed on to the 50 ohm socket the nut and stem provide a connection point for earthing the set or for connecting it to a suitable couterpoise.

65. To improve antenna efficiency, two devices known as capacity wallets are provided. One is incorporated in the carry-bag supplied, the other is a separate item which may be hooked over the operator's belt or carried in a pocket. On both wallets a fairly long lead is provided and for normal operation either or both wallets may be connected to the earth point described in paragraph 64 above.

66. The types of antenna which may be used are:

(a) A 3,65m (12ft) whip (supplied)

(b) A retractable wire aerial

(c) A slant wire aerial

(d) A dipole

67. The whip will normally be used when the set is carried on the operator's back. One or both of the capacity wallets should be used.

68. One of the other antennas may be used if the set is standing on the ground. The retractable wire antenna is connected to the whip antenna socket and the earthing point on the 50 ohm socket cover may be connected to one or more suitable couterpoises such as:

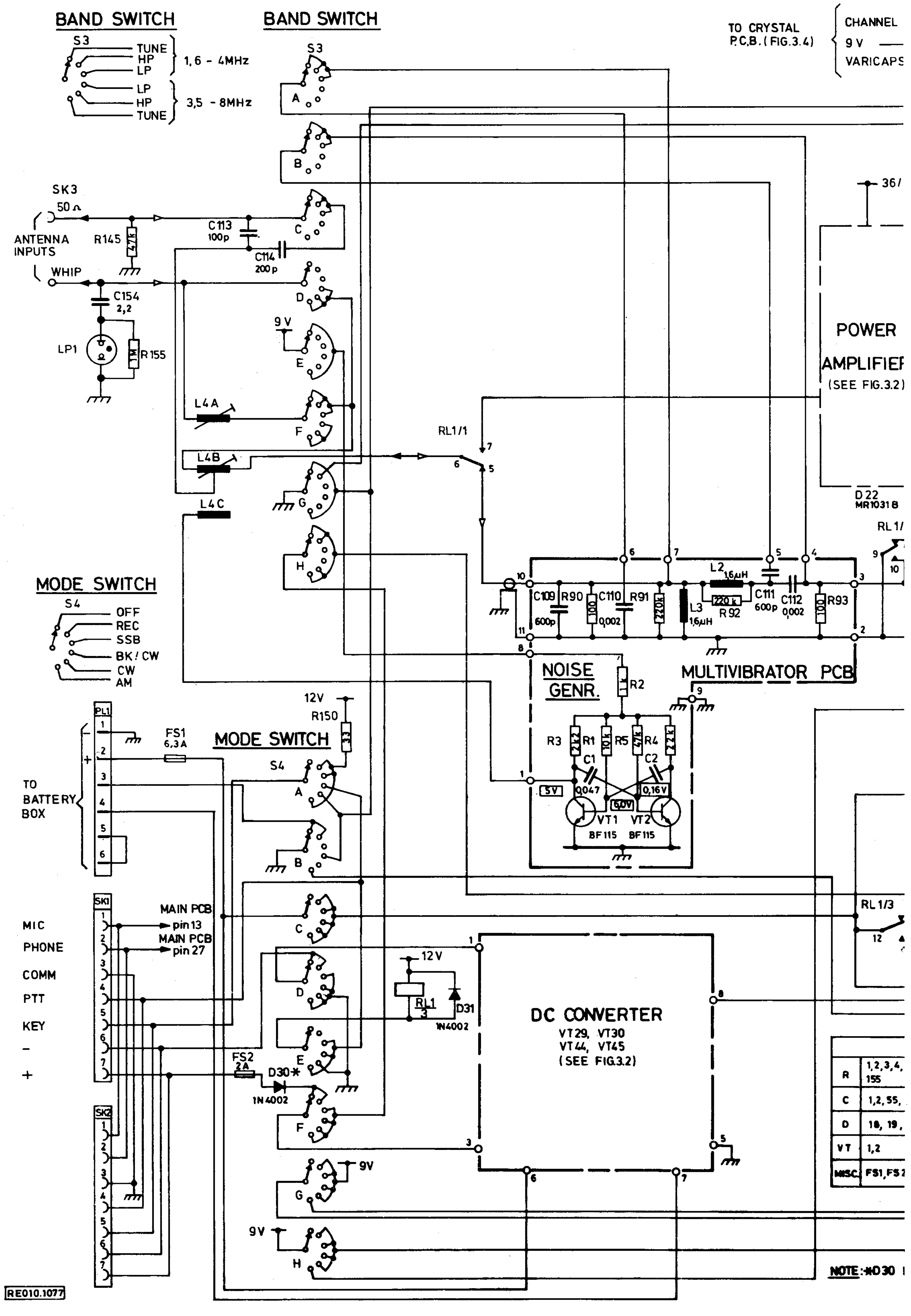
(a) The separate capacity wallet which is then slipped into the operator's pocket.

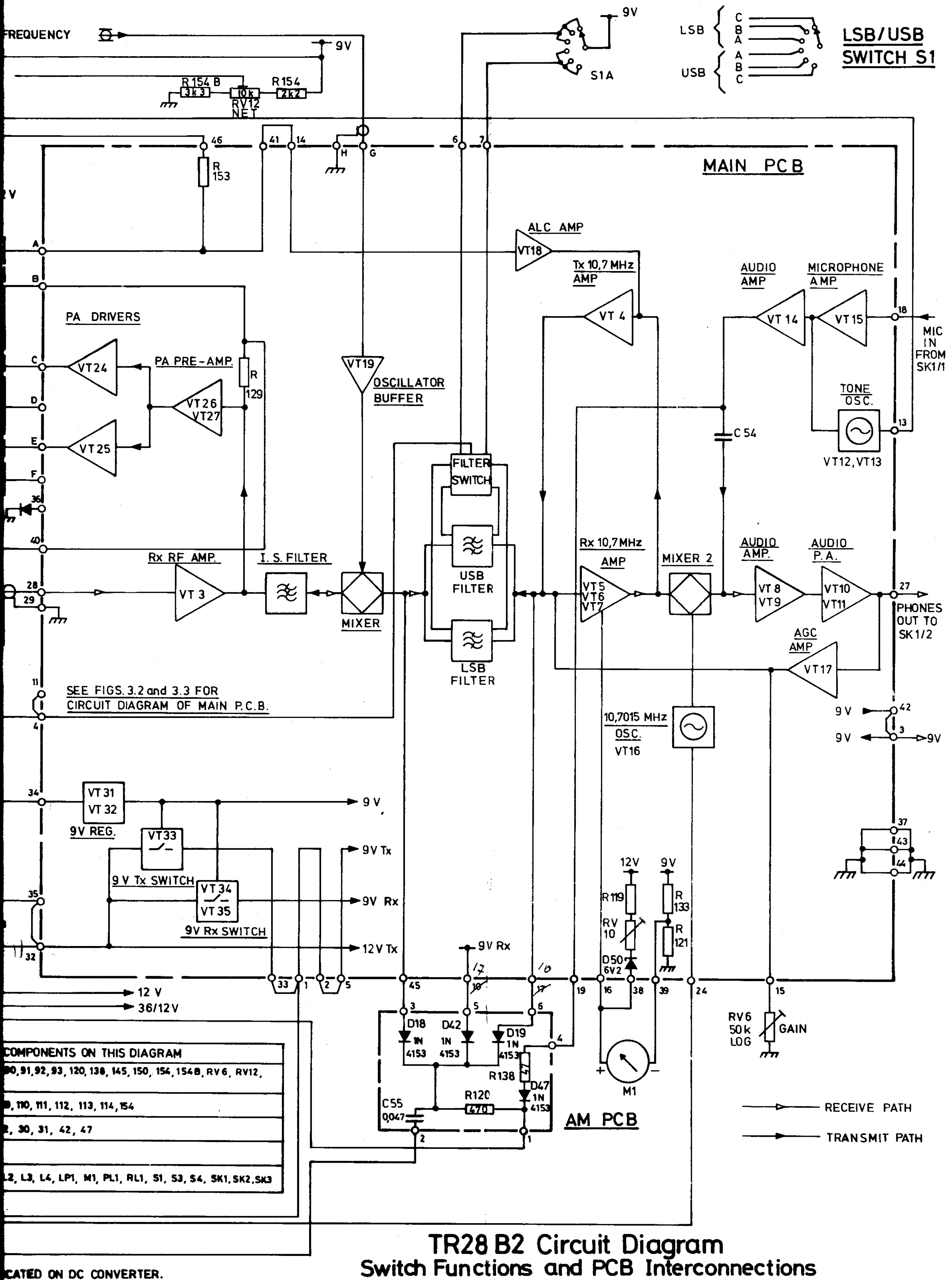
(b) A length of wire laid out along the ground or weighted and thrown into water.

(c) A motor vehicle chassis.

69. If the slant wire antenna is used, this is connected to the 50 ohm socket and other earthing arrangements must be used. A suggested method is to solder a piece of wire to the outer of the plug used to connect the antenna to the 50 ohm socket.

70. A dipole is also fitted into the 50 ohm socket but in this case no earthing arrangements are required.

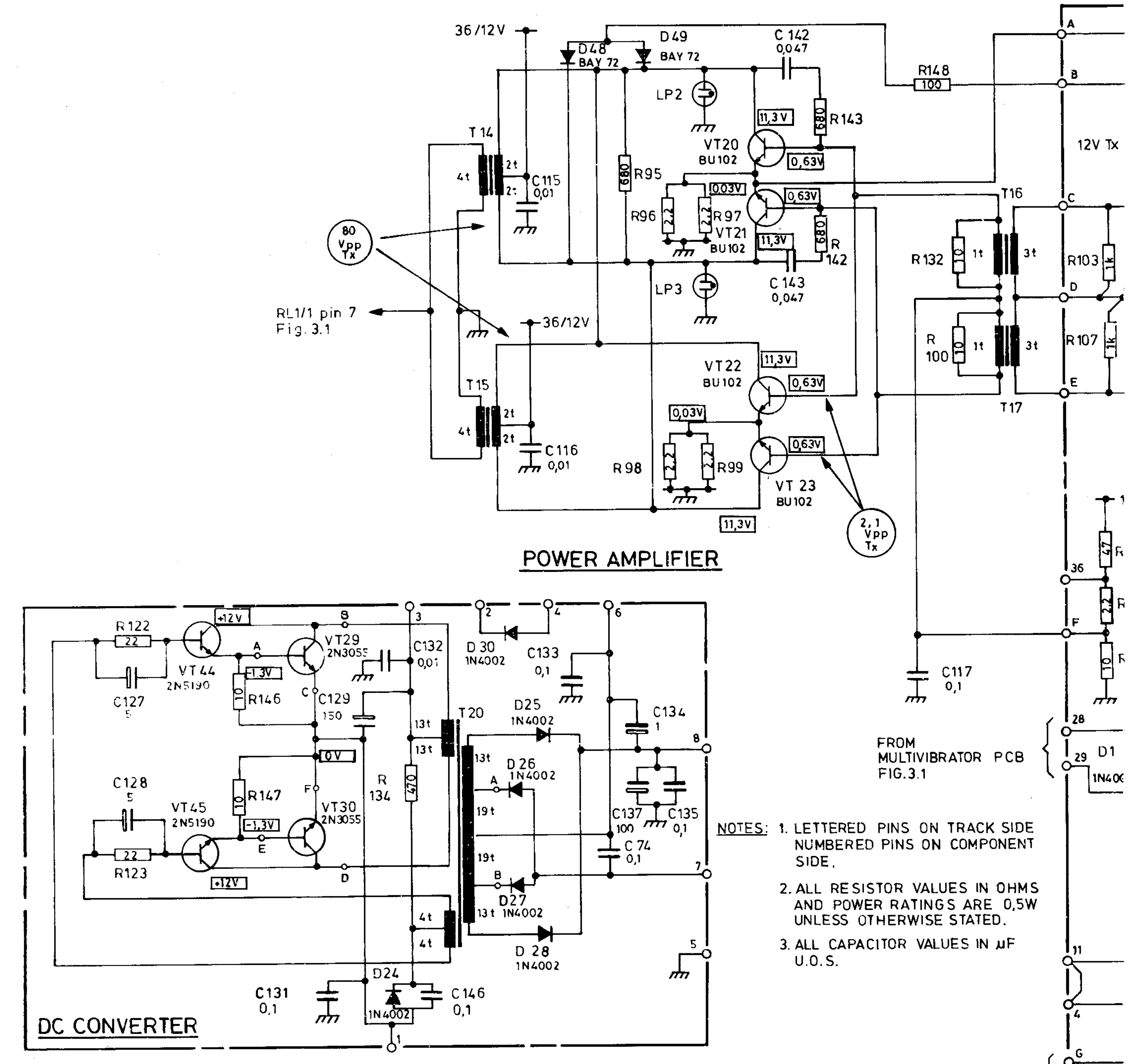

BAND SWITCH
S3
TUNE
HP
LP
1,6 - 4MHz
LP
HP
TUNE
3,5 - 8MHz
BAND SWITCH
S3
A
B
C
D
E
F
G
H
TO CRYSTAL P.C.B. (FIG.3.4)
CHANNEL
9 V
VARICAPS
SK3
50 Ω
ANTENNA INPUTS
R145
47k
C113 100p
C114 200p
WHIP
C154 2,2
LP1
1M
R155
9 V
L4A
L4B
L4C
RL1/1
POWER
AMPLIFIER
(SEE FIG.3.2)
36
D22 MR1031B
RL1/
MODE SWITCH
S4
OFF
REC
SSB
BK / CW
CW
AM
C109 600p
R90 100
C110 0,002
R91 220k
L3 1,6μH
L2 1,6μH
220 k
R92
C111 600p
C112 0,002
R93 100
NOISE GENR.
R2 1 k
MULTIVIBRATOR PCB
R3 2k2
R1 10 k
R5 47k
R4 2k2
C1 0,047
C2
5V
6,0V
0,16V
VT1 BF115
VT2 BF115
12V
R150
33
PL1
FS1 6,3 A
MODE SWITCH
S4
TO BATTERY BOX
SK1
MIC
PHONE
COMM
PTT
KEY
-
+
MAIN PCB pin 13
MAIN PCB pin 27
RL1/3
12
12V
RL1 3
D31 1N4002
DC CONVERTER
VT29, VT30
VT44, VT45
(SEE FIG.3.2)
FS2 2A
D30*
1N4002
9V
SK2
R 1,2,3,4, 155
C 1,2,55,
D 18, 19,
VT 1,2
MISC. FS1,FS2
NOTE: *D30
RE010.1077



TR28 B2 Circuit Diagram
Switch Functions and PCB Interconnections

Fig. 3.1

R	122,123	146,147	154	95,96,97, 98, 99	142,143,148	100,101,102,103,106,107, 132
C	123, 127	131	115,116, 129, 131, 132, 146	74, 133, 134,135, 137	117, 142, 143	
D			24, 26, 27,30	25, 26, 48, 49		
NT		29,30,44,45			20, 21, 22, 23	
MISC.			T14, T15, T20	LP2, LP3		T16, T17



NOTES:
1. LETTERED PINS ON TRACK SIDE NUMBERED PINS ON COMPONENT SIDE.
2. ALL RESISTOR VALUES IN OHMS AND POWER RATINGS ARE 0,5W UNLESS OTHERWISE STATED.
3. ALL CAPACITOR VALUES IN μF U.O.S.

TEST LEVELS

[ ] DC VOLTAGES MEASURED WITH AVO MODEL 8 (20 000 Ω/V)

RECEIVER

(μV) OPEN CIRCUIT RF SIGNAL GENERATOR VOLTAGE (RMS) TO GIVE 0,15 V AT TOP OF AF PRESET GAIN CONTROL (RV2)
RF= 5MHz
IF= 10,7 MHz

(V) 1kHz AF VOLTAGE (RMS) PRESENT TO GIVE 0,15 AT TOP OF RV2 MEASURED WITH AC VTVM

TRANSMITTER

Tx TESTING	5 MHz	50 Ω LOAD CONNECTED ACROSS 50 Ω RF OUTPUT:
FUNCTION	SSB	TUNE FOR MAXIMUM OUTPUT
ATU	HI TUNE	(Vpp Tx) VOLTAGE PRESENT MEASURED WITH 10pF PROBE WHEN Tx DELIVERING 12,5 W INTO 50 Ω LOAD.

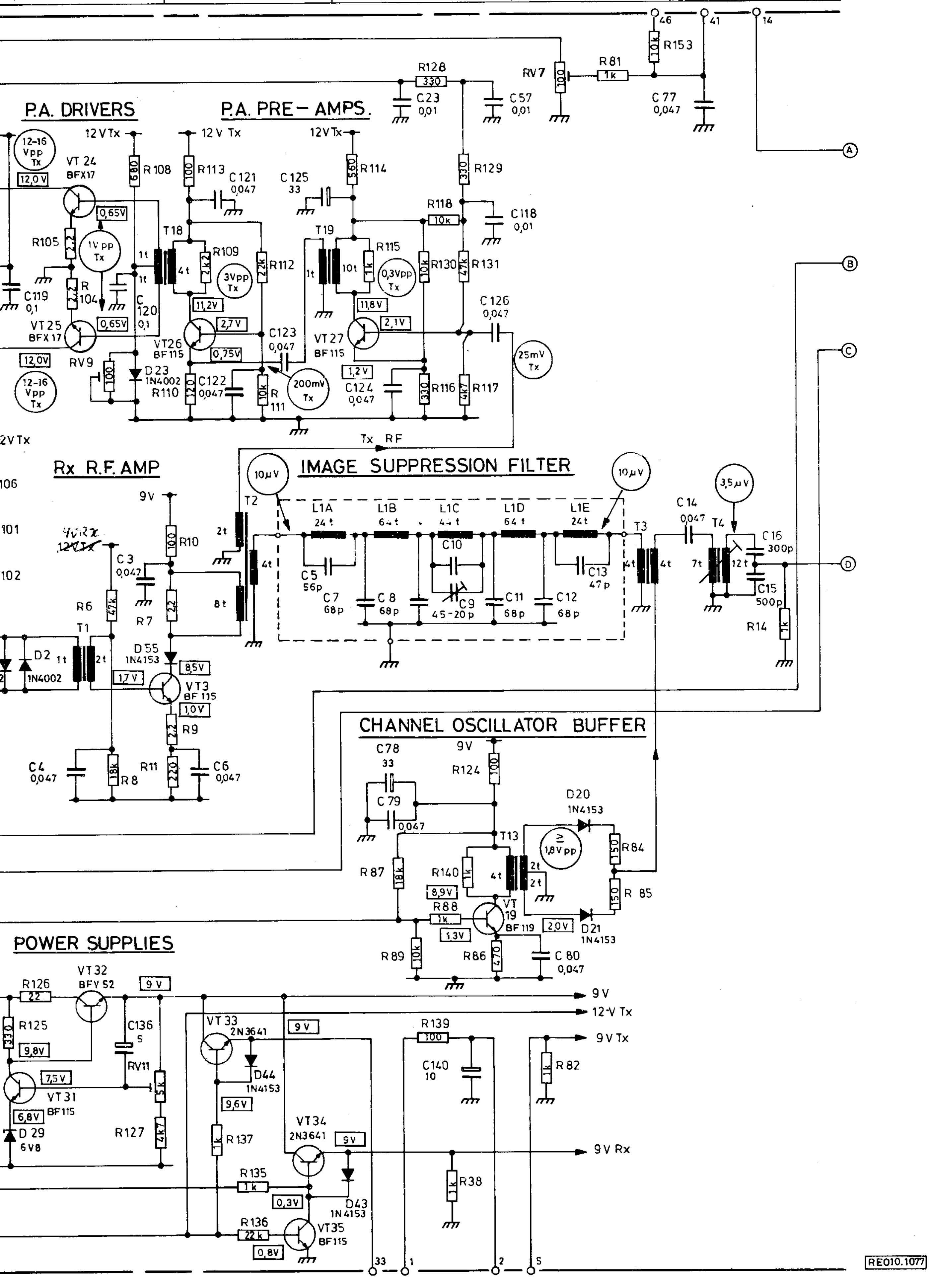
TR28 B2-Circuit Diagram

Main PCB and Power Amplifier (Sheet 1)

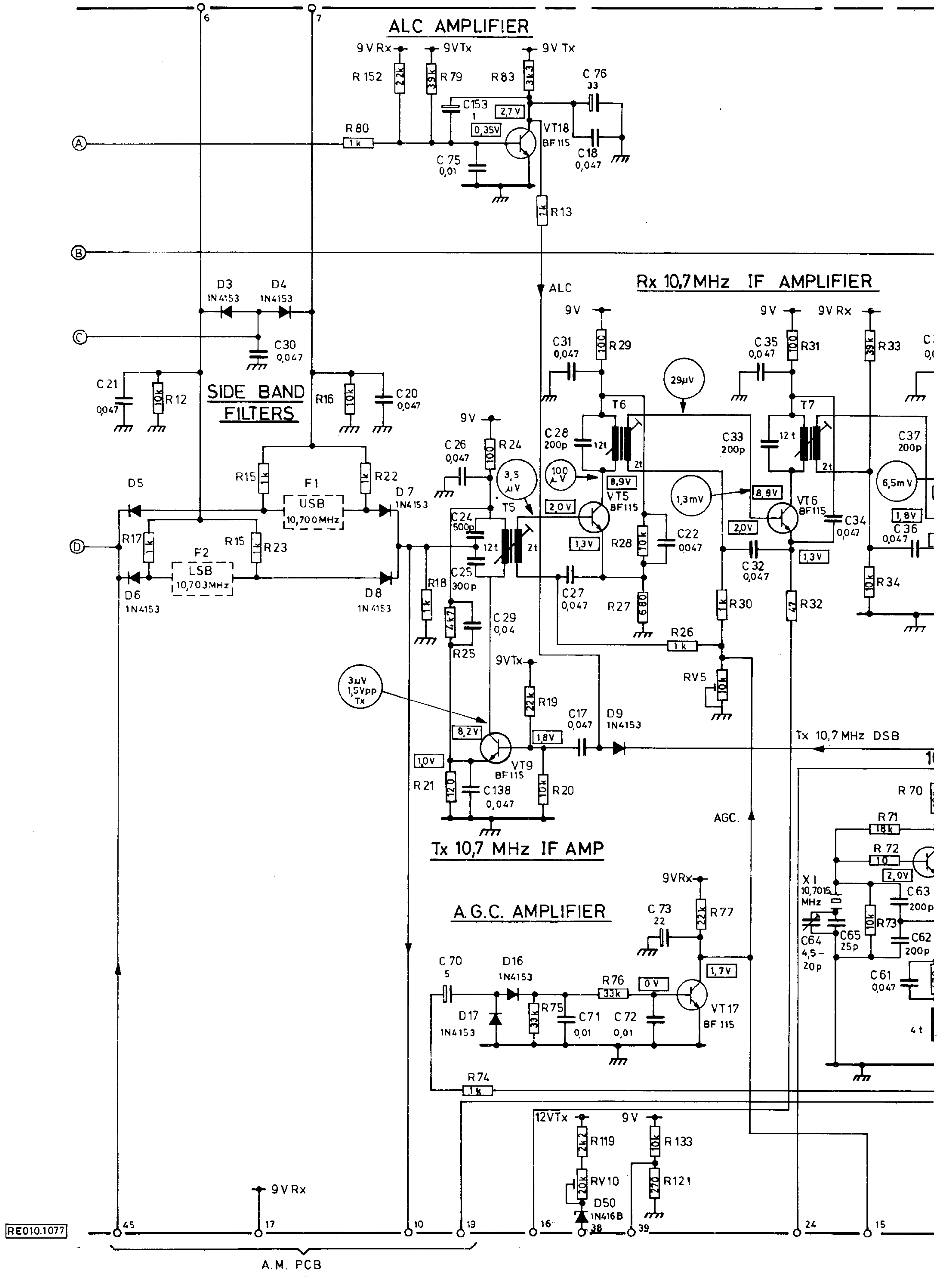
Fig. 3. 2

FROM RL 1/3 pin 11 FIG. 3.1

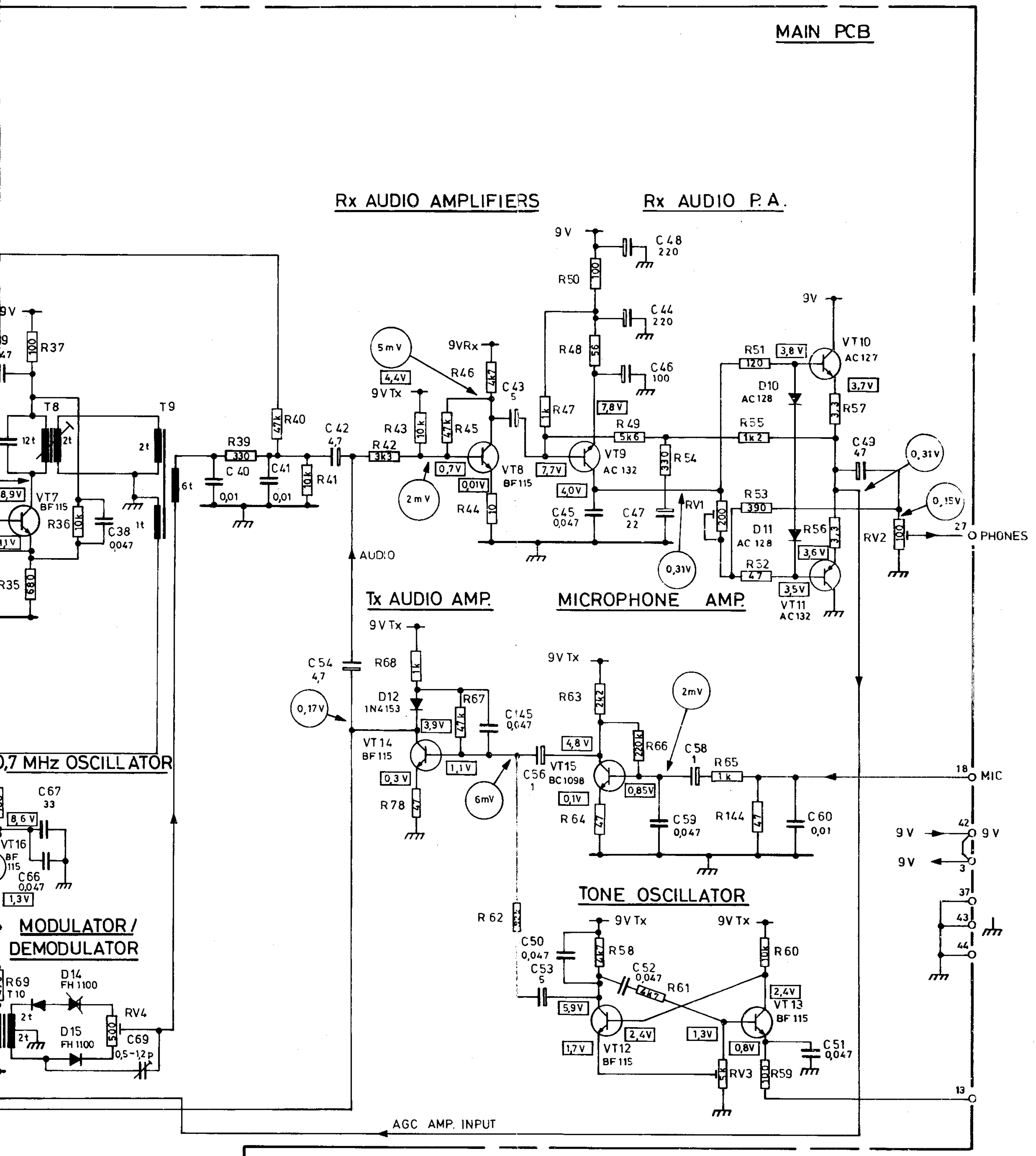
6,7,8,9,10,11,104,105,108,125, 126,127, RV9, RV11	109, 110, 111, 112, 113, 135, 136, 137	38, 86, 87, 88, 89, 114, 115, 116, 117, 118, 124, 128, 129, 130, 131, 139, 140	81, 82, 84, 85, 153, RV7	14
3,4, 119, 120, 136	5,6, 121, 122, 123, 125	7, 8, 9, 10, 11, 23, 57, 78, 79, 118, 124, 126, 140	12, 13, 80	14, 15, 16, 77
1, 2, 23, 29	44	43	20, 21	
3, 24, 25, 31, 32	26, 33, 34, 35	19, 27		
T1, T18	L1A, T2, T19	L1B, L1C	L1D, L1E, T3, T13	T4



R	12, 15, 17, 23	16, 22, 80, 152	13, 18, 19, 20, 21, 24, 25, 74, 75, 79, 83, 119, RV 10	26, 27, 28, 29, 30, 76, 77, 121, 133	31, 32, 33, 34, 71, 72, 73	3[illegible]
C	21, 30	20	17, 24, 25, 26, 27, 28, 29, 31, 70, 70, 71, 75, 138, 153	18, 22, 72, 73, 76	32, 33, 34, 35, 36, 61, 62, 63, 64, 65	3[illegible]
D	3, 5, 6	4, 7, 8	16, 17, 50	9		14[illegible]
VT			4, 18	5, 17	6	7, [illegible]
MISC.	F 2	F 1	T5	T 6	T7, XI	T[illegible]

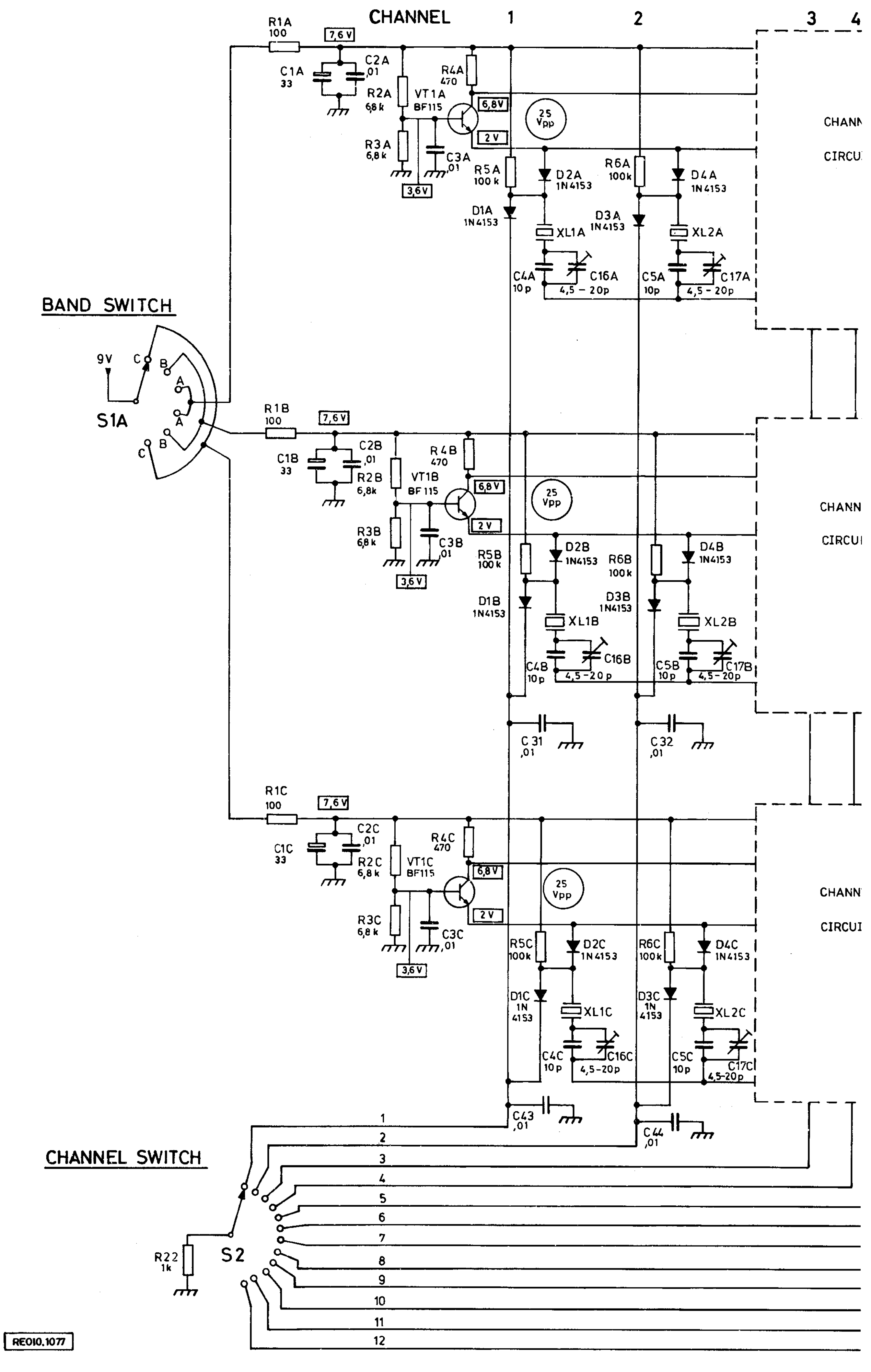


, 36, 37, 69, 70, RV4	39, 40, 41	42, 43, 45, 67, 68, 78	44, 46, 47, 48, 49, 50, 58, 62, 63, 64	51, 52, 53, 54, 55, 59, 60, 61, 65, 66, 144, RV3	56, 57, RV2
, 38, 39, 66, 67	40, 41, 69	42, 54	43, 44, 45, 46, 48, 50, 52, 53, 56, 145	47, 58, 59, 60	49, 51
15		12		10, 11	
16		14	8, 9, 12, 15	13	10, 11
, T10	T9				

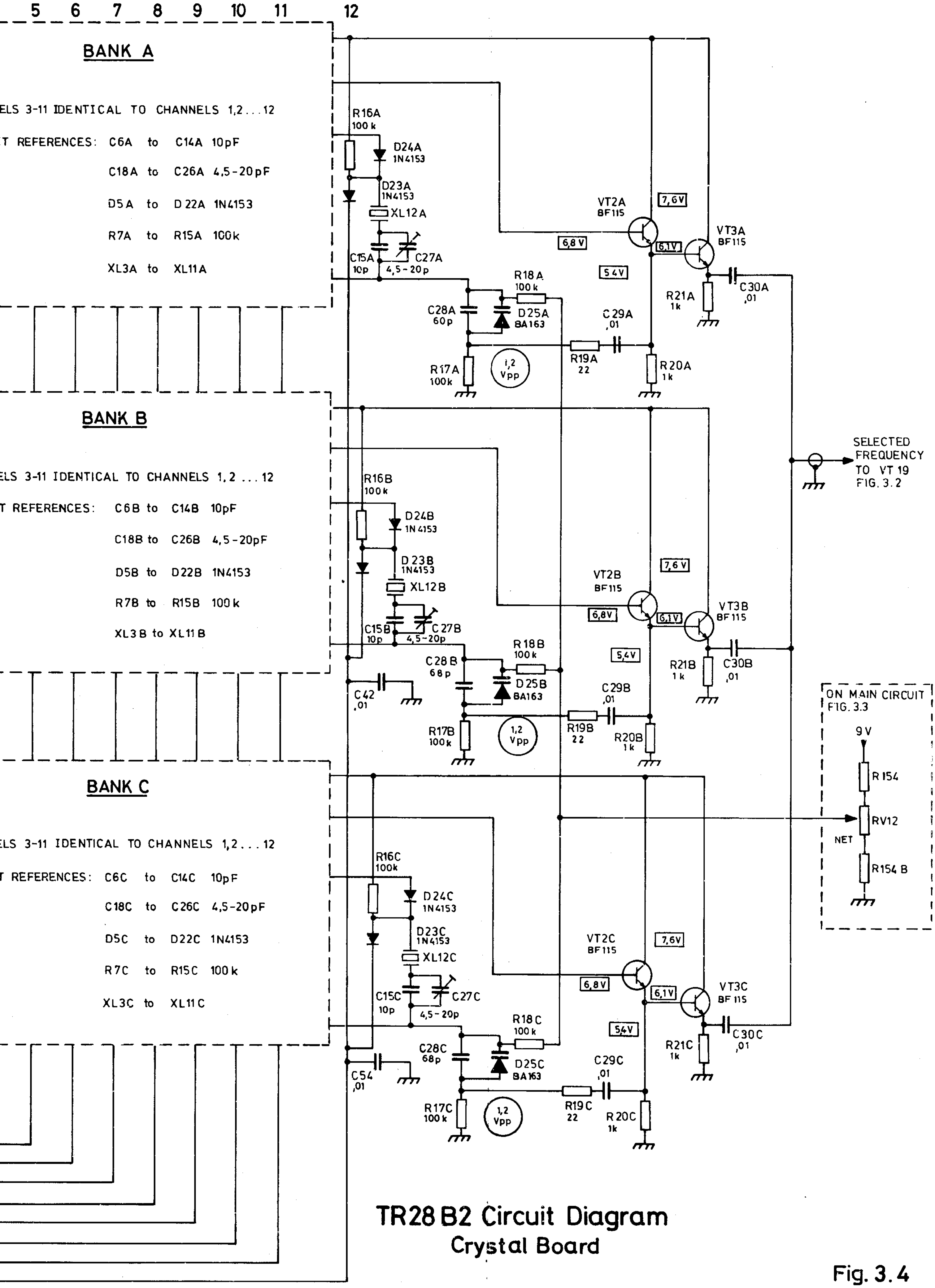


TR28-Circuit Diagram
Main PCB and Power Amplifier (Sheet 2)

Fig. 3.3

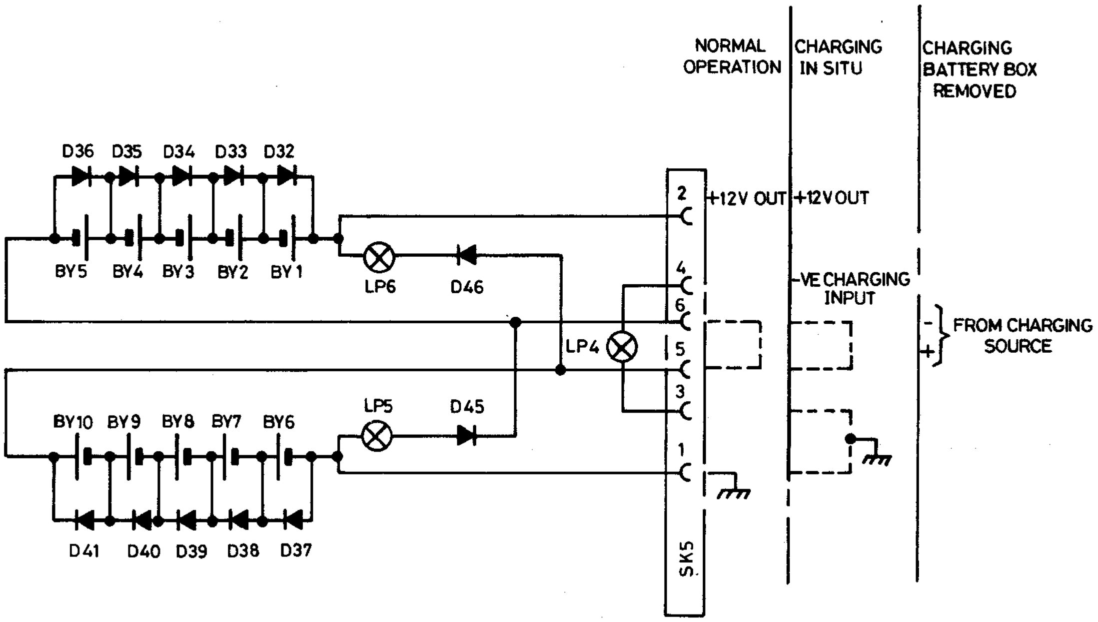


CHANNEL 1 2 3 4
BAND SWITCH
S1A
9V
R1A 100
7,6 V
C1A 33
C2A ,01
R2A 6,8k
R3A 6,8k
R4A 470
VT1A BF115
6,8V
2 V
3,6V
C3A ,01
25 Vpp
R5A 100k
D1A 1N4153
D2A 1N4153
XL1A
C4A 10p
C16A 4,5 - 20p
R6A 100k
D3A 1N4153
D4A 1N4153
XL2A
C5A 10p
C17A 4,5 - 20p
CHANN
CIRCU
R1B 100
C1B 33
C2B ,01
R2B 6,8k
R3B 6,8k
R4B 470
VT1B BF115
C3B ,01
R5B 100k
D1B 1N4153
D2B 1N4153
R6B 100k
D3B 1N4153
D4B 1N4153
XL1B
XL2B
C4B 10p
C16B 4,5-20p
C5B 10p
C17B 4,5-20p
C 31 ,01
C 32 ,01
R1C 100
C1C 33
C2C ,01
R2C 6,8k
R3C 6,8k
R4C 470
VT1C BF115
C3C ,01
R5C 100k
D1C 1N 4153
D2C 1N4153
XL1C
C4C 10p
C16C 4,5-20p
R6C 100k
D3C 1N 4153
D4C 1N4153
XL2C
C5C 10p
C17C 4,5-20p
C43 ,01
C44 ,01
CHANNEL SWITCH
S2
R22 1k
1 2 3 4 5 6 7 8 9 10 11 12
RE010.1077



TR28 B2 Circuit Diagram
Crystal Board

Fig. 3.4

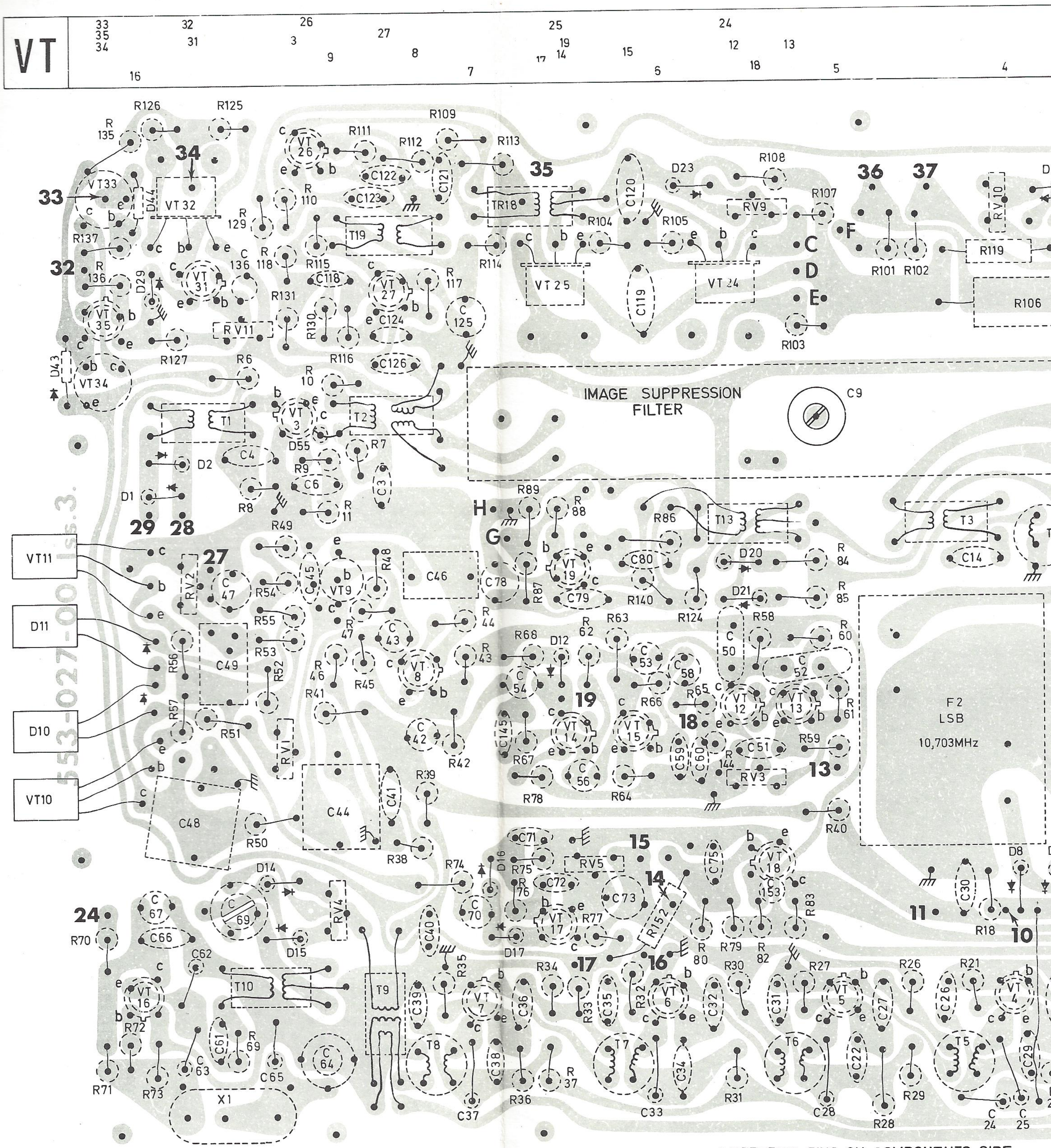


BY 1 TO BY 10: 1,2 V 5AH NI CD CELL
D32 TO D41, D45, D46 } DIODE IN 4002
LP4 : LAMP 12V 18W
LP5 LP6 : LAMP 12V 10W

TR 28 B2 - Circuit Diagram
Battery Box

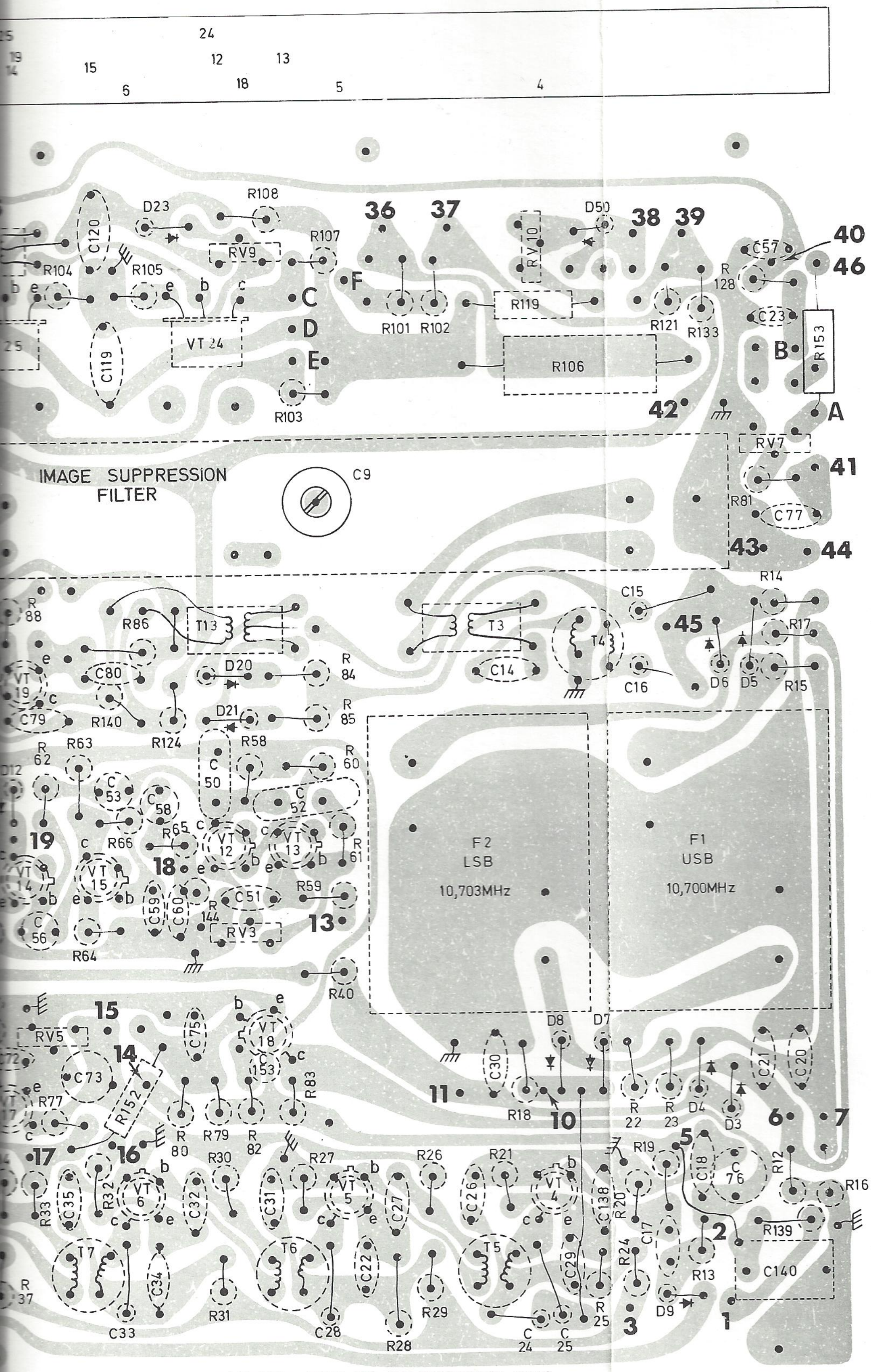
RE 010 · 1077

Fig. 3.5



VIEW FROM TRACK SIDE

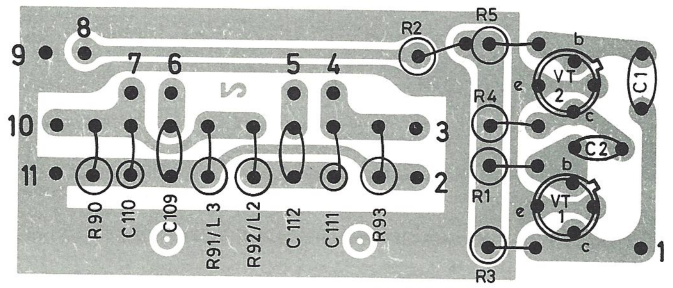
LETTERED PINS ON COMPONENTS SIDE
NUMBERED PINS ON TRACK SIDE



LETTERED PINS ON COMPONENTS SIDE
NUMBERED PINS ON TRACK SIDE

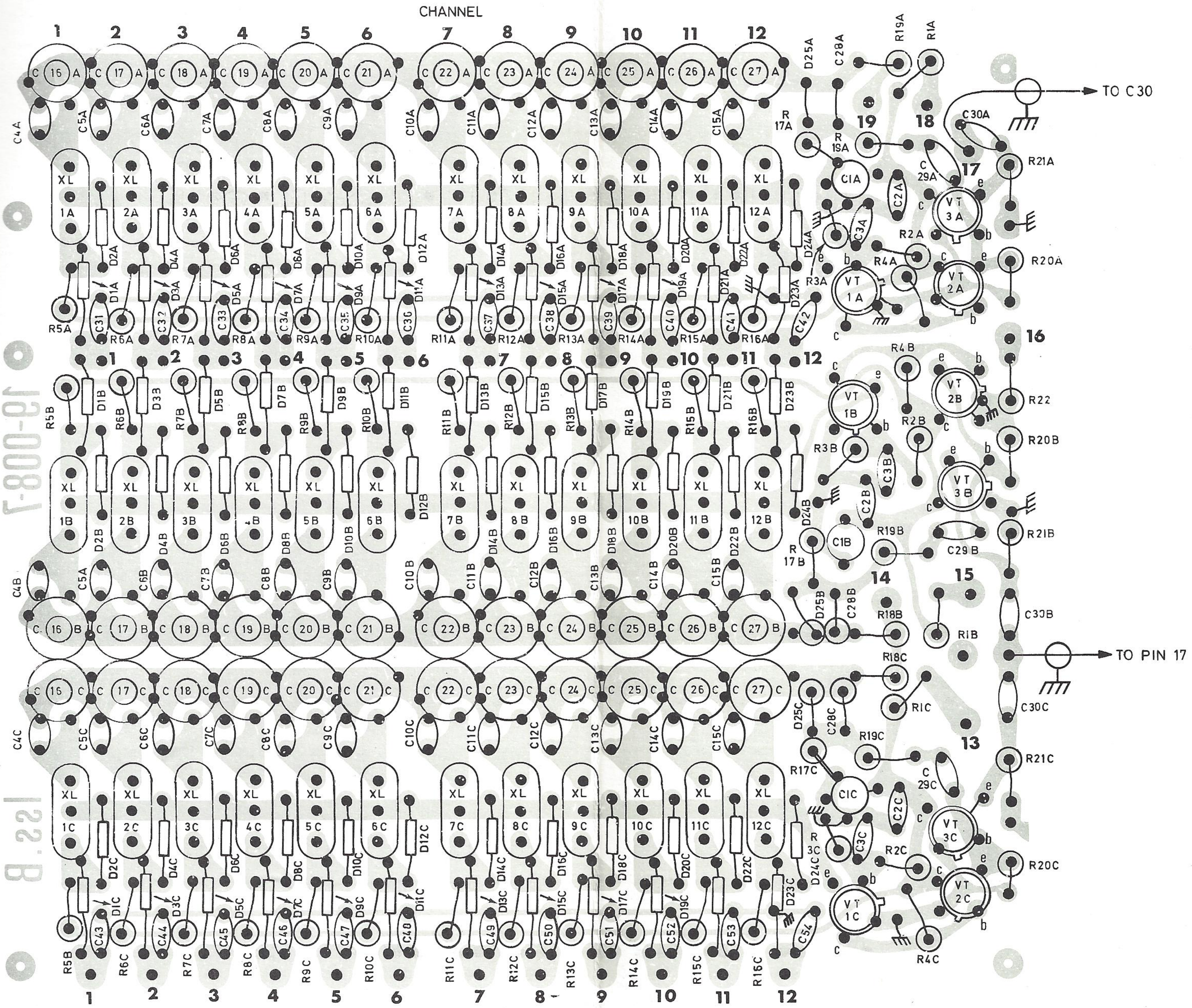
TR 28 B2 Component Layout
Main PCB

Fig. 3.6

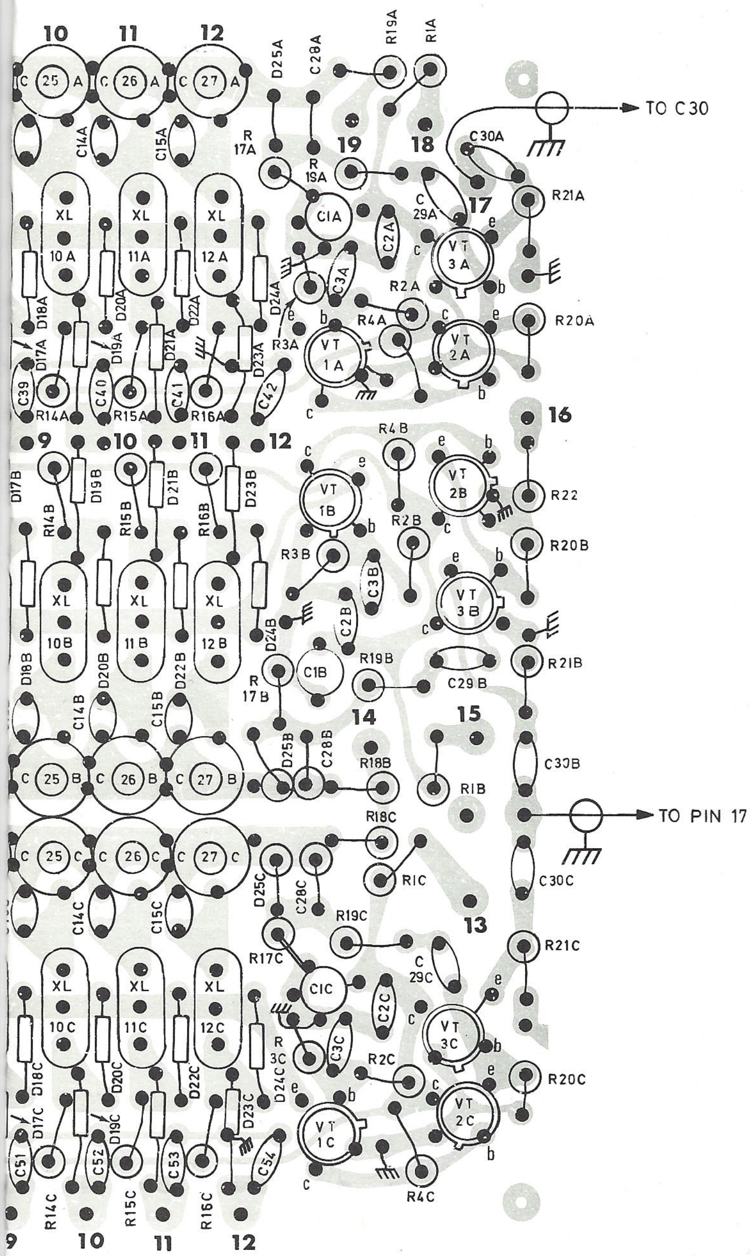


PIN	ROUTING
1	SIGNAL OUTPUT TO L4
2	RF LINE COMMON
3	RF OUTPUT TO RF AMP
4,5	C 112 SWITCHING
6,7	C 109 SWITCHING
8	9V ON TUNE
9	COMMON
10	RF INPUT
11	RF LINE COMMON

TR 28 B2 Component Layout
Multivibrator PCB



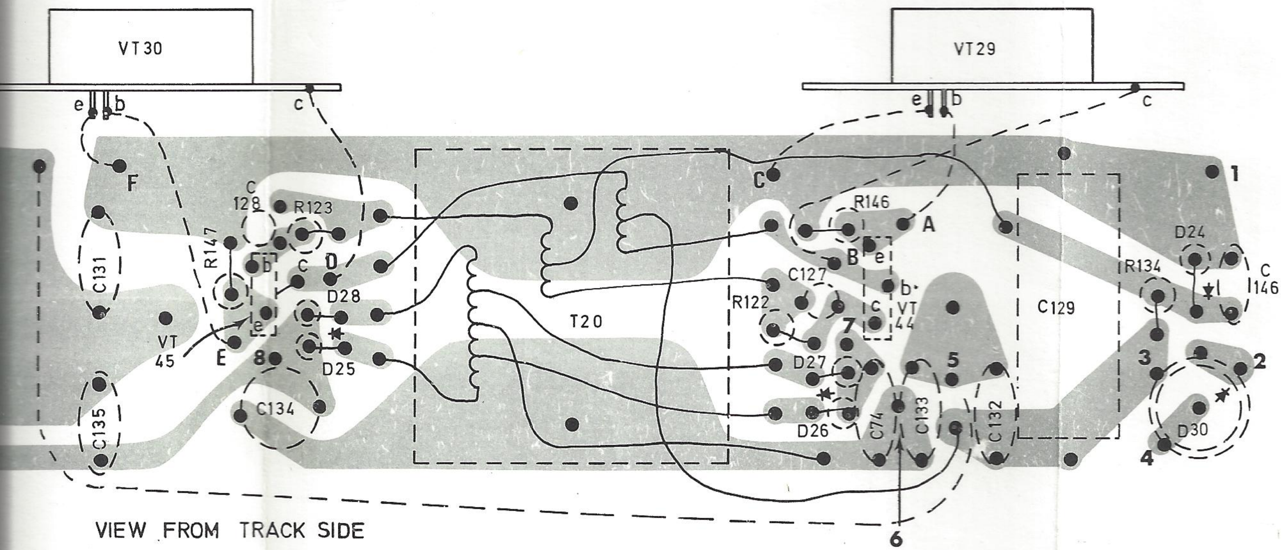
TR 28



PIN	FUNCTION
13	9V TO BANK C
14	FROM NET CONTROL
15	9V TO BANK B
16	CHAN SWITCH WIPER
17	OUTPUT
18	9V TO BANK A
19	FROM NET CONTROL

TR 28 B2 - Component Layout
Crystal Board

Fig. 3.8

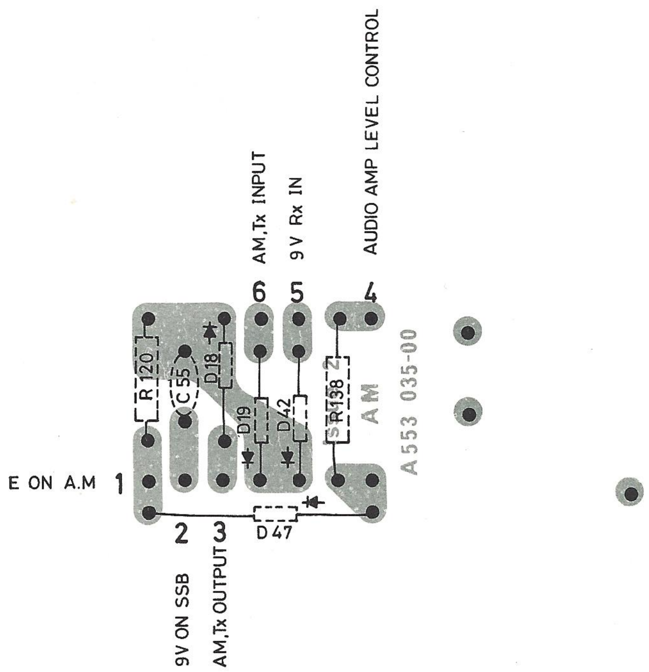


VIEW FROM TRACK SIDE

NUMBERED PINS ON TRACK SIDE-LETTERED PINS ON COMPONENTS SIDE.

PIN	ROUTING
1	CHARGING INPUTS FROM EXTERNAL SOURCE
2	
3	
4	
5	COMMON
6	BATTERY INPUT
7	NEGATIVE CHARGE OUTPUT
8	36V OR 12V OUTPUT

TR 28 B2 Component Layout
DC Converter



VIEW FROM TRACK SIDE

TR 28 B2 Component Layout
AM PCB

RE 010-1077

Fig. 3.10

CHAPTER 4

TESTING TO SPECIFICATION

Contents

CHAPTER 4

TESTING TO SPECIFICATION

PART 1 - GENERAL

INTRODUCTION

1. The following tests are designed to check that the complete equipment is operating correctly and that it meets the specified performance data.

TEST EQUIPMENT

2. The following test equipment is required:

(a) RF Signal General
(b) Two-tone Audio Generator
(c) Spectrum Analyser
(d) Frequency Counter
(e) Oscilloscope
(f) Audio Millivoltmeter (VTVM)
(g) Wattmeter
(h) 50 ohm Dummy Load
(j) Variable Stabilised d.c. Power Supply
(k) Crystals:
12,7015MHz
14,7015MHz
16,7015MHz
18,7015MHz

PART 2 - TRANSMITTER

INITIAL SETTING UP

3. Set up the equipment as follows:

(1) Remove the battery box.
(2) Set the front panel controls:

Mode Switch	-	OFF
GAIN Control	-	fully clockwise
CHANNEL Switch	-	see Note below
NET Control	-	centre position
LSB - USB Switch	-	LSB (A, B or C depending on crystal bank used)
BAND Switch	-	HP on appropriate band for crystal used

NOTE The set may be tested on any convenient frequency but a mid-band frequency of about 5MHz is recommended.

(3) Connect the 50 ohm dummy load, through the wattmeter, to the 50 ohm antenna socket.

(4) Arrange for pins 3 and 4 of either of the front panel sockets to be shortcircuited when necessary. This may be achieved with a simple on/off switch. When it is required that the pins are to be shorted, the phrase "switch to transmit" will be used. "Release the switch" will indicate that the pins are to be open-circuited.

(5) Connect 12,6V d.c. to the plug on the bottom of the set: positive to pin 2, negative to pin 1.

CW POWER MEASUREMENTS

4. Check CW power output as follows:

(1) Set the mode switch to BK CW.

(2) Switch to transmit and check that the meter pointer is between the two marks in the centre of the scale.

(3) Adjust the TUNE control for maximum reading on the wattmeter. Check that the power output is 12,5 ±1dB.

(4) Set the LSB - USB switch to USB. Adjust the TUNE control for maximum reading on the wattmeter and check that this reading is 12,5W ±1dB.

(5) Set the BAND switch to LP on the band in use, readjust the TUNE control for maximum reading and check that this reading is 5W ±1dB. Return the BAND switch to HP.

(6) Set the CHANNEL switch to each position for which a crystal is fitted in turn. At each position:

(i) Set the BAND switch to HP on the appropriate band.

(ii) Adjust the TUNE control for maximum reading on the wattmeter.

(iii) Check that this reading is 12,5W ±1dB.

(7) Release the switch. Return the CHANNEL and BAND switches to their original settings.

(8) Set the mode switch to CW and the BAND switch to TUNE on the appropriate band.

(9) Adjust the TUNE control for maximum reading on the wattmeter and check that this reading is 12,5W ±1dB. Return the mode switch to BK CW and the BAND switch to LP.

SSB POWER MEASUREMENTS

SSB P.E.P. Output/Intermodulation Products

5. Without altering the controls, check the power output as follows:

(1) Set the mode switch to SSB.

(2) Connect the oscilloscope across the dummy load.

(3) Connect the spectrum analyser via a suitable attenuator across the dummy load. (The voltage at the dummy load terminals is approximately 150V).

(4) Connect the two-tone generator to pins 1 and 3 (common) of one of the front panel sockets.

(5) Switch to transmit and adjust the TUNE control for maximum reading on the wattmeter. Release the switch.

(6) Set the BAND switch to HP.

(7) Set audio tones to 600Hz and 2kHz.

(8) Switch to transmit and adjust the amplitude of the two tones to obtain third order intermodulation products of -20dB as displayed on the spectrum analyser.

(9) Adjust the oscilloscope vertical calibration until the two-tone envelope is between two vonvenient horizontal lines on the graticule. Note the amplitude in volts and call this V2

(10) Switch of the 2kHz tone and note the amplitude of the remaining signal on the oscilloscope. Call this V1

(11) Note the power output on the wattmeter and call this P1

(12) Release the switch

(13) Calculate the peak envelope power from the following formula:

$$P.E.P. = P1 \frac{V2^2}{V1}$$

P.E.P. to be 25W ±1dB for crystals with frequencies between 12,7015MHz and 18,7015MHz.

Carrier Suppression

6. With the same test set-up measure carrier suppression as follows:

(1) Disconnect the tone generator.

(2) Switch to transmit and locate the carrier on the spectrum analyser. (This will be 600Hz away from the single-tone waveform).

(3) Note the difference in dBs between the tone amplitude and the carrier amplitude. Call this difference dB1

(4) Release the switch.

(5) Calculate the carrier suppression:

Carr. Supp. = dB1 + dB2

where $dB2 = 20 \log_{10} \frac{V2}{V1}$ (see paragraph 5 above) or 6dB

To be 40dB minimum.

Unwanted Sideband Suppression

7. Continue with the same test set-up:

(1) Set the LSB-USB switch to LSB.

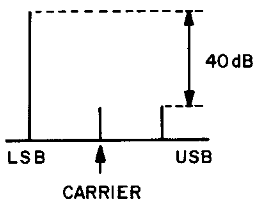
(2) Set the frequency of the tone generator in use to 1kHz.

(3) Switch to transmit and adjust the TUNE control for maximum reading on the wattmeter.

(4) Adjust the tone generator output to the position which gives a reading of 12W on the wattmeter.

(5) Locate both sideband signals on the spectrum analyser. (See sketch).

(6) Check the difference in amplitude (in dBs) between the LSB and USB signals. To be at least 40dB.



(7) Set the LSB-USB switch to USB and check the difference between the USB and LSB signals. To be at least 40dB.

(8) Release the switch and switch off both tones.

AM POWER MEASUREMENTS

8. Measure the AM PEP output with the test set-up unchanged:

(1) Set the BAND switch to HP.

(2) Set the mode switch to AM.

(3) Switch to transmit and adjust the TUNE control for maximum reading on the wattmeter. This should be 3W minimum.

(4) Remove all test equipment.

MEASUREMENT OF RADIATED HARMONICS AND SPURIOUS SIGNALS

9. This test should be carried out in an open field. The procedure is as follows:

(1) Remove the cover from the TR28 and locate the A bank crystals.
Fit crystals into the following positions:

Position	Crystal frequency
A1	12,7015MHz
A2	14,7015MHz
A3	16,7015MHz
A4	18,7015MHz

Refit the cover.

(2) Place the TR28, complete with battery box, on the ground.

(3) Connect the 3,6 metre whip antenna in a vertical position to the WHIP socket on the front of the TR28.

(4) Mount the 2,4 metre whip antenna on a non-conducting base, place 32 metres away from the TR28 and fit 12 x 3,5 metre bare copper wire radials spaced at 30^{o} under the antenna base. Bond the radials together at a point directly underneath the antenna and bond the spectrum analyser earth to these radials.

(5) Connect the spectrum analyser input socket to the 2,4 metre antenna by means of a coaxial cable (impedance to match spectrum analyser input impedance).

(6) Set the TR28 front panel controls as follows:

mode switch - CW
GAIN Control - fully clockwise
CHANNEL Switch - A1
NET Control - centre position
LSB-USB Switch - USB A
BAND Switch - 1,6 - 4 TUNE

(7) Set the CHANNEL and BAND switches to each position given in the table opposite and at each position:

(i) Adjust the TR28 TUNE control for maximum brightness of the neon lamp.

(ii) Set the spectrum analyser frequency control to the frequency given in the fourth column of the table.

(iii) Adjust the spectrum analyser attenuator control to bring the meter needle back to a previously chosen reference point. (See Note below)

NOTE The reference point should be established on the first measurement at 2MHz. All other measurements should be marked as dBs plus or minus relative to the reference point, in the 'Attenuator Setting' column of the table.

TR28 OUTPUT			SPECTRUM ANALYSER		Serial Number	Remarks
Band	Channel	Frequency	Frequency input setting	Attenuator setting		
1,6 - 4HP	1	2MHz	2MHz	Ref. point	1	In the Attenuator setting' column tabulate the difference in dBs between the actual reading and the reference reading
3,5 - 8HP	2	4MHz	4MHz		2	
3,5 - 8HP	3	6MHz	6MHz		3	
3,5 - 8HP	4	8MHz	8MHz		4	
1,6 - 4HP	1	2MHz	4MHz		5	
1,6 - 4HP	1	2MHz	6MHz		6	
3,5 - 8HP	2	4MHz	8MHz		7	
3,5 - 8HP	2	4MHz	12MHz		8	
3,5 - 8HP	3	6MHz	12MHz		9	
3,5 - 8HP	3	6MHz	18MHz		10	
3,5 - 8HP	4	8MHz	16MHz		11	
					12	
					13	
					14	

(8) On a sheet of graph paper (X axis - frequency, Y axis -dBs), plot a curve for measurements serial numbered 1 to 4. Extrapolate until the curve covers 2MHz to 18MHz.

(9) Measure the difference in dBs between the 2MHz reference point and the points on the graph for 12MHz, 16MHz and 28MHz. Add these differences to the "Attenuator Setting" column of the Table for serial numbers 12, 13 and 14.

(10) Compare the following measurements:

Serial No.		Serial No.
2	with	5
3	with	6
4	with	7
8	with	12
9	with	12
10	with	14
11	with	13

In all cases the right hand measurement must be at least 40dB below the left hand measurement.

(11) Set the TR28 CHANNEL switch to A1 and adjust the TUNE control for maximum brightness of the neon lamp.

(12) Slowly rotate the spectrum analyser frequency control from 2MHz to 18MHz and watch the meter. Any spurious signals encountered between these frequencies should be plotted on the graph. Each spurious signal must be at least 40dB below the point on the curve immediately above it.

(13) Set the TR28 CHANNEL switch to A2, A3 and A4 in turn. At each position, adjust the TUNE control for maximum brightness of the neon lamp and then carry out instruction (12) above.

(14) Remove all test equipment. Replace the test crystals with those to be used in normal operation.

NET CONTROL

10. Check the netting control range as follows:

(1) Set the FUNCTION switch to AM.

(2) Select the channel having the lowest frequency.

(3) Tune the TRANSCEIVER to this frequency. Switch the BAND switch to the corresponding frequency band - LP position.

(4) Transmit into a dummy load. Measure the transmitter frequency using the frequency counter. This should equal the crystal frequency - IF (10,7015MHz). Adjust the netting control to obtain this frequency.

(5) Turn NET control fully clockwise. The radiated frequency should increase by more than 100Hz.

(6) Turn NET control fully counter clockwise. The radiated frequency should decrease by more than 100Hz.

PART 3 - RECEIVER

INITIAL SETTING UP

11. Set up the equipment for the receiver tests as follows:

(1) Remove the battery box.

(2) Set the front panel controls:

Mode switch	-	OFF
GAIN Control	-	fully clockwise
CHANNEL Switch	-	see Note under paragraph 3, instruction 2
Net Control	-	centre position
LSB-USB Switch	-	LSB
BAND Switch	-	HP on appropriate band for crystal used

(3) Connect 12,6V d.c. to the plug on the bottom of the set: positive to pin 2, negative to pin 1.

(4) Connect the VTVM and the oscilloscope to pins 2 and 3 (common) of one of the front panel sockets.

NOTE All sig. gen. levels e.m.f.

(5) Connect the r.f. signal generator to the 50 ohm antenna socket.

Signal generator settings:

frequency	-	crystal frequency minus 10,7025MHz
modulation	-	none
output	-	1μV e.m.f.

SENSITIVITY TESTS

12. Check the receiver sensitivity as follows:

(1) Set the mode switch to REC.

(2) Adjust signal generator frequency to give 1kHz output from RX.

(3) Adjust the TUNE CONTROL for maximum audio amplitude on the oscilloscope.

(4) Increase the signal generator output to 3μV.

(5) Check for a reading of between 320 and 520mV on the VTVM.

(6) Reset the signal generator frequency to crystal frequency minus 10,7005MHz.

(7) Set the LSB-USB switch to USB and adjust signal generator frequency to give 1kHz output from RX.

(8) Check for a sine wave on the oscilloscope and for a reading of 320 to 520mV on the VTVM.

(9) Reset the signal generator.

frequency - approximately crystal frequency minus 10,7015MHz
modulation - 30% at 1kHz
output - 30μV e.m.f.

(10) Set the mode Switch to AM.

(11) Check for a VTVM reading of 60mV minimum.

SIGNAL-TO-NOISE RATIO

13. With the same test set-up, check the signal-to-noise ratio as follows:

(1) Reset the signal generator:

frequency - crystal frequency minus 10,7005MHz
modulation - none
output - 1μV

(2) Set the mode switch to REC.

(3) Rotate the GAIN control anti-clockwise until a convenient reading (say 0dB) is shown on the VTVM. Call this dB4

(4) Interrupt the signal generator output and note the reading on the VTVM. Call this dB5

(5) Calculate the signal-to-noise ratio.

S/N ratio = dB4 - dB5
To be a minimum of 10dB

(6) Reconnect the signal generator and reset its frequency to crystal frequency minus 10,7025MHz.

(7) Set the LSB-USB switch to LSB and carry out (4), (5) and (6) above.

AGC OPERATION

AGC Threshold

14. Without altering the test set-up, check AGC as follows:

(1) Set the GAIN control fully clockwise and note the reading in dBs on the VTVM.

(2) Increase the signal generator output in 1dB steps and note that the VTVM reading also increases in 1dB steps.

(3) Continue increasing the signal generator output to the point where the increase in VTVM reading is less than 1dB. This point must be between 1μV and 3μV signal generator output.

AGC Range

15. Check AGC range as follows:

(1) Increase the signal generator output to 3μV and note the reading in dBs on the VTVM. Call this dB6

(2) Increase the signal generator output to 1mV and note the reading in dBs on the VTVM. Call this dB7

(3) Calculate the AGC range:

Range = dB7 - dB6
To be not greater than 3dB

SELECTIVITY TEST

16. With the same test set-up, check selectivity as follows:

(1) Reset the signal generator output to 1μV.

(2) Connect the counter across the VTVM terminals.

(3) Adjust the signal generator frequency for a reading of 1,000kHz on the counter.

(4) Rotate the GAIN control anti-clockwise for a reading of about 30mV on the VTVM. The receiver circuits should not now be subject to AGC control: check by increasing the signal generator output and noting that the VTVM reading rises by the same amount. If it does not, reduce the gain slightly and recheck. Maintain a counter reading of 1,000kHz by carefully adjusting the signal generator frequency. Call the final VTVM reading (in dBs) .... R

(5) Increase the signal generator output by 6dB and decrease the frequency carefully until the VTVM reading falls to level R. The counter should now read approximately 300Hz. Note the exact reading and call this f1

(6) Increase the signal generator frequency to the point where the VTVM again reads level R. The counter should now read about 2,6kHz. Note the exact reading and call this f2

(7) Increase the signal generator output by 34dB.

(8) Increase the signal generator frequency to the point where the VTVM reading falls to level R. Note the counter reading and call this f3

(9) Decrease the signal generator frequency carefully, below f1, to the point where the VTVM again reads R. Note the counter reading and call this f4

(10) Check the following results obtain:

f1 = 100Hz - 500Hz.

f2 = f1 = 2kHz minimum

f3 = f4 = 5,5kHz maximum

(11) Set the LSB-USB switch to USB and carry out (3) to (10) for the upper side band circuits.

(12) Return the signal generator output to 3μV.

IMAGE REJECTION

17. The image frequency is crystal frequency plus 10,7015MHz. With the same test set-up, check for rejection of this frequency as follows:

(1) Set the signal generator output to 1μV and if necessary, re-adjust its frequency to give a reading of 1,000kHz on the counter. Note the signal generator output in dBs and call this dB8

(2) Adjust the TR28 GAIN control to give a convenient reference reading (say 0dB) on the VTVM.

(3) Reset the signal generator frequency to the image frequency.

(4) Increase the signal generator output to the point where the VTVM reading is at the previously chosen reference. If necessary, re-adjust both the signal generator frequency and output until the reference reading is obtained on the VTVM with a counter reading of 1,000kHz.

(5) Note the signal generator output in dBs and call this dB9

(6) Check image rejection:

Image Rejection = dB9 - dB8

To be not less than 75dB

IF REJECTION

19. Check i.f. rejection with the same test set-up:

(1) Reset the signal generator output to 1μV and its frequency to approximately crystal frequency minus 10,7MHz.

(2) Adjust the TR28 GAIN control for a convenient reference reading (say 0dB) on the VTVM. Re-adjust the signal generator frequency and the GAIN control until the reference reading on the VTVM is obtained for a 1,000kHz reading on the counter.

(3) Reset the signal generator frequency to 10,7015MHz.

(4) Increase the signal generator output until the previously chosen reference reading is obtained on the VTVM. Note the signal generator output in dBs and call this dB10

(5) Check IF rejection:

IF Rejection = dB10 - dB8

To be not less than 60dB

(6) Remove all test equipment.

BATTERY CHARGING CIRCUITS

19. Check the battery charging circuits as follows:

(1) Connect the 120 ohm resistor across pins 2 and 4 of the plug on the bottom of the set.

(2) Connect the multimeter (25V d.c. range) across the resistor: red lead to pin 2, black lead to pin 4.

(3) Set the mode switch to SSB.

(4) Connect 12V d.c. to pins 7 (positive) and 6 (negative).

(5) Set the mode switch to REC and OFF in turn. At each position check that the multimeter reads approximately 14V d.c.

(6) Remove all test equipment.

CHAPTER 5

DETAILED TESTING

Contents

CHAPTER 5

DETAILED TESTING

GENERAL

1. These tests are intended to assist in fault finding should the transceiver fail to meet a specified parameter during the tests to specification. The following tests should be made with the transceiver removed from its case (four allen screws behind the handles) and connected to a power supply unit.

NOTE Earth or common connections for test equipment should be made to an earth point on the main p.c. board or the board being tested. Earth connections must not be made to the chassis of the transceiver.

TEST EQUIPMENT

2. The test equipment listed below will be required. A suitable instrument is shown in brackets but instruments having equivalent characteristics may also be used.

(a) RF Signal Generator (Marconi TF 144H)
(b) AF Signal Generator (Marconi TF 2100)
(c) Oscilloscope (Tektronix 454)
(d) Frequency Counter
(e) Audio VTVM (Heathkit Model IM-38)
(f) Wattmeter, 50W (Bird Thru-line)
(g) 50 ohm dummy load
(h) Variable Power Supply, 12V d.c. at 6A
(i) Multimeter (AVO 8)
(j) Crystals, type CR69/U at the following frequencies:
  12,700MHz (1 off)
  15,700MHz (1 off)
  17,700MHz (1 off)
  18,500MHz (1 off)
(k) 100k ohm 0,5W carbon resistor
(l) 0,01μF 10V capacitor

TRANSCEIVER CURRENT MEASUREMENTS

3. Measure supply currents as follows:

(1) Set the front panel controls:
  GAIN - fully clockwise
  Mode - OFF
  BAND - LP 3.5 - 8
  others - Immaterial
(2) Remove FS1.
(3) Connect the power supply unit to PL1 pins 2 (positive) and 1. Set for a 12V output.
(4) Connect the h.m.t. to either front panel AUDIO socket.

(5) Connect the multimeter across FS1 fuse holder and check the following currents.

Mode switch	BAND switch	Current	Remarks
REC	LP	40 to 55mA	
SSB	LP	350 to 400mA	
BK CW	LP	350 to 400mA	With PTT
CW	LP	350 to 400mA	Switch operated
AM	LP	350 to 400mA	
SSB	HP	550 to 750mA	

(6) Release the PTT switch, remove the multimeter and replace the fuse.

POWER SUPPLY CHECKS

Regulator Output

4. Check the regulated and switched power supplies:

(1) Connect the multimeter between main p.c. board pin 3 (positive) and a convenient earth point on the board (not to chassis). Multimeter to read 9,0V ±0,05V. If it does not, adjust RV11 for this reading.

(2) Connect the multimeter positive to board pin 17 and check for a voltage of 9,0V ±0,1V.

(3) With the mode switch at SSB and the BAND switch at LP operate the PTT switch and check that the 9V at pin 17 disappears.

(4) Connect the multimeter to board pin 33 and check for 9,0V ±0,1V. Release the PTT switch.

5. If any of the above readings are not obtained the figures in the Table below may be used as a guide to the levels which can be expected around the power supply circuits. The measurements were made with a multimeter.

Transistor	DC Voltages			Remarks
	c	b	e	
VT31	9,8V	7,5V	6,9V	
VT32	11,3V	9,8V	9,0V	Mode switch to REC
VT33	9,0V	9,6V	9,0V	Mode switch to SSB
VT34	9,0V	0,3V	0V	BAND switch to LP
VT35	0,3V	0,8V	0V	PTT switch operated

DC Converter Output

6. Check the voltage at the converter output pin:

(1) Set the BAND switch to HP and the mode switch to SSB.

(2) Connect the multimeter between a convenient earth point and Converter pin 6.

(3) Operate the PTT switch and check for a multimeter reading of approximately 36V. Release the PTT switch.

7. If the above reading is not obtained the following readings, which were taken with a multimeter and the transceiver set for high power SSB Transmission, may be used as a guide to the levels which can be expected around the circuit.

Transistor	DC Voltages			Remarks
	c	b	e	
VT29	12V	-1,3V	0V	With PTT switch
VT30	12V	-1,3V	0V	operated

RECEIVER TESTS

Audio Circuits

8. Check the audio circuits as follows:
 (1) Set the front panel control:
 MODE switch - REC
 GAIN control - fully clockwise
 CHANNEL switch - channel 1
 NET control - central
 LSB - USB switch - LSB A
 BAND switch - LP 3,5 - 8
 TUNE control - immaterial
 (2) Connect the h.m.t. to either of the front panel AUDIO sockets.
 (3) Connect the 100k ohm resistor in series with the AF signal generator output lead. Connect the lead to the junction of R40 and C42. (This point is marked PROD DET on the p.c. board). Set the signal generator
 frequency - 1kHz
 output - zero
 (4) Connect the VTVM to VT9 collector.
 (5) Increase the signal generator output for a reading of 0,31V ±0,03V on the VTVM.
 (6) Connect the VTVM to board pin 27 and adjust RV2 for a reading of 0,15V.
 (7) Check as follows:

VTVM to	Measurement
VT9 base	5mV max.
VT8 collector	5mV max.
PROD DET	4mV max.
VT8 base	2mV max.

 (8) Remove the signal generator and VTVM.

9. If the above figures are not obtained, the following voltages, taken with a multimeter, may be used as a guide to the levels which can be expected around the circuits.

Transistor	DC Voltages			Remarks
	c	b	e	
VT8	4,4V	0,75V	0,1V	Measured with the transceiver on receive
VT9	4,0V	7,7V	7,8V	
VT10	9,0V	3,6V	3,5V	
VT11	0V	3,4V	3,5V	

Crystal Oscillator (VT16) and Oscillator Buffer (VT19) Checks

10. Check the two circuits as follows:
   (1) Connect the oscilloscope to D14 anode (marked '02' on the main p.c. board).
   (2) Check for a signal with an amplitude of 1,8V minimum, peak to peak.
   (3) Fit the 15,700MHz crystal into position 1 of the A bank on the Crystal Board.
   (4) Connect the oscilloscope to D20 anode. (marked '01' on the main p.c. board).
   (5) Check for a signal with a peak to peak amplitude of 2,0V minimum.

11. Should the above readings not be obtained the figures in the table below may be used as a guide to the levels which can be expected in a correctly operating circuit.

Transistor	DC Voltages			Remarks
	c	b	e	
VT16	8,6V	2,6V	2,0V	Measured with the transceiver on receive
VT19	8,6V	2,6V	2,0V	

Receiver IF Amplifier Tests

12. Check the 10,7MHz amplifiers as follows:
   (1) Connect the VTVM across pins 2 and 3 of the remaining AUDIO socket.
   (2) Connect the 0,01μF capacitor in series with the r.f. signal generator output lead.
   Signal generator settings:
      frequency - 10,7015MHz
      modulation - none
      output - zero
   (3) Connect the signal generator output lead to each of the following points in turn. At each point:
      (i) Set the signal generator output control to the point which gives a 0,15V reading on the VTVM.
      (ii) Check that the signal generator output is within the limits given in the table.
      (iii) If the output is not obtained tune the coil indicated for maximum reading on the VTVM and carry out (i) and (ii) again.

Signal Generator		If not obtained
lead to	output	
VT7 col	6,4mV approx.	
VT7 base	300μV max.	T8
VT6 col	1,3mV max.	
VT6 base	29μV max.	T7
VT5 col	110μV max.	
VT5 base	3,5μV max.	T6
VT4 col	3,0μV max.	

(4) Connect the signal generator to the input of the LSB filter (this point marked 'F1A' on the p.c. board) and set the signal generator output to 2,8µV.

(5) Check that the VTVM reads 0,15V. If the reading is above or below this figure:

(i) Tune T5 for maximum reading on the VTVM.

(ii) Adjust RV5 for a VTVM reading of 0,15V.

13. If the set does not meet the specified requirements the following figures, taken with a multimeter, may be used as a guide to the levels which can be expected around the circuits.

Transistor	DC Voltages			Remarks
	c	b	e	
VT5	8,9V	2,0V	1,3V	Measured with the transceiver on receive
VT6	8,9V	2,0V	1,3V	
VT7	8,9V	1,6V	1,2V	
VT17	2,0V	0V	0V	

Receiver RF Circuits

14. Check the r.f. circuits as follows:

(1) Connect the r.f. signal generator (still with the 0,01µF capacitor in series with the output lead) to the junction of T2 secondary and the image suppression filter (this point marked 'TP4' on the p.c. board).

(2) Reset the signal generator frequency to approximately 5MHz. Adjust the output and frequency controls for a 1kHz tone in the h.m.t. earpiece and a reading of 0,15V on the VTVM.

(3) Connect the signal generator output to the junction of the image suppression filter and T3 (marked 'TP3' on the p.c. board). Reset the output for a reading of 0,15V on the VTVM and check that the signal generator output is 30µV maximum.

(4) If the above reading is not obtained, tune T4 for maximum output on the VTVM and recheck as in (3).

(5) Connect the signal generator output to TP4 (see (1)), reset the output for a reading of 0,15V on the VTVM and check that the signal generator output is 30µV maximum.

(6) Remove the 15,700MHz crystal from the A1 position.

(7) Connect the frequency counter to VT4 collector.

(8) Set the mode switch to AM operate the PTT switch and check for a counter reading of 10,7015MHz ±2Hz. If necessary, adjust C64 for this reading.

(9) Disconnect the counter, reset the mode switch to REC and replace the 15,700MHz crystal in position A1.

(10) Connect the signal generator to the points given in the table below in turn. At each point:

(i) Set the signal generator output to give a reading of 0,15V on the VTVM.

(ii) Check that the signal generator output is within the limit given in the Table.

Signal Generator		Remarks
Lead to	Output	
VT3 col	100µV max.	*Junction T1 and D1 anode. Adjust TUNE control for max. on VTVM and reset sig. gen. for 0,15V on VTVM
VT3 base	2µV max.	
TP5*	2µV max.	
50 ohm socket	2µV max.	

15. If the results are not obtainable, the following measurements, made with the multimeter, may be used as a guide to the levels which can be expected around VT3.

Transistor	DC Voltages			Remarks
	c	b	e	
VT3	8,5V	1,7V	1,0V	Mode switch to REC and BAND switch to TUNE

Signal to Noise Ratio

16. Check the signal to noise ratio with the test set up used for the r.f. checks:

(1) Set the r.f. signal generator output to 1μV and note the reading in dBs on the VTVM. Call this dB1

(2) Temporarily remove the carrier input to the set. (on the TF 144H signal generator this can be achieved by operating the INTERRUPT CARRIER control). Note the new reading in dBs on the VTVM and call this dB2

(3) Calculate the signal to noise ratio from the following:
S+N/N = dB1 - dB2
To be not less than 10dB

(4) Reset the signal generator frequency to 10,7025MHz and set its output to 2μV.

(5) Check that the reading on the VTVM does not exceed 300mV. If it does, adjust C9 for minimum reading and recheck.

(6) Replace the 15,700MHz crystal in position A1 with the 18,500MHz crystal.

(7) Set the signal generator frequency to approximately 7,8MHz and adjust the frequency control for maximum reading on the VTVM.

(8) Set the signal generator output to give a reading of 0,15V on the VTVM. Signal generator output to be not greater than 2μV.

(9) Repeat (1) to (3) above. Signal to noise ratio to be not less than 10dB.

(10) Replace the 18,500MHz crystal in position A1 with the 12,700MHz crystal.

(11) Set the BAND switch to LP1,6 - 4.

(12) Set the signal generator frequency to 2MHz and adjust the frequency control for maximum reading on the VTVM.

(13) Set the signal generator output to give a reading of 0,15V on the VTVM. Signal generator output to be not greater than 2μV.

(14) Repeat (1) to (3) above. Signal to noise ratio to be not less than 10dB.

(15) Set the mode switch to OFF. Remove all test equipment. Replace the crystal in position A1 with a crystal of the required operational frequency.

Multivibrator

17. The remaining circuit in the receiver is the multivibrator. A fault on this circuit will be shown when it is impossible to tune the set on receive. No particular tests for this circuit are given but the following figures, taken with a multimeter, may be used as a guide to the levels which can be expected around the circuit.

Transistor	DC Voltages			Remarks
	c	b	e	
VT1 VT2	0,55V 5,0V	0,28V 0,6V	0V 0V	mode switch at REC and BAND switch at TUNE

TRANSMITTER TESTS

Note: Unless otherwise stated each transmitter measurement is made with the PTT switch operated.

Crystal Oscillator Check

18. Check the crystal oscillator frequency:

(1) Connect the power supply unit to PL1 pins 2 (positive) and 1. Set for a 12V output.
(2) Connect the wattmeter and dummy load to the 50 ohm antenna socket.
(3) Connect the h.m.t. to either of the front panel AUDIO sockets.
(4) Remove the crystal (if any) in position 1 of bank A on the Crystal Board.
(5) Set the front panel controls:

mode switch	-	AM
GAIN control	-	fully clockwise
CHANNEL switch	-	channel 1
NET control	-	central
LSB-USB switch	-	LSB A
BAND switch	-	LP 3.5 - 8
TUNE control	-	fully clockwise

(6) Connect the counter to VT4 collector and check for a reading of 10,7015MHz ±2Hz. If necessary adjust C64 for this reading.
(7) Disconnect the counter.

Carrier Suppression

19. Check carrier suppression as follows:

(1) Set the mode switch to SSB.
(2) Connect the oscilloscope to VT4 collector and check the amplitude of any vestigial carrier. To be not greater than 20mV.
(3) If the amplitude is high reduce by the following method:
  (i) Note the amplitude of the carrier shown on the oscilloscope.
  (ii) Turn C69 clockwise by not more than 5^{0}.
  (iii) Adjust RV4 for minimum amplitude on the oscilloscope and note this amplitude.
  (iv) If it is less than that noted in (i) continue as in (ii) and (iii) until the minimum carrier level is found.
  (v) If the amplitude is greater than in (i) carry out (ii) and (iii), turning C69 anti-clockwise until the minimum amplitude is found.

Side Tone Circuits

20. Check that sidetone is fed to the h.m.t.:

(1) Set the BAND switch to TUNE and (with the PTT switch operated) check for a clear tone in the earpiece. RV3 may be adjusted if a distorted tone is heard.
(2) Connect the oscilloscope to the junction of R40, C42 (PROD DET) and check for a signal of 0,7V peak to peak.

Overload Protection Circuit

21. Connect the multimeter to pin B (junction R128, C23) of the main p.c. board and check for a reading of 5,3V ±0,3V.

ALC Circuits

22. Check the ALC circuits as follows:
(1) Fit the 15,700MHz crystal into the A1 position on the Crystal Board.
(2) Connect the multimeter to VT18 collector and check for a reading of 2,7V ±0,2V.
(3) Adjust the TUNE control for maximum output on the wattmeter. If this is not 12,5W:
(i) Adjust RV7 for this value.
(ii) Readjust the TUNE control for maximum output.
(iii) Continue in this manner until maximum output is 12,5W.

23. If any of the above readings cannot be obtained the following figures, taken with a multimeter, may be used as a guide to the levels which can be expected around VT18.

Transistor	DC Voltages			Remarks
	c	b	e	
VT18	2,7V	0,4V	0V	on low power s.s.b. transmission

Transmitter Amplifier Circuits

24. Check the amplifier circuits as follows:
(1) Connect the oscilloscope to each of the following points in turn and check that the levels are as shown in the table. (Note that with the BAND switch at TUNE, operating the PTT switch brings the transmitter into the high power condition).

Oscilloscope to	Peak to Peak Voltages	Remarks
VT4 col	1,5V to 3,0V	All measurements with PTT switch operated.
VT24 base	1V	
VT24 col	12V to 16V	
VT25 base	1V	
VT25 col	12V to 16V	
VT20 base	2,1V	
VT20 col	80V	
VT21 base	2,1V	
VT21 col	80V	
VT22 base	2,1V	
VT22 col	80V	
VT23 base	2,1V	
VT23 col	80V	
RL1 pin 7	120V	

(2) Set the BAND switch to HP 3.5 - 8.
(3) With the 0,01μF capacitor in series with the output lead connect the r.f. signal generator to VT26 emitter.

Signal generator settings:

frequency - 5,0MHz
modulation - none
output - 50mV approx.

(4) Adjust the TUNE control for maximum output on the wattmeter.

(5) Increase the signal generator output for a reading of 12,5W on the wattmeter. Signal generator output at this point to be approximately 200mV. Return the signal generator output to zero.

(6) Connect the signal generator to VT27 base.

(7) Increase the signal generator output for a reading of 12,5W on the wattmeter. Signal generator output at this point to be approximately 25mV.

25. If any of the above figues are not obtained the voltages around the circuits, taken with a multimeter and shown in the table below, may be used as a guide to the levels which can be expected.

Transistor	DC Voltages			Remarks
	c	b	e	
VT4	8,3V	1,6V	0,9V	All measurements taken on SSB low power transmission
VT20	11,3V	0,63V	0,03V	
VT21	11,3V	0,63V	0,03V	
VT22	11,3V	0,63V	0,03V	
VT23	11,3V	0,63V	0,03V	
VT24	12V	0,65V	0,01V	
VT25	12V	0,65V	0,01V	
VT26	11,2V	2,7V	0,75V	
VT27	11,8V	2,1V	1,2V	
VT20	36V			
VT21	36V			
VT22	36V			On SSB high power transmission.
VT23	36V			

Transmitter Audio Circuits

26. Check the audio circuits as detailed below:

(1) Connect the a.f. signal generator to pins 1 and 3 (common) of the remaining AUDIO socket.
Signal generator settings:

frequency - 1kHz
output - To give 12,5W on wattmeter
(Adjust TUNE control for maximum output)

(2) Check for the voltages given in the table below

Measuring Instrument	Measuring point	Voltage
VTVM	Junction R40, C42 (PROD DET)	120mV to 390mV
VTVM	VT13 base	120mV to 155mV
Oscilloscope	VT14 col	1,4V p to p
Multimeter	D9 anode	0,5V to 1,2V
Multimeter	main board pin b	4,8V to 5,3V

(3) Disconnect the a.f. signal generator.

27. If any of the readings are not obtained the following figures, taken with a multimeter, may be used as a guide to the levels which can be expected around the audio circuits.

Transistor	DC Voltages			Remarks
	c	b	e	
VT12	7,0V	2,2V	1,5V	Measurements taken with mode switch to BK CW and PTT operated
VT13	2,2V	1,3V	0,7V	
VT14	3,5V	1,0V	0,3V	
VT15	5,0V	0,8V	0,1V	

Mode Outputs Check

28. Check the power outputs at the following mode switch positions:

(1) Set the mode switch to BK CW and adjust the TUNE control for maximum output on the wattmeter. To be 12,5W minimum. Note the actual reading.

(2) Set the LSB - USB switch to USB A and note the reading on the wattmeter. To be within 0,2W of the reading noted in (1).

(3) Check for the following power outputs on the modes given in the table below:

Mode switch	BAND switch	Wattmeter reading	Remarks
BK CW	LP 3.5 - 8	3W approx.	Adjust the TUNE control for maximum output before taking each reading
AM	HP 3.5 - 8	2W to 4W	
Replace the 15,700MHz crystal in position A1 with the 17,700MHz crystal			
BK CW	HP 3.5 - 8	12W min.	
BK CW	LP 3.5 - 8	1,5W to 4W	
AM	HP 3.5 - 8	1W to 2W	

Replace the 17,700MHz crystal in position A1 with the 12,700MHz crystal

Mode switch	BAND switch	Wattmeter reading	Remarks
AM	HP 1.6 - 4	4W to 8W	
BK CW	HP 1.6 - 4	6W to 8W	
BK CW	LP 1.6 - 4	1,4W to 2W	

Meter Setting

29. Set the mode switch to SSB and the BAND switch to LP 1.6 - 4. Operate the PTT switch and check that the meter needle is between the two dots in the centre of the scale. If it is not, adjust RV10 for this reading.

CHAPTER 6

PARTS LIST

Contents

CHAPTER 6

PARTS LIST

INTRODUCTION

1. The component tolerances and ratings given in this parts list are optimum. However if such components are not immediately available alternatives with closer tolerances or higher voltage or wattage ratings may be used in manufacture or supplied as replacement.

2. When ordering replacements please quote the full description including the circuit reference and order no.

Cct. Ref.	Description	Value	Tol. %	Rating	Order No.	Codification
	The following circuit reference numbers are not used: Resistors - R94, R141, R149, R151 Capacitors - C19, C68, C81-C108, C113, C114, C130, C139, C141, C144, C147 - C152 Diodes - D13, D50, D51, D52, D53, D54 Transistors- VT28					
3.	<u>CHASSIS ASSEMBLY</u>					
	<u>Resistors</u>	<u>Ohms</u>		<u>Watts</u>		
R95	Carbon	680	10	0,5	20-013-5	
R96 R97 R98	Carbon	2,2	5	0,5	20-040-5	
R99 R100 R132	Carbon	10	10	0,5	20-011-3	
R142 R143	Carbon	680	10	0,5	20-013-5	
R145	Carbon	47k	10	0,5	20-015-7	
R148	Carbon	100	10	0,5	20-012-5	
R150	Carbon	33	10	0,5	20-011-9	
R154	Carbon	2k2	10	0,5	20-014-6	
R154B	Carbon	3k3	5	0,5	20-044-3	
R155	Carbon	1M	5	0,25	20-037-3	
RV6	Carbon variable	50k			22-000-2	
RV12	Carbon variable	10k			20-000-1	
	<u>Capacitors</u>	<u>μF</u>		<u>Volts</u>		
C113	Silver mica	100p	10	500	26-528-2	
C114	Silver mica	200p	10	500	26-568-5	
C115 C116 C117	Ceramic disc	0,1	20	50	26-310-3	
C142 C143	Ceramic disc	0,047	20	50	26-290-3	
C154	Ceramic disc	2,2p		500	26-005-2	
	<u>Miscellaneous</u>					
VT20 VT21 VT22 VT23	Transistor BU102				36-004-5	
D22	Diode MR1031B				36-034-4	
D31	Diode 1N4002				36-039-6	
D48 D49	Diode BAY72				36-030-6	
T14/T15	Transformer, output				31-000-9	
T16/T17	Transformer, coupling				31-000-8	
L4	ATU coil				31-001-8	
	Ferrite rod for ATU coil				18-010-9	
M1	Meter, 1mA				35-038-9	
FS1	Fuse link 6,3A (On DC Converter				29-004-0	
FS2	Fuse link 2A chassis)				29-001-7	
LP1 LP2 LP3	Lamp, neon				35-000-1	
PL1	Plug, 6-way				33-008-3	
SK1 SK2	Socket, 7-way				33-018-1	
SK3	50 ohm socket				33-034-1	

Cct. Ref.	Description	Value	Tol. %	Rating	Order No.	Codification
	Miscellaneous (Cont.)					
S1	Switch 2P 66W (LSB-USB)				32-081-9	
S2	Switch SP 12W (CHANNEL)				32-080-4	
S3	Switch 8P 6W (BAND)				32-120-7	
S4	Switch 8P 6W (MODE)				32-120-6	
RL1	Relay 4P c/o				34-008-6	
	Desiccator				42-270-1	
4.	MAIN PCB ASSEMBLY					
	Resistors	Ohms		Watts		
R6	Carbon	47k	10	0,5	20-015-7	
R7	Carbon	2k2	10	0,5	20-014-1	
R8	Carbon	18k	10	0,5	20-015-2	
R9	Carbon	2,2	5	0,5	20-040-5	
R10	Carbon	100	10	0,5	20-012-5	
R11	Carbon	220	10	0,5	20-012-9	
R12	Carbon	10k	10	0,5	20-014-9	
R13 R14 R15	Carbon	1k	10	0,5	20-013-7	
R16	Carbon	10k	10	0,5	20-014-9	
R17 R18	Carbon	1k	10	0,5	20-013-7	
R19	Carbon	22k	10	0,5	20-212-2	
R20	Carbon	10k	10	0,5	20-014-9	
R21	Carbon	120	10	0,5	20-012-6	
R22 R23	Carbon	1k	10	0,5	20-013-7	
R24	Carbon	100	10	0,5	20-012-5	
R25	Carbon	4k7	10	0,5	20-014-5	
R26	Carbon	1k	10	0,5	20-013-7	
R27	Carbon	680	10	0,5	20-013-5	
R28	Carbon	10k	10	0,5	20-014-9	
R29	Carbon	100	10	0,5	20-012-5	
R30	Carbon	1k	10	0,5	20-013-7	
R31	Carbon	100	10	0,5	20-012-5	
R32	Carbon	47	10	0,5	20-012-1	
R33	Carbon	39k	10	0,5	20-015-6	
R34	Carbon	10k	10	0,5	20-014-9	
R35	Carbon	680	10	0,5	20-013-5	
R36	Carbon	10k	10	0,5	20-014-9	
R37	Carbon	100	10	0,5	20-012-5	
R38	Carbon	1k	10	0,5	20-013-7	
R39	Carbon	330	10	0,5	20-013-1	
R40	Carbon	47k	10	0,5	20-015-7	
R41	Carbon	10k	10	0,5	20-014-9	
R42	Carbon	3k3	10	0,5	20-014-3	
R43	Carbon	10k	10	0,5	20-014-9	
R44	Carbon	10	10	0,5	20-011-3	
R45	Carbon	47k	10	0,5	20-015-7	
R46	Carbon	4k7	10	0,5	20-014-5	
R47	Carbon	1k	10	0,5	20-013-7	
R48	Carbon	56	10	0,5	20-012-2	
R49	Carbon	5k6	10	0,5	20-014-6	
R50	Carbon	100	10	0,5	20-012-5	
R51	Carbon	120	10	0,5	20-012-6	
R52	Carbon	47	10	0,5	20-012-1	
R53	Carbon	390	10	0,5	20-013-1	
R54	Carbon	330	10	0,5	20-013-1	
R55	Carbon	1k2	10	0,5	20-013-8	
R56 R57	Carbon	3,3	5	0,5	20-040-7	
R58	Carbon	4k7	10	0,5	20-014-5	
R59	Carbon	100	10	0,5	20-012-5	
R60	Carbon	10k	10	0,5	20-014-9	

Cct. Ref.	Description	Value	Tol. %	Rating	Order No.	Codification
	Resistors (Cont.)	Ohms		Watts		
R61	Carbon	4k7	10	0,5	20-014-5	
R62	Carbon	82k	10	0,5	20-016-0	
R63	Carbon	2k2	10	0,5	20-014-1	
R64	Carbon	47	10	0,5	20-012-1	
R65	Carbon	1k	10	0,5	20-013-7	
R66	Carbon	220k	10	0,5	20-016-5	
R67						
R67	Carbon	47k	10	0,5	20-015-7	
R68	Carbon	1k	10	0,5	20-013-7	
R69	Carbon	470	10	0,5	20-013-3	
R70	Carbon	100	10	0,5	20-012-5	
R71	Carbon	18k	10	0,5	20-015-2	
R72	Carbon	10	10	0,5	20-011-3	
R73	Carbon	10k	10	0,5	20-014-9	
R74	Carbon	1k	10	0,5	20-013-7	
R75 R76	Carbon	33k	10	0,5	20-015-5	
R77	Carbon	22k	10	0,5	20-015-3	
R78	Carbon	47	10	0,5	20-012-1	
R79	Carbon	39k	10	0,5	20-015-6	
R80						
R81	Carbon	1k	10	0,5	20-013-7	
R82						
R83	Carbon	3k3	10	0,5	20-014-3	
R84 R85	Carbon	150	10	0,5	20-012-7	
R86	Carbon	470	10	0,5	20-013-3	
R87	Carbon	18k	10	0,5	20-015-2	
R88	Carbon	1k	10	0,5	20-013-7	
R89	Carbon	10k	10	0,5	20-014-9	
R101	Carbon	2,2	5	0,5	20-040-5	
R102	Carbon	10	10	0,5	20-011-3	
R103	Carbon	1k	10	0,5	20-013-7	
R104 R105	Carbon	2,2	5	0,5	20-040-5	
R106	Wirewound	47	10	5	21-000-1	
R107	Carbon	1k	10	0,5	20-013-7	
R108	Carbon	680	10	0,5	20-013-5	
R109	Carbon	2k2	10	0,5	20-014-1	
R110	Carbon	120	10	0,5	20-012-6	
R111	Carbon	10k	10	0,5	20-014-9	
R112	Carbon	22k	10	0,5	20-015-3	
R113	Carbon	100	10	0,5	20-012-5	
R114	Carbon	560	10	0,5	20-013-4	
R115	Carbon	1k	10	0,5	20-013-7	
R116	Carbon	330	10	0,5	20-013-1	
R117	Carbon	4k7	10	0,5	20-014-5	
R118	Carbon	10k	10	0,5	20-014-9	
R119	Carbon	2k2	10	0,5	20-014-1	
R121	Carbon	270	10	0,5	20-013-0	
R124	Carbon	100	10	0,5	20-012-5	
R125	Carbon	330	10	0,5	20-013-1	
R126	Carbon	22	10	0,5	20-011-7	
R127	Carbon	4k7	10	0,5	20-014-5	
R128 R129	Carbon	330	10	0,5	20-013-1	
R130	Carbon	10k	10	0,5	20-014-9	
R131	Carbon	4k7	10	0,5	20-014-5	
R133	Carbon	10k	10	0,5	20-014-9	
R135	Carbon	1k	10	0,5	20-013-7	
R136	Carbon	22k	10	0,5	20-015-3	
R137	Carbon	1k	10	0,5	20-013-7	
R139	Carbon	100	10	0,5	20-012-5	
R140	Carbon	1k	10	0,5	20-013-7	
R144	Carbon	47	10	0,5	20-012-1	
R152	Carbon	22k	10	0,5	20-015-3	
R153	Carbon	10k	10	0,5	20-015-3	
RV1	Carbon preset	220		0,2	22-001-1	

Cct. Ref.	Description	Value	Tol. %	Rating	Order No.	Codification
	Resistors (Cont.)	Ohms		Watts		
RV2	Carbon preset	100		0,2	22-000-9	
RV3	Carbon preset	4k7		0,2	22-001-5	
RV4	Carbon preset	470		0,2	22-001-2	
RV5	Carbon preset	10k		0,2	22-001-6	
RV7 RV9	Carbon preset	100		0,2	22-000-9	
RV10	Carbon preset	22k		0,2	22-001-8	
RV11	Carbon preset	4k7		0,2	22-001-5	
	Capacitors	µF		Volts		
C3 C4	Ceramic disc	0,047	20	50	26-280-1	
C5	Polystyrene	56p	10	125	27-120-8	
C6	Ceramic disc	0,047	20	50	26-280-1	
C7 C8	Polystyrene	68p	2,5	125	27-140-8	
C9	Trimmer	4,5 - 20p			28-001-8	
C10	Polystyrene	10p	2,5	125	27-020-7	
C11	Polystyrene	68p	2,5	125	27-140-8	
C12	Polystyrene	68p	2,5	125	27-140-8	
C13	Polystyrene	47p	2,5	125	27-110-7	
C14	Ceramic disc	0,047	20	50	26-280-1	
C15	Polystyrene	500p	10	63	27-300-5	
C16	Polystyrene	300p	10	63	27-240-3	
C17	Ceramic disc	0,047	20	50	26-280-1	
C18	Ceramic disc	0,047	20	50	26-280-1	
C20	Ceramic disc	0,047	20	50	26-280-1	
C21	Ceramic disc	0,047	20	50	26-280-1	
C22	Ceramic disc	0,047	20	50	26-280-1	
C23	Ceramic disc	0,01	20	50	26-250-2	
C24	Polystyrene	500p	10	63	27-300-5	
C25	Polystyrene	300p	10	63	27-240-3	
C26	Ceramic disc	0,047	20	50	26-280-1	
C27	Ceramic disc	0,047	20	50	26-280-1	
C28	Polystyrene	200p	10	63	27-210-4	
C29	Ceramic disc	0,047	20	50	26-280-1	
C30	Ceramic disc	0,047	20	50	26-280-1	
C31	Ceramic disc	0,047	20	50	26-280-1	
C32	Ceramic disc	0,047	20	50	26-280-1	
C33	Polystyrene	200p	10	63	27-210-4	
C34	Ceramic disc	0,047	20	50	26-280-1	
C35	Ceramic disc	0,047	20	50	26-280-1	
C36	Ceramic disc	0,047	20	50	26-280-1	
C37	Polystyrene	200p	10	63	27-210-4	
C38	Ceramic disc	0,047	20	50	26-280-1	
C39	Ceramic disc	0,047	20	50	26-280-1	
C40	Ceramic disc	0,01	20	50	26-250-2	
C41	Ceramic disc	0,01	20	50	26-250-2	
C42	Tantalum	4,7	-20	10	25-200-1	
C43	Tantalum	4,7	-20	10	25-200-1	
C44	Tantalum	220	-20	10	25-460-1	
C45	Ceramic disc	0,047	20	50	26-280-1	
C46	Tantalum	100	-20	10	26-400-2	
C47	Tantalum	22	-20	16	25-300-1	
C48	Tantalum	220	-20	20	25-460-1	
C49	Tantalum	47	-20	10	25-360-6	
C50	Mylar	0,047	20	100	26-818-1	
C51	Ceramic disc	0,047	20	50	26-280-1	
C52	Mylar	0,047	20	100	26-818-1	
C53	Tantalum	4,7	-20	10	25-200-1	
C54	Tantalum	4,7	-20	10	25-200-1	
C56	Tantalum	1	-20	35	25-120-2	
C57	Ceramic disc	0,01	20	50	26-250-2	
C58	Tantalum	1	-20	35	25-120-2	

Cct. Ref.	Description	Value	Tol. %	Rating	Order No.	Codification
	Capacitors	µF		Volts		
C59	Ceramic disc	0,047	20	50	26-280-1	
C60	Ceramic disc	0,01	20	50	26-250-2	
C61	Ceramic disc	0,047	20	50	26-280-1	
C62	Polystyrene	200p	10	63	27-210-4	
C63	Polystyrene	200p	10	63	27-210-4	
C64	Trimmer	4,5 - 20p			28-001-8	
C65	Polystyrene	25p	2,5	125	27-080-4	
C66	Ceramic disc	0,047	20	50	26-280-1	
C67	Tantalum	33	-20	10	25-340-1	
C69	Trimmer	2-2p			28-003-0	
C70	Tantalum	4,7	-20	10	25-200-1	
C71	Ceramic disc	0,01	20	50	26-250-2	
C72	Ceramic disc	0,01	20	50	26-250-2	
C73	Tantalum	22	-20	16	25-300-1	
C75	Ceramic disc	0,01	20	50	26-250-2	
C76	Tantalum	33	-20	10	25-340-1	
C77	Ceramic disc	0,047	20	50	26-280-1	
C78	Tantalum	33	-20	10	25-340-1	
C79	Ceramic disc	0,047	20	50	26-280-1	
C80	Ceramic disc	0,047	20	50	26-280-1	
C118	Ceramic disc	0,1	20	50	26-310-3	
C119	Ceramic disc	0,1	20	50	26-310-3	
C120	Ceramic disc	0,1	20	50	26-310-3	
C121	Ceramic disc	0,047	20	50	26-280-1	
C122	Ceramic disc	0,047	20	50	26-280-1	
C123	Ceramic disc	0,047	20	50	26-280-1	
C124	Ceramic disc	0,047	20	50	26-280-1	
C125	Tantalum	33	-20	25	25-340-1	
C126	Ceramic disc	0,047	20	50	26-280-1	
C136	Tantalum	4,7	-20	10	25-200-1	
C138	Ceramic disc	0,047	20	50	26-280-1	
C140	Tantalum	10	-20	16	25-260-1	
C145	Ceramic disc	0,0047	20	50	26-230-2	
C153	Tantalum	1	-20	35	25-120-2	
	Miscellaneous					
VT3	Transistor BF115				36-003-7	
VT4	Transistor BF115				36-003-7	
VT5	Transistor BF115				36-003-7	
VT6	Transistor BF115				36-003-7	
VT7	Transistor BF115				36-003-7	
VT8	Transistor BF115				36-003-7	
VT9	Transistor AC132				36-000-5	
VT10	Transistor AC127				36-000-3	
VT11	Transistor AC132				36-000-5	
VT12	Transistor BF115				36-003-7	
VT13	Transistor BF115				36-003-7	
VT14	Transistor BF115				36-003-7	
VT15	Transistor BC109B				36-003-3	
VT16	Transistor BF115				36-003-7	
VT17	Transistor BF115				36-003-7	
VT18	Transistor BF115				36-003-7	
VT19	Transistor BF115				36-003-7	
VT24	Transistor BFX17				36-004-1	
VT25	Transistor BFX17				36-004-1	
VT26	Transistor BF115				36-003-7	
VT27	Transistor BF115				36-003-7	
VT31	Transistor BF115				36-003-7	
VT32	Transistor BSY24 or BFY52				36-004-3	
VT33	Transistor 2N3641				36-016-0	
VT34	Transistor 2N3641				36-016-0	
VT35	Transistor BF115				36-003-7	
D1	Diode 1N4002				36-039-6	
D2	Diode 1N4002				36-039-6	
D3	Diode 1N4153				36-040-4	
D4	Diode 1N4153				36-040-4	
D5	Diode 1N4153				36-040-4	
D6	Diode 1N4153				36-040-4	

Cct. Ref.	Description	Value	Tol. %	Rating	Order No.	Codification
	Miscellaneous (Cont.)					
D7	Diode 1N4153				36-040-4	
D8	Diode 1N4153				36-040-4	
D9	Diode 1N4153				36-040-4	
D10	Transistor AC128 (strapped as				36-000-4	
D11	Transistor AC128 diode)				36-000-4	
D12	Diode 1N4153				36-040-4	
D14	Diode FH1100				36-034-1	
D15	Diode FH1100				36-034-1	
D16	Diode 1N4153				36-040-4	
D17	Diode 1N4153				36-040-4	
D20	Diode 1N4153				36-040-4	
D21	Diode 1N4153				36-040-4	
D23	Diode 1N4002				36-039-6	
D29	Zener diode MZ1000/8	6V2			36-033-4	
D43	Diode 1N4153				36-040-4	
D44	Diode 1N4153				36-040-4	
D50	Zener diode MZ1000/8	6V2			36-033-4	
D55	Diode 1N4153				36-040-4	
X1	Crystal	10,7015MHz			37-000-4	
F1	USB sideband filter	10,700MHz			37-006-6	
F2	LSB sideband filter	10,703MHz			37-006-7	
T1	Transformer, r.f. input				31-002-3	
T2	Transformer, r.f. output				31-002-4	
T3	Transformer, filter output				31-002-2	
T4	Transformer, mixer				31-000-4	
T5	Transformer, i.f.				31-000-3	
T6	Transformer, i.f.				31-000-3	
T7	Transformer, i.f.				31-000-3	
T8	Transformer, i.f.				31-000-3	
T9	Transformer, mixer				31-002-5	
T10	Transformer, oscillator				31-002-8	
T13	Transformer, oscillator				31-002-8	
T18	Transformer, power amplifier				31-002-9	
T19	Transformer, power amplifier				31-002-6	
L1	Inductor, filter				31-000-7	
5.	MULTIVIBRATOR PCB ASSEMBLY					
	Resistors	Ohms		Watts		
R1	Carbon	10k	10	0,5	20-014-9	
R2	Carbon	1k	10	0,5	20-013-7	
R3	Carbon	2k2	10	0,5	20-014-1	
R4	Carbon	2k2	10	0,5	20-014-1	
R5	Carbon	47k	10	0,5	20-015-7	
R90	Carbon	100	10	0,5	20-012-5	
R91	Carbon	220k	10	0,5	20-016-5	
R92	Carbon	220k	10	0,5	20-016-5	
R93	Carbon	100	10	0,5	20-012-5	
	Capacitors	µF		Volts		
C1	Ceramic disc	0,047	20	50	26-280-1	
C2	Ceramic disc	0,01	20	50	26-250-2	
C109	Ceramic disc	0,002	20	50	26-220-1	
C110	Polystyrene	600p	2,5	63	27-320-4	
C111	Polystyrene	600p	2,5	63	27-320-4	
C112	Ceramic disc	0,022	20	50	26-220-1	
	Miscellaneous					
VT1	Transistor BF115				36-003-7	
VT2	Transistor BF115				36-003-7	
L2	Choke wound on R92	1,6µH				
L3	Choke wound on R91	1,6µH				

Cct.Ref.	Description	Value	Tol.°/o	Rating	Order No.	Codification
6.	AM PCB ASSEMBLY					
	Resistors	Ohms		Watts		
R120	Carbon	470	10	0,5	20-208-1	
R138	Carbon	47	10	0,5	20-012-1	
	Capacitors	µF		Volts		
C55	Ceramic disc	0,047	20	50	26-280-1	
	Miscellaneous					
D18	Diode 1N4153				36-040-4	
D19	Diode 1N4153				36-040-4	
D42	Diode 1N4153				36-040-4	
D47	Diode 1N4153				36-040-4	
7.	CONVERTER PCB ASSEMBLY					
	Resistors	Ohms		Watts		
R122	Carbon	22	10	0,5	20-011-7	
R123	Carbon	22	10	0,5	20-011-7	
R134	Carbon	470	10	0,5	20-013-3	
R146	Carbon	10	10	0,25	20-011-3	
R147	Carbon	10	10	0,25	20-011-3	
	Capacitors	µF		Volts		
C74	Ceramic disc	0,1	20	50	26-310-3	
C127	Tantalum	4,7	-20	10	25-200-1	
C128	Tantalum	4,7	-20	10	25-200-1	
C129	Electrolytic	220	-10	25	24-240-4	
C131	Ceramic disc	0,1	20	50	26-310-3	
C132	Ceramic disc	0,1	20	50	26-310-3	
C133	Ceramic disc	0,1	20	50	26-310-3	
C134	Tantalum	10	-20	50	25-260-6	
C135	Ceramic disc	0,1	20	50	26-310-3	
C137	Electrolytic	100	-10	63	24-201-3	
C146	Ceramic disc	0,2		12	26-320-1	
	(Monolithic)	(0,22)	(±20)	(100V)	(26-322-5)	
	Miscellaneous					
VT29	Transistor 2N3055 (On DC Converter chassis)				36-015-0	
VT30	Transistor 2N3055				36-015-0	
VT44	Transistor 2N5190				36-021-0	
VT45	Transistor 2N5190				36-021-0	
D24	Diode 1N4002				36-039-6	
D25	Diode 1N4002				36-039-6	
D26	Diode 1N4002				36-039-6	
D27	Diode 1N4002				36-039-6	
D28	Diode 1N4002				36-039-6	
D30	Diode 1N4002				36-039-6	
T20	Transformer, inverter				30-000-4	
8.	BATTERY BOX ASSEMBLY					
	Miscellaneous					
D32	Diode 1N4002				36-039-6	
D33	Diode 1N4002				36-039-6	
D34	Diode 1N4002				36-039-6	
D35	Diode 1N4002				36-039-6	
D36	Diode 1N4002				36-039-6	
D37	Diode 1N4002				36-039-6	

Cct. Ref.	Description	Value	Tol. %	Rating	Order No.	Codification
	Miscellaneous (Cont.)					
D38	Diode 1N4002				36-039-6	
D39	Diode 1N4002				36-039-6	
D40	Diode 1N4002				36-039-6	
D41	Diode 1N4002				36-039-6	
D45	Diode 1N4002				36-039-6	
D46	Diode 1N4002				36-039-6	
BY1	Ni Cd. cell 1,2V, 5Ah*				42-280-1	
BY2	Ni Cd. cell 1,2V, 5Ah*				42-280-1	
BY3	Ni Cd. cell 1,2V, 5Ah*				42-280-1	
BY4	Ni Cd. cell 1,2V, 5Ah*				42-280-1	
BY5	Ni Cd. cell 1,2V, 5Ah*				42-280-1	
BY6	Ni Cd. cell 1,2V, 5Ah*				42-280-1	
BY7	Ni Cd. cell 1,2V, 5Ah*				42-280-1	
BY8	Ni Cd. cell 1,2V, 5Ah*				42-280-1	
BY9	Ni Cd. cell 1,2V, 5Ah*				42-280-1	
BY10	Ni Cd. cell 1,2V, 5Ah*				42-280-1	
LP4	Lamp, filament, 18W				35-008-5	
LP5	Lamp, filament, 10W				35-008-4	
LP6	Lamp, filament, 10W				35-008-4	
SK5	Socket, 6-way				33-010-5	
	Printed circuit board for connecting cells				19-000-8	
	*7Ah cells may be used in later equipments					

9. CRYSTAL PCB ASSEMBLY

NOTE: The components detailed below represent those required for one crystal bank, except capacitors C31 to C54. The same number of components are required for each bank and are defined on the circuit diagram by the suffixes A, B and C.
e.g. R1A, R1B, R1C .... C9A, C9B, C9C.

Cct. Ref.	Description	Value	Tol. %	Rating	Order No.	Codification
	Resistors	Ohms		Watts		
R1	Carbon	100	10	0,5	20-012-5	
R2	Carbon	6k8	10	0,5	20-014-7	
R3	Carbon	6k8	10	0,5	20-014-7	
R4	Carbon	470	10	0,5	20-013-3	
R5 to R18	Carbon	100k	10	0,5	20-016-1	
R19	Carbon	22	10	0,5	20-011-7	
R20	Carbon	1k	10	0,5	20-013-7	
R21	Carbon	1k	10	0,5	20-013-7	
R22	Carbon	1k	10	0,5	20-013-7	
	Capacitors	µF		Volts		
C1	Tantalum	33	-20	10	25-340-1	
C2	Ceramic disc	0,01	20	50	26-250-2	
C3	Ceramic disc	0,01	20	50	26-250-2	
C4 to C15	Ceramic disc	10p	10	50	26-040-3	
C16 to C27	Trimmer	4,5 - 20p			28-001-8	
C28	Polystyrene	68p	2,5	125	27-140-8	
C29 to C54	Ceramic disc	0,01	20	50	26-250-2	

Cct. Ref.	Description	Value	Tol. %	Rating	Order No.	Codification
	Miscellaneous					
VT1	Transistor BF115				36-003-7	
VT2	Transistor BF115				36-003-7	
VT3	Transistor BF115				36-003-7	
D1 to D24	Diode 1N4153				36-040-4	
D15	Varicap diode MV1405				36-121-1	
XL1 to XL12	Crystal - state frequency when ordering				37-002-5	

APPENDIX A

NICKEL CADMIUM BATTERIES - TECHNICAL NOTES

1. All the battery chargers supplied by Grinel are so designed that by using them, the safety and long life of the batteries are assured.

2. Should Grinel battery chargers not be available, the following technical notes are offered so that the user may derive the maximum benefit from these remarkable batteries.

3. Each battery consists of 10 cells. The electrodes of the cell are made from sintered nickel mesh, the negative electrode impregnated with cadmium hydroxide and the positive electrode impregnated with nickel hydroxide. The electrodes are separated by a porous spacer, which is impregnated with the electrolyte, potassium hydroxide solution. During the charging process the nickel hydroxide $Ni(OH)_2$ at the positive electrode is converted to beta-nickel-hydroxy-oxide NiOOH and the cadmium hydroxide $Cd(OH)_2$ at the negative electrode is converted to metallic cadmium.

4. As soon as the cell is fully charged, a secondary reaction occurs. The electrolyte is decomposed, releasing oxygen gas. At low charging this gas dissolves in the electrolyte and travels to the negative electrode, where it combines with the metallic cadmium to form cadmium hydroxide and the process can continue indefinitely without physical release of excess oxygen.

5. In practice it has been found that if the capacity of a battery in ampere-hours (Ah) is C, then below 90% of full charge, the maximum current the battery may be charged with is

$$1_1 = \frac{C}{1\ \text{hour}}$$

Above 90% of full charge the rate must be reduced to a maximum of

$$1_2 = \frac{C}{10\ \text{hours}}$$

6. The battery used in this equipment is 5 Ah capacity and the two charging currents which may be used are:

$$1_1 = \frac{C}{1\ \text{hour}} = \frac{5}{1} = 5 \text{ amps maximum below 90\% charge}$$

$$1_2 = \frac{C}{10\ \text{hours}} = \frac{5}{10} = 0{,}5 \text{ amps maximum above 90\% charge}$$

7. While these nickel cadmium cells can be charged at 5 amps, extreme precautions must be taken to prevent overcharging. As explained in the previous paragraph, overcharging at a high rate will produce free oxygen and this can generate sufficient pressure to cause the cell to explode. Charging at a high rate from a constant voltage charge can also produce a second phenomenon - "thermal run-away". This can be caused at any time after the cell is 90% charged. As the cell approaches full charge the e.m.f. of the cell tends to drop slightly due to a small internal temperature increase caused by the charging current. This drop in e.m.f. will cause the charging current to increase, increasing the internal heat, further lowering the cell e.m.f. and thus further increasing the charging current. Unless the charge is terminated, this process will reach the stage where the complete destruction of the cell, with possible explosion due to boiling electrolyte, will occur.

8. From the foregoing it can be concluded that the safest method of charging nickel cadmium batteries is to charge from a constant current source at a rate not exceeding 0,5 amps. In order to fully charge a battery at 0,5 amps the charging must be continued for 12 to 14 hours. Overcharging can be permitted at this rate without damage to the cell. For optimum results the cells should be charged at an ambient temperature in excess of $50^{o}F$ ($10^{o}C$).

9. If for operational reasons it is necessary to charge the cells at rates in excess of 0,5 amps full precautions must be taken to ensure that overcharging does not occur. Even a few minutes overcharge at 5 amps can cause a cell to explode and in any case the oxygen produced by an overcharge is not quickly reabsorbed into the cell, causing a concentration in the cell electrolyte together with a reduction in capacity. If high rate charging is required it is advisable to use a special charging circuit which reduces the charging current to 0,5 amps or below as soon as the battery is 90% charged.

10. Alternatively, if the state of charge of the battery is known accurately before recharging is commenced, the time required to bring the battery to 90% charge can be calculated, after which time the charging rate should be dropped to the 0,5 amps. For example, take a battery that is known to be exactly half charged, i.e. 2,5Ah remain in the battery and 2,5Ah must be replaced. Up to 90% of 5Ah = 4,5Ah so our half-charged battery may have 2Ah (4,5Ah - 2,5Ah) replaced at 5 amps. The remaining 0,5Ah must be replaced at 0,5 amps. The first part of the charge will take:

$\frac{2Ah}{5A}$ = 0,4 hours or 24 minutes which will bring the battery up to 90% full charge. The Final part of the charge will take:

$\frac{0,5Ah}{0,5A}$ = 1 hour or 60 minutes

11. If the state of charge of the battery is not known the battery should be discharged through a suitable lamp load (a 12V 80W car bulb is suitable) until the battery voltage is 1,0V per cell (10,0V for the battery in this equipment). The battery will then be fully discharged and can then be charged for 54 minutes at 5 amperes, after which time the charging rate should be reduced to 500 milliamps at which rate, charging can continue indefinitely.

12. Cells in batteries can also be damaged during discharge if the discharge is to deep. The capacity of individual cells will vary slightly, consequently the cell with the lowest capacity will become fully discharged first. If discharge is allowed to proceed beyond this point the low capacity cell will be reverse charged. The reversal of one cell will produce a drop in the battery output voltage, but if the remainder of the cells in the battery are much greater in capacity the terminal voltage of the battery may still be higher than the normal end point and the reversal of one cell will not be obvious from a meter reading.

13. A certain degree of protection is built into nickel cadmium cells and short periods of reversal do not damage the cells, they will return to normal on recharging. However, deep reverse charging can permanently damage the cell. In the battery in this equipment additional protection is provided by silicon diodes placed across each cell which effectively short circuit any cell which becomes fully discharged. To avoid the risk of cell damage due to reverse charging, it is recommended that batteries should not be discharged beyond the point where the individual cell voltage is 1,0V.

14. The capacity of the battery is affected by the ambient temperature during discharge. At temperatures between $15^{o}C$ and $30^{o}C$ full capacity can be expected. At $0^{o}C$, 90% of capacity is obtained and at $45^{o}C$, 75% of capacity. Battery terminal voltages will be somewhat lower than those obtained at normal ambient as the temperature is increased or decreased.

15. Nickel cadmium cells will lose a part of their charge during storage. At normal ambient temperature an initially fully charged cell will retain 70% of its capacity after 30 days and 50% after 60 days. These periods can be extended by storing the batteries at lower than normal ambient, but not freezing, temperatures.

16. Finally, there is one point which may not be immediately obvious. Nickel cadmium cells are alkaline devices, consequently, exposure to acid fumes or, more seriously, contact with acid is to be avoided. If possible, separate charging facilities should be set up for alkaline batteries, but if the batteries have to be charged on a plant normally used for lead acid cells the top of the bench should be washed down with a weak solution of sodium carbonate in water before placing the alkaline batteries in position. Alternatively, the bench top can be covered with a sheet of P.V.C. which can easily be washed as required.

17. Recently, cells of 7Ah capacity have become available and these are now being used in some Grinel equipments. These cells may be charged to 90% of fully capacity at 7A, the remaining 10% being replaced at 700mA. Alternatively a 700mA charge for 14 hours will recharge a fully discharged cell.

18. The NiCd cells have their ampere-hour capacity marked on them and this must be ascertained before starting the charge. If it is not possible to check the capacity it should be assumed (for TR28 equipments) that this is 5Ah and the complete battery charged accordingly.